



BETTER SHIPS, BLUE OCEANS

Activity plan SITO 2027

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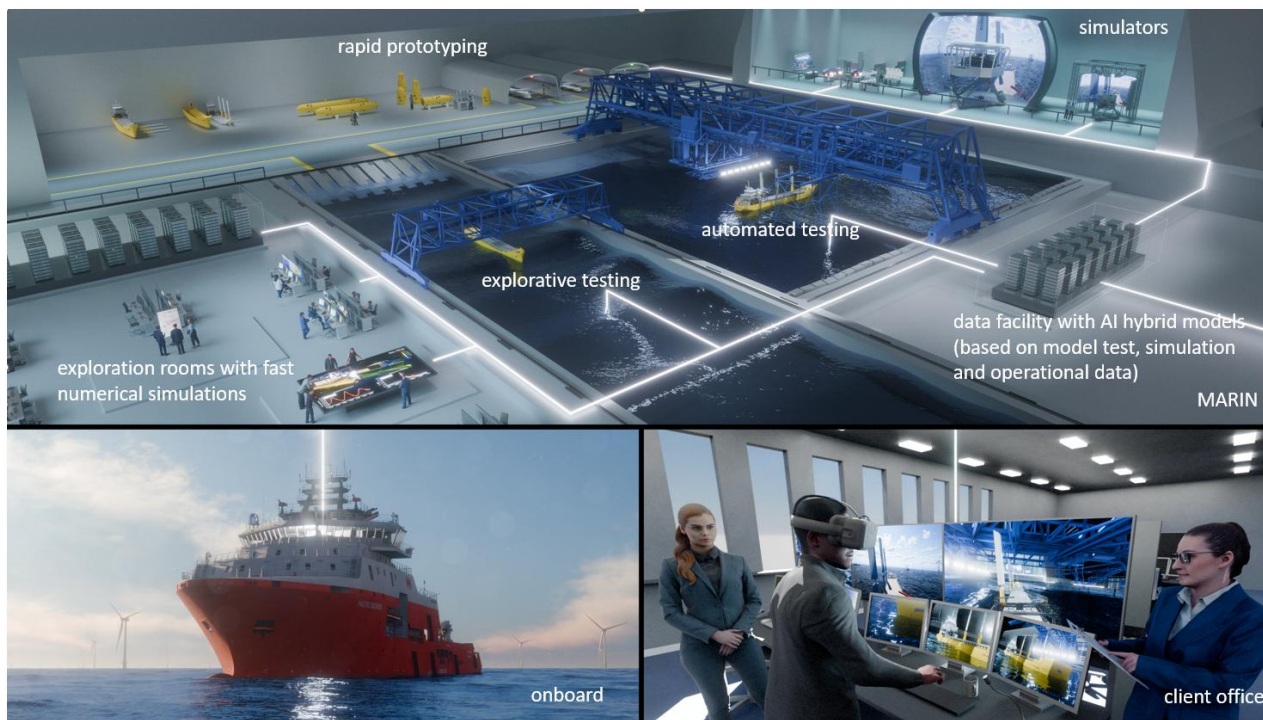
1 INTRODUCTION

The government funding for MARIN is used for research for the government, society, and the broad maritime sector, focused on MARIN's strategic mission: 'MARIN is committed to the sustainable, safe, and secure use of the oceans for a thriving maritime sector.' We aim to provide solutions for concept development, design, and operations by combining all our methods and facilities.

This government funding consists of *Instituutssubsidie* (basic funding), *Programmasubsidie* for ministries, *Infrastructuursubsidie* for the renewal of facilities, and *Instandhoudingsbijdrage* for maintenance of the existing facilities.

The *Instituutssubsidie* gives MARIN the opportunity to contribute to the seas, ports, and rivers of the future: zero-emission ships, safe shipping, sustainable energy and food production, innovative floating solutions, autonomous ships, and effective vessels for maritime safety such as for the Royal Navy and Government Shipping Company. We build on key technologies such as digitization, artificial intelligence, robotics, simulation techniques as well as high-quality measurements, both on-board and in our laboratory test facilities.

In 2027, the *Instituutssubsidie* will be €8.553 million, after deduction of the pre-financing for the new simulator centre. This pre-financing is compensated by a budget of €6.0 million, which can be used over a period of 5 years. In the coming year, we plan to use €0.645 million of this additional budget. The *Instandhoudingsbijdrage* for maintenance of our facilities will amount to €0.859 million.



The funding for defence-specific knowledge development will be €7.317 million in 2027, in addition to the work that MARIN carries out for the Royal Navy's renewal programs under the *Defensienota*, and in addition to co-financing of projects from the European Defence Fund.

With the ministry of I&W we have established a broader research programme for shipping safety in the North Sea. In addition, there are smaller programs for inland shipping, making shipping more sustainable and for knowledge development regarding wet infrastructure such as bridges and locks. In 2027, the ministry has allocated a budget of €2.250 million for this, in addition to the existing resources for software maintenance. Cooperation with the Ministry of I&W partly takes place via Rijkswaterstaat.

The cooperation agreement with Rijkswaterstaat is also being further specified. In addition to the maintenance of forecasting methods and programmes, research is being included in the programme.

In 2027, *Programmasubsidie* will be provided by the ministries of LVVN and KGG. For these two ministries, we are a.o. working on the development of a zero-emission shrimp cutter.

MARIN has three large projects running from recent FTO calls: SeaLab, DigiLab, and Maritime Innovation Lab. In SeaLab we develop a modularized measurement system for quick installation on board. DigiLab provides us with the opportunities to collaborate with other institutes in extending our Digital capabilities. In Maritime Innovation Lab we repurpose our shallow water basin for collaborative innovation in the maritime sector. These projects are funded through *Infrastructuursubsidie*.

This MARIN Activities Plan SITO provides a brief overview of MARIN's role in the maritime sector and gives highlights of the planned research for 2027. In addition, there is a more detailed appendix to this Activity Plan: the MARIN RD&I Agenda 2027. This appendix goes into more detail about the plans and describes how MARIN's own investments in development and maintenance contribute to the implementation of knowledge developed with government funding.

2 MARIN'S ROLE TOWARDS GOVERNMENT AND MARITIME SECTOR

2.1 MARIN Strategy 'Oceans of Opportunities'

For nearly a century, MARIN has been a beacon of knowledge and innovation in the maritime world, driven by a highly motivated team and a dedicated network in the public and private sector.

We live in turbulent times, with multiple transitions moving forward. Energy transition, digitalization, climate change and geopolitical developments that are more complex than we have seen in the last decades. With our new strategy 'Oceans of Opportunities', we choose to embrace the dynamics that come with these transitions. We cooperate and navigate with the maritime sector as circumstances change. We aim to be more agile and resilient, by continuously developing our team and by carefully selecting our integrated activities.



MARIN continues to be the independent knowledge institute with a strong focus on the future of the maritime sector. Like the other TO2 institutions, MARIN has three main tasks: developing, applying, and disseminating knowledge to solve societal questions and support government tasks and policy; empowering the innovative strength and competitive position of the Netherlands; and managing strategic research facilities that are unique in the Netherlands and internationally.

In our new strategy, we are building on our previous strategy and under the same motto 'Better ships, Blue oceans'. However, as the world is rapidly changing and MARIN itself is continuously evolving as well, we are sharpening our mission and vision.

That is what we stand for, our mission:

*MARIN is committed to the sustainable, safe
and secure use of the oceans¹ for a thriving maritime sector.*

We believe that our oceans must be responsibly used as this is the way forward to truly support society. A responsible use is essential for a thriving maritime sector with clean transport, with secure and clean energy and by securing territorial safety, trade routes and infrastructure at sea. Safe operations,

¹ When we use the word 'oceans' we want to be concise, but are implicitly referring to every other relevant (inland) body of water, like seas, rivers, canals, etc.

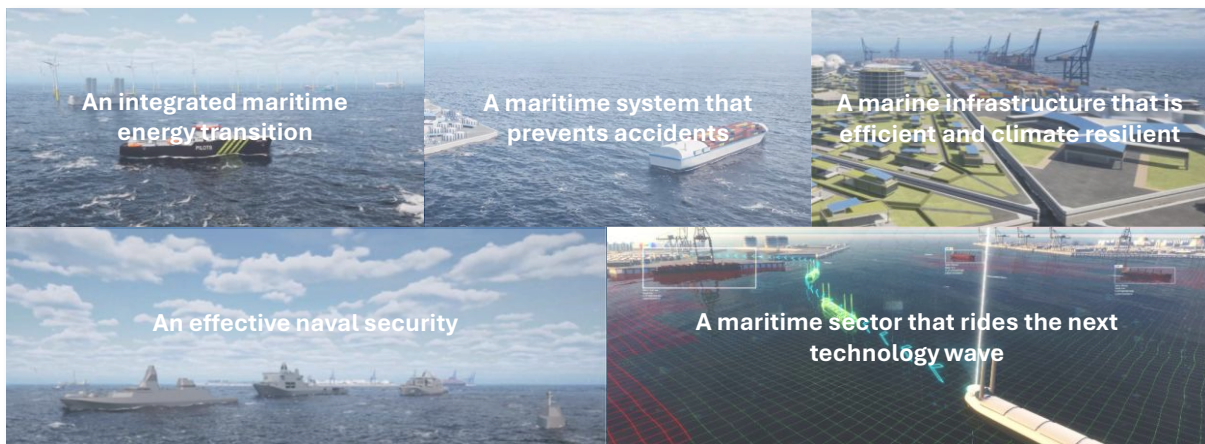
protecting human life, nature and economic value are key aspects. And vice versa, a thriving maritime sector is needed to achieve sustainable, safe and secure use of the oceans.

Driven by our mission, we will help our clients to innovate and to be competitive and we will assist policymakers with the right knowledge to support and guide the transitions. Because with the right focus there are oceans of opportunities for MARIN and the maritime sector.

This is what we aim for, our vision:

By 2032, we have achieved the following with and within the maritime sector:

- **An integrated maritime energy transition**, with innovations for sustainable energy production and fuel logistics, and zero-emission shipping.
- **A maritime system that prevents accidents**, with innovations to increase the safety of shipping and offshore operations while maintaining efficiency, including decision support and autonomous shipping.
- **A marine infrastructure that is efficient and climate resilient**, with efficient shipping on waterways and innovations for floating port industry and housing.
- **An effective naval security**, with rapid-cycle innovations to ensure territorial safety, protect trade routes, and safeguard vital infrastructure at sea.
- **A maritime sector that rides the next technology wave**, with data driven digital and artificial intelligence innovations to design and operate efficiently.



Our visions are closely aligned and directly contribute to the strategic objectives of both the Netherlands and the European Union. These objectives are reflected in a series of key policy initiatives. They include the Draghi Report on the Future of European Competitiveness, and the current and future innovation and industrial policies in the Netherlands, focusing on safe, circular, and zero-emission shipping, sustainable blue economy, accessible waterways and ports, and maritime safety, fisheries, food and energy. They also include the Sector Agenda for the Maritime Industry, the Maritime Master Plan, the Safety at Sea programme, the Kennisplan Zee, the Defence Strategy for Industry and Innovation and the National Technology Strategy.

To navigate that future, we made four strategic choices. At the core lies our search for the right balance between our scope to create impact and be unique versus feasibility. The strategic choices are:

1. We create impact across the entire maritime sector by engaging across five markets.

We are committed to achieving our vision with the maritime industry and governments across the entire spectrum of the maritime markets. That is why we are actively involved in five important market segments: Transport and Shipping, Passengers and Yachting, Defence, Offshore energy and Blue growth, and Marine infrastructure and Spatial planning. We want our knowledge development and services for these markets to play a direct and meaningful role in realizing our

vision. In all five markets we are working together to drive the maritime energy transition, prevent accidents and accelerate the digitalisation of the sector.

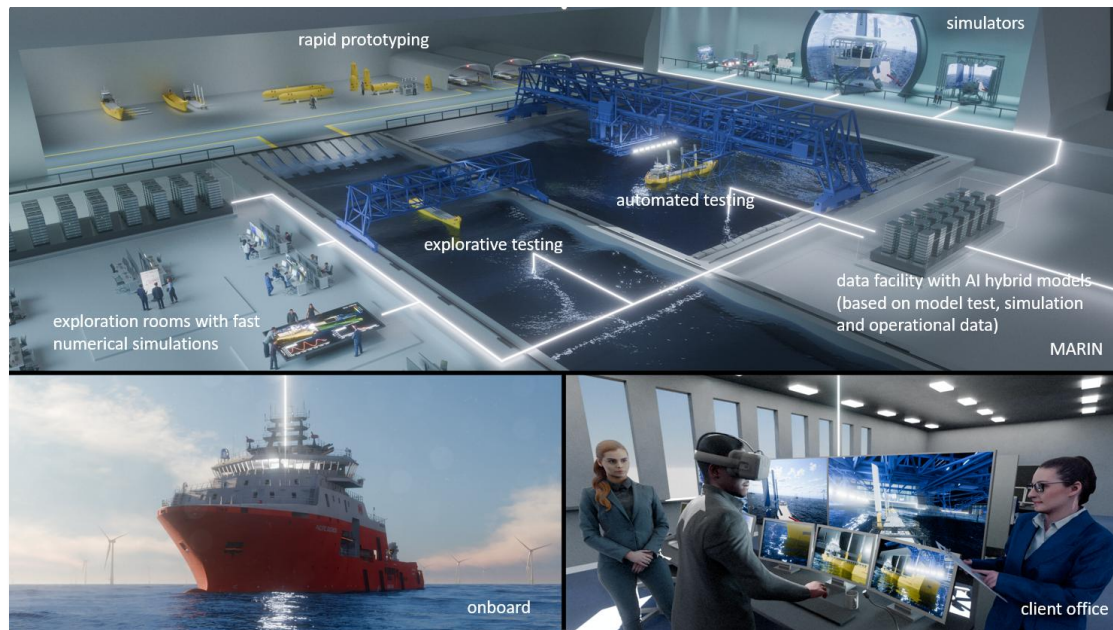


Vision for 2032	MARIN market groups				
	Transport and Shipping	Passengers and Yachting	Defence	Offshore energy and Blue growth ¹	Marine infrastructure and Spatial planning
An integrated maritime energy transition	✓	✓	✓	✓	✓
A maritime system that prevents accidents	✓	✓	✓	✓	✓
A marine infrastructure that is efficient and climate resilient	✓			✓	✓
An effective naval security			✓		
A maritime sector that rides the next technology wave	✓	✓	✓	✓	✓

2. **We create Impact from concept to operation by deploying our expertise across four roles:** assessing design and operations, accelerating client's innovations, exploring emerging technologies and advising policymakers and regulators. We choose to strengthen two of these roles: make a stronger commitment to advice policy makers and regulators and help our clients much more with their innovations by exploring alternatives together, in concept phase and during operations. This is essential to create impact, realize our vision and increase our resilience. This is how we evolve our roles:



3. **We build a unique position by linking our strengths in our networks, knowledge base and research methods.** We are a leading organization, driven by strong sector engagement, national and international collaboration, and recognized expertise. We pioneer AI applications in the maritime domain, conduct advanced measurements in our model basins and at sea, and perform cutting-edge simulations and use high-fidelity simulators. By combining our strengths, we create unique value that is difficult to copy by others. This unique value enables our clients to achieve greater success in their activities. Our clients can experience and evaluate their designs, operations and/or policies before they are built or implemented. This allows them to optimise and innovate their solutions with our support. We aim to provide this experience at MARIN, at our clients' offices or onboard.



4. **We create coherence and efficiency in our operations: generic where possible, specific where needed.** We are more aware than ever that the broad impact we aim for is only possible if we choose coherence and efficiency in our operations. We focus on synergy in our services across markets, in our research methods and R&D and in our internal collaboration, where we work from a common base that allows us to operate with agility across the organization. This means a clear focus on shared priorities and common interests.

2.2 Our services

Delivering on these roles requires an integrated set of services. We have created a comprehensive overview of the services we provide to the different markets: desk studies, advanced computational modelling and optimisation, physical model testing, full-scale measurements, and simulator-based investigations. A key observation underlying this agenda is that our services share many commonalities. By systematically identifying and analysing these shared elements, it became possible to move beyond case-specific solutions and instead develop reusable knowledge, scalable methods, and transferable tools in our generic research programmes.

This perspective led to the definition of five high-level services along with ten core capabilities, which form the backbone of the research agenda. These capabilities capture the essential expertise required to address both current demands and emerging questions, while enabling synergy across application areas. By focussing research and development around these capabilities, we can more effectively prioritise research and investments and maximise impact. The high-level services are being elaborated into market roadmaps. These roadmaps feed into the market-specific research programmes that build upon the generic research for all markets.

After the analysis, the following high-level services have been defined. For each service we indicate what roles we aim to fulfil. Each service is underpinned by use cases for the different markets. These services will be further elaborated in the upcoming market roadmaps. The services build on one or more capabilities that will be developed in our RD&I agenda in the coming years. These capabilities are discussed in Chapter 3.



Scenario analysis for transitions

We provide integrated maritime foresight and simulation services that enable stakeholders to confidently navigate complex transitions in energy, logistics, and maritime operations. By combining advanced exploration tools within a single, coherent framework, we offer system-level insight into interconnected maritime ecosystems, from vessel fleets and supply chains to ports, infrastructure and energy networks. Our scenario-based approach allows clients to test “what if” strategies under realistic technological, regulatory, and operational developments, while evaluating trade-offs across emissions, cost, safety, efficiency, and societal impact. Through interactive workshops and close stakeholder engagement, we support alignment between policymakers and industry, translating complex analyses into clear, actionable strategies. This enables clients to make robust, future-proof decisions, avoid costly malinvestments, and build resilient systems in an uncertain and evolving maritime landscape.

Rapid exploration of concepts.

We accelerate innovation in the maritime sector. As industry faces major transitions — digitalisation, sustainability, autonomous systems, and increasing system complexity — we provide a safe, independent environment for experimentation, validation, optimisation, and scaling of new solutions. We do this by combining our expertise in innovation management and deep market knowledge with our unique technical capabilities. By mobilizing multidisciplinary expert teams and leveraging modelling, simulation, experimental insight, and operational experience, we help clients react quickly and confidently. Our independent status makes us a trusted advisor. By strengthening collaboration, guiding the innovation process, and supporting stakeholders with our expertise (policy, human factors, safety, technical...), we enable robust, future-proof innovations that create impact across the entire maritime value chain.

Efficient development of prototypes

We turn complex maritime ideas into validated, high-performance solutions by combining scientific rigor with hands-on engineering. We offer access to world-class hydrodynamic expertise, advanced calculations and simulations, model-testing and on-board measurement capabilities, and multidisciplinary researchers who co-develop prototypes with industry partners. We do this together with the sector, with fast iteration cycles. This means clients don’t just get a prototype. They get one that is proven, optimized, and de-risked before real-world deployment, reducing development costs, shortening innovation cycles, and increasing confidence in performance at sea.

Objective clarity on performance

We give clients full confidence that their vessels, offshore structures, or infrastructure perform as intended and comply with the governing basis of design, operational requirements, and regulatory expectations. We achieve this by delivering decision-ready insights based on a combination of numerical modelling, physical testing, simulator studies and training, and on-board measurements. This integrated approach reduces project risk, ensures early identification of potential non-compliances, and provides robust, validated evidence to support design choices, optimize design and operations, and ensure safe, efficient, and future-proof system performance throughout the lifecycle.

Measurable performance improvement during operations.

We enable maritime operators to understand how their vessels, systems, and crews truly perform in real-world conditions — and to turn those insights into safer, more efficient, and more predictable operations. By combining high-quality onboard measurements, advanced analytics, human-factor insight, and validated predictive models, we provide a complete picture of operational performance that goes far beyond traditional monitoring. Clients gain actionable intelligence on system behaviour, crew interaction, environmental influences, and asset health, supported by our independent expertise and deep hydrodynamic knowledge. This empowers operators to optimise decision-making, reduce risk, extend asset lifetime, and continuously improve operations through data-driven feedback loops and digital-twin-based predictive and advising capabilities.

2.3 Knowledge partner

MARIN is a dynamic force for cooperation in the national and international maritime sector. We lead and cooperate within numerous Joint Industry Projects and networks.

National cooperation

In the Netherlands, this starts with Nederland Maritiem Land, involving all Dutch maritime branches and central companies. We are particularly active in the Innovation Council, directly connected to Top Consortium for Knowledge and Innovation Maritime, to accelerate innovations and strengthen collaboration.

MARIN has played an active role in shaping the R&D scheme for the mobility sectors, the Maritime Masterplan, and previously the innovation contract under the Dutch Top Sectors policy. In addition, MARIN provides the chair of TKI Maritiem, ensuring strong alignment between MARIN's developments and national innovation programs. We also chair the Innovation Council of Nederland Maritiem Land (NML), where leaders from the Dutch maritime industry come together to shape the innovation agenda for the sector.

To stimulate fundamental maritime research, MARIN collaborates with TU Delft, NLDA, TNO, and major market players within the Maritime Knowledge Centre (MKC). We also maintain long-term collaborations with the following universities and institutions to strengthen our knowledge development and to support students during their graduation projects:

- **TU Delft**
Our longstanding collaboration with the Department of Marine & Transport Technology within the Faculty of Mechanical, Maritime and Materials Engineering (3mE) at TU Delft includes the appointment of a part-time professor (0.3 FTE), guest lectures, supervision of students during graduation and PhD trajectories, and participation in examination and doctoral committees. In addition, we collaborate on industry-sponsored projects and support PhD programmes through MARIN.
Cooperation has also expanded with the Faculty of Electrical Engineering, Mathematics and Computer Science, particularly in the field of numerical mathematics. Furthermore, we maintain

close ties with the Ports and Waterways section within the Hydraulic Engineering department of the Faculty of Civil Engineering and Geosciences.

- **University of Twente**
Here too, MARIN has a long-standing collaboration with the faculties of Engineering Technology, Science & Technology, and Electrical Engineering, Mathematics and Computer Science. This partnership is formalised through a Memorandum of Understanding between the University of Twente and MARIN. We work together on various NWO-funded projects, and MARIN regularly supervises MSc graduation students.
- **University of Groningen**
The Department of Mathematics and Computer Science has a long-term collaboration with MARIN focused on the development of a non-stationary CFD solver (COMFLOW) for violent free-surface flows. The development of COMFLOW is now continuing within a dedicated user group.

International cooperation

Internationally, MARIN has been leading the Cooperative Research Ships (CRS) for over 55 years, bringing together shipyards, suppliers, shipowners, navies, classification societies, and research institutes. We also collaborate with international navies through the Cooperative Research Navies. MARIN spearheads various Joint Industry Projects, organizing networks like the Floating Energy Research Forum, BlueForum, and the Vessel Operator Forum. These forums facilitate sharing experiences, promoting sustainable practices, and discussing new technologies. This drives innovation and collaboration in the maritime sector.



MARIN has been a key player in organizing the maritime sector at the European level. For four years, we chaired the Waterborne Technology Platform, uniting ship owners, shipyards, equipment suppliers, class societies, and research institutes. This platform aims to shape the European research agenda in Horizon Europe and secure funding for maritime, inland, and blue-growth research. Together, we have established a co-programming partnership with the European Commission on zero-emission shipping, running until 2030. The Waterborne has taken the initiative to renew the partnership and expand it in the direction of digitisation. In 2019, MARIN joined the European Sustainable Shipping Forum. The European Commission created this to discuss the latest innovations and regulations and provide input for IMO discussions.

Academic collaboration

To strengthen long-term knowledge development for the maritime sector, MARIN collaborates with various international universities and institutes. We actively approach leading research groups within our field of expertise and aim to establish multi-year partnerships through the supervision of MSc and PhD students and the delivery of guest lectures.

Within our research programmes and themes, we collaborate concretely with the following universities:

- Sustainable Propulsion
 - Chalmers University, Gothenburg, Sweden: This university is internationally leading in the development of knowledge on ship resistance and propulsion, particularly in the application of Computational Fluid Dynamics.
 - Instituto Superior Técnico, Lisbon, Portugal: This technical university has a large aerospace faculty. We collaborate with them to improve simulations of ship propellers.
- Manoeuvring
 - University of Iowa, Iowa City, Iowa, USA: This university is internationally recognised for its expertise in ship manoeuvring, both through experimental techniques and CFD.
 - A collaboration has been initiated with the Universities of Ghent and Duisburg, as well as with Flanders Hydraulics, BAW (Federal Waterways Engineering and Research Institute), and DST (Development Centre for Ship Technology and Transport Systems Duisburg).
 - University of Genua, Italy: with this university we collaborate on research for developing manoeuvring models.
 - University of Istanbul, Türkiye: we collaborate on the use of AI for manoeuvring applications.
- Waves & Motions
 - ENSTA Bretagne (École Nationale Supérieure des Techniques Avancées), France: We work with this technical university on modelling ships in waves.
 - University of Massachusetts – Amherst, USA: We collaborate on modelling floating wind turbines and wave impacts.
 - University of Duisburg-Essen, Germany: We work with the maritime engineering department on modelling physics in large waves.
 - University of Leeds, United Kingdom: Together with the mathematics faculty, we work on rapid prediction of wave propagation over long distances.
- CFD Development
 - Instituto Superior Técnico, Lisbon, Portugal: In addition to propeller simulations, we collaborate on improving CFD techniques based on the latest insights from aerospace engineering.
 - University of Iowa, Iowa City, Iowa, USA: We work with this major maritime player on organising an international workshop.

MARIN places great importance on sharing its knowledge and expertise worldwide. Therefore, we actively contribute to standardisation and quality assurance in maritime research through the International Towing Tank Conference (ITTC) and the International Ship and Offshore Structures Congress (ISSC). In 2023, we joined the International Marine Simulator Forum (IMSF).

Within our collaboration with universities, we are increasingly focussing on the new technologies as put forward in the Dutch *Nationale Technologie Strategie*. Within this national strategy, key emerging technologies have been defined that will be supported to strengthen innovation in the Netherlands. The maritime sector is not directly mentioned in this strategy, but key technologies that are of great interest to the sector are Artificial Intelligence (AI) and Quantum Technologies. AI is already an integral part of our research agenda with the sector; quantum technologies are emerging and first explorative studies are being programmed in our agenda.

Knowledge partner of Ministry of Infrastructure and Water Management

In 2022, MARIN sent the white paper 'Heading for shipping safety' to the Ministry of Infrastructure & Water Management and Rijkswaterstaat. Serious shipping accidents on our busy waterways and the North Sea pose major risks to crew, passengers, the environment and the economy. With larger ships, more shipping movements, and wind farm constructions, shipping safety is under increasing pressure. This situation demands national and international action to raise maritime safety levels.

MARIN proposed strengthening cooperation with the Ministry to enhance maritime safety. As an independent knowledge partner, MARIN can support the government's proactive, risk-based approach

with its unique facilities and expertise. A targeted long-term knowledge agenda is essential for this collaboration. The Ministry has decided to fund a multi-year research program with MARIN, starting in 2024, to address these safety challenges. Additionally, MARIN works on nautical tool development, the Green Deal and sustainable shipping programs with TNO.



Knowledge partner of Ministry of Defence

Our research for the Ministry of Defence focuses on developing and maintaining naval platforms that deliver maximum operational effectiveness. We aim to ensure that these platforms remain relevant throughout their operational lifetime with consideration of safety and sustainability. The ministry involves MARIN intensively in general knowledge and innovation, such as in the Kennisnetwerk Zee Network and the Dutch Naval Design. MARIN's expertise is crucial for the Defence Industrial Strategy, ensuring that the Netherlands has a stable base of knowledge, technology and industrial capacity to protect its vital and allied interests.

Currently, MARIN is deeply involved in all renewal programmes of the Royal Netherlands Navy. These programmes include the mine countermeasures vessels, submarines and the replacement of fast raiding interception and special forces crafts. They also cover the replacement of M-frigates, air defence and command frigates, and the amphibious toolbox. A key area is the introduction and integration of uncrewed systems in mixed crewed-uncrewed operations. This includes efforts to reduce crew sizes on large navy vessels, considering aspects as safe navigation, collision avoidance, situational awareness and safe launch and recovery of assets. MARIN plays a central role in addressing these complex challenges.



Increased defence budgets have allowed the Ministry of Defence to invest in strengthening the knowledge base at the knowledge institutes (TNO, NLR and MARIN) since 2023. While our focus was primarily on hydrodynamics, recent years have seen a shift towards simulation techniques, AI-based advisory systems, uncrewed systems, and risk-bearing exploratory research, such as developing the modular Autonomous Underwater Vehicles and hydrofoils.

Knowledge partner Ministry of Agriculture, Fisheries, Food Security and Nature

In 2024 the Ministry of Agriculture, Fisheries, Food Security and Nature published a vision: 'Food from the sea and large waters'. In this document a sustainable future is envisioned for traditional fisheries and other forms of food production at sea. MARIN plays an important role in the safety and sustainability of these producers. Firstly, research is performed into the stability of fishing vessels and reducing the emissions of the vessels. Other offshore food producing is still in its infancy, MARIN knowledge on offshore structures and operations is essential for a successful future for these industries.

Cooperation in the TO2-federation

Within the TO2-federation, MARIN collaborates closely with the other Applied Research Organizations (TO2) in the Netherlands, including Deltares, NLR, TNO, and WUR. The TO2 institutions have three main tasks: developing, applying, and disseminating knowledge to solve societal questions and support government tasks and policy; empowering the innovative strength and competitive position of the Netherlands; and managing strategic research facilities that are often unique in the Netherlands and internationally.

Every four years, a committee evaluates the five TO2 institutions based on the protocol for the evaluation and monitoring of applied research organizations (EMTO). The overarching evaluation committee TO2 (Committee Gielen) was positive about the quality, impact and vitality of the TO2 institutions in its final report of April 2026: *"The TO2 institutes play a leading role in the field of innovation, and all TO2 institutes are regarded by the stakeholders (in their field) nationally and internationally as authoritative and leading institutes. The limited available financial resources for the knowledge base and research facilities pose a number of challenges for the institutes, but despite this, the TO2 institutes fulfil an important, central role in the Dutch knowledge ecosystem, whereby they generally fulfil their main tasks in a good manner."*

We have strengthened our cooperation on several themes, including: The North Sea, Digital collaboration (DigiLab, DigiShape), Energy transition (Zero Emission Lab and Maritime Masterplan) and Defence. More specifically, our collaboration per institute focuses on:

- TNO: emission-free sailing, autonomous sailing, underwater noise, sustainable energy at sea, marine infrastructures, digitalization, data science and human factors.
- Deltares: ports and waterways, marine infrastructures, floating construction, energy from water, environmental conditions, digitalization, data science and Computational Fluid Dynamics.
- Wageningen University & Research (WUR): impact on ecology, fisheries, seaweed cultivation and digitalization.
- NLR: aerodynamics, Computational Fluid Dynamics, human factors, simulation and virtual reality, and digitalization.

The committee Gielen also asks for attention to bottlenecks regarding, for example, government financing of the knowledge base and large research facilities, accessibility for SMEs, cooperation with universities of applied sciences, and to lower the threshold for knowledge exchange with SMEs.

3 RD&I AGENDA IN 2027

3.1 Multi-year RD&I agenda

In our strategy “Oceans of Opportunities” we decided to work with an integrated Research, Development, and Implementation (RD&I) agenda to advance our knowledge and technology. The RD&I agenda serves to realise our vision for the maritime sector: an integrated maritime energy transition, a maritime system that prevents accidents, a maritime infrastructure that is efficient and climate resilient, an effective naval security, and a maritime sector that rides the next technology wave.

This RD&I agenda replaces the Technology Plan, and the annual R&D Implementation Plans that previously guided our strategy. It not only replaces these plans but also expands upon them. The RD&I agenda encompasses knowledge and technology developments, as well as process improvements and developments in our basins, simulator centre, and digital services and infrastructure.

We believe these developments are interconnected and should be aligned as much as possible. We are shifting from planning developments based on funding schemes to focusing on the coherence of all our work towards new services for our markets. The RD&I agenda targets short, medium, and long-term developments, combining market pull and technology push. The market roadmaps provide input to our RD&I agenda. The agenda will be aligned biannually with the market roadmaps.

We focus our research on synergies across the market services: generic where possible, market-specific where necessary. We want to emphasise that only when generic is truly not possible, we adopt a market-specific approach. We recognise that market-specific research will be necessary. Therefore, our RD&I agenda consists of a MARIN generic RD&I component and a market-specific RD&I component.

Capabilities

We have made an analysis of the generic capabilities needed for the five main services and their underlying use cases. We defined 10 generic capabilities that we need to develop or improve on:

Multi-domain scenario analysis

For strategic studies for maritime transitions, we aim to strengthen the capability for multi-domain scenario analysis to support robust decision-making under uncertainty. This involves further developing modular, interoperable models and structured data frameworks that allow consistent simulation of complex maritime systems across multiple domains. These models will enable the exploration and comparison of long-term scenarios, capturing interactions between technological, operational, economic, and environmental factors. By integrating diverse data sources and model components, we can construct coherent scenario analyses that span multiple months or years, providing insight into the lifecycle performance of ships, offshore structures, and supporting infrastructure. This approach enables stakeholders to evaluate trade-offs, assess risks, and make informed strategic decisions in an uncertain and evolving context.



Design space exploration

Design space exploration is a key capability for next-generation design of ships and offshore structures, enabling engineers to systematically evaluate a wide range of design options under realistic operational conditions. Instead of relying on a limited number of concept iterations, this approach allows designers to explore multi-disciplinary solution spaces in a structured and efficient way, linking technical design choices directly to operational performance, mission requirements, and lifecycle considerations.

At the core of this capability is the integration of advanced physical and digital models that capture the key phenomena governing system behaviour. This includes resistance, propulsion and energy systems, structural behaviour, and control systems, as well as interactions with the environment such as waves, wind, and currents. Physical models need to be manufactured rapidly, and automatic model testing will facilitate quick design cycles. By combining these elements within a unified framework, it becomes possible to assess trade-offs between performance, efficiency, safety, and cost in a consistent manner. Importantly, operational aspects are explicitly incorporated, ensuring that designs are optimised not only for design conditions but also for real-world usage.

Rapid prototyping

Rapid prototyping is a key capability for accelerating innovation in the design and development of ships and offshore structures and their (sub)systems. It focuses on the ability to quickly assemble, deploy, and evaluate both physical and digital proofs of concept, enabling fast iteration of concepts and solutions. In a field where design choices are increasingly complex and multidisciplinary, rapid prototyping allows engineers to test ideas early, reduce uncertainty, and converge more efficiently toward robust designs.

At the core of this approach is the use of modular software frameworks, reusable models, and scalable data-driven methods. By building on interchangeable components, new configurations can be created and evaluated with minimal setup effort. This modularity extends to both numerical environments and physical testing, enabling consistent transitions between simulations, experiments, and real-world applications. Proofs-of-concept may include on board advisory systems and full-scale monitoring systems, building on a modular measurement systems, simulation models and human-interfacing. As a result, prototype iterations that previously required a significant timespan can now be executed quickly and systematically.

Integrated high-fidelity modelling

Integrated high-fidelity modelling is essential for reliably assessing complex maritime systems. Modern ships and offshore structures operate in environments where hydrodynamics, propulsion, structural behaviour, control systems, and environmental forces are strongly coupled. Evaluating these effects in isolation is no longer sufficient; instead, there is a need for consistent, cross-disciplinary models that can capture interactions and trade-offs between subsystems under realistic operational conditions.

This capability focuses on advancing both physical and digital modelling approaches to achieve higher accuracy and consistency across domains. High-fidelity CFD, time-domain simulations, structural models, and control system representations are systematically calibrated and integrated, ensuring that the physical assumptions are compatible throughout the modelling chain.

A key aspect is the establishment of robust calibration and validation procedures. High-fidelity models are continuously verified against model tests, full-scale measurements, and operational data to ensure accuracy and to quantify uncertainty. This creates confidence in the predictive capability of integrated simulations, enabling their use in design decisions, performance guarantees, and operational planning.

Operational data-model integration

For in-service performance insights and optimisation, we aim to strengthen the capability for operational data–model integration by tightly connecting real-world measurements with predictive models. This integration will enable a continuous feedback loop in which operational data—collected from vessels and offshore structures—is systematically used to update, validate, and improve model predictions. Depending on the application, this can range from periodic data assimilation, where models are recalibrated at defined intervals, to near real-time learning, where models adapt dynamically as new

data becomes available. By aligning measured performance with simulated behaviour, we can continuously refine model accuracy and ensure that predictions remain representative of actual operating conditions.

This data-driven loop will support ongoing performance monitoring, anomaly detection, and proactive optimisation of operations. Predictive models, informed by live or regularly updated data streams, will provide actionable insights into efficiency, safety, and reliability, enabling operators to make better-informed decisions. Over time, this approach will create a self-improving system in which both data and models evolve together, enhancing understanding of system behaviour.

Multi-objective optimisation

We aim to develop an advanced capability for multi-objective optimisation to support complex and competing service requirements. This approach will explicitly incorporate risk as a new key dimension. By embedding risk directly into optimisation workflows, we can better support decisions under uncertainty and improve the resilience of engineered systems. This capability will be built on the integrated workflow of high-fidelity modelling across multiple disciplines. To complement high-fidelity modelling, we will expand the use of reduced-order models based on data-driven approaches. These models will be derived from an evolving database of experiments and high-fidelity simulations, providing a computationally efficient representation of complex systems. By combining accuracy with speed, reduced-order models will enable rapid exploration of large design spaces and facilitate iterative optimisation processes. This hybrid approach will significantly enhance our capability to perform multi-objective optimisation in practical time limits and will facilitate **design space exploration** and **rapid prototyping**.

Human-in-the-loop test environment

We aim to strengthen our capability to rapidly deploy interactive human-in-the-loop test environments across MARIN, client offices, and onboard vessels. These environments will be built on modular and flexible models that can be quickly adapted and retrained using newly generated experimental and operational data. This enables fast iteration cycles and ensures that simulations remain up to date with the latest insights and conditions. At client offices, staff will be able to immerse themselves in simulation environments that leverage our advanced libraries of models and data, enabling intuitive exploration and understanding of design performance and trade-offs.

In parallel, we will extend these capabilities onboard by linking real-time measurements with dynamic simulation environments to create a hybrid physical–virtual setting. Building on the IT capabilities developed in **Ecosystem collaboration**, this integrated environment will connect the vessel, the client's office, and MARIN into a unified collaborative platform, enabling continuous interaction, joint experimentation, and real-time decision support across all locations.

Data-model backbone

We will establish a consistent data and model backbone that enables reuse, versioning, and full traceability across developments and projects. Central to this is the adoption of FAIR data principles, ensuring that all data are *Findable*, *Accessible*, *Interoperable*, and *Reusable*. This implies structured metadata, persistent identifiers, and standardized formats that make datasets easy to discover and retrieve across teams and applications. These FAIR principles will create a robust data foundation that supports efficient collaboration, reduces duplication, and enhances the value extracted from existing and future datasets.

Building on this data foundation, we will ensure full traceability of mathematical models and AI models throughout their lifecycle. Validation and verification of mathematical models and training of AI models will be systematically linked to FAIR-compliant datasets, enabling transparent documentation of model accuracy, limitations, and applicability. Each model will carry a clear record of its calibration history, underlying assumptions, and validation evidence. In parallel, we will implement traceability of model usage across projects, capturing where, how, and for what purpose models are applied. This includes version control, dependency tracking, and documentation of input–output relationships, ensuring reproducibility and auditability of (AI generated) results. By tightly coupling data and models within a

unified backbone, we will enable consistent, reliable, and auditable workflows that strengthen confidence in analyses and predictions.

Data generation and model quality

We want to strengthen our capability for systematic and automated data generation, tightly integrated with the established FAIR-based **data-model backbone**. In our model basins, this involves the deployment of automated testing that enable controlled, repeatable, and high-throughput experimentation. In parallel, our compute clusters will support large-scale automated simulations, generating high-fidelity numerical data across a wide range of conditions and design variations. This dual approach—physical and digital—will create a continuous, scalable stream of high-quality data, significantly enhancing our ability to explore design spaces and operational scenarios.

Building on this automated data generation capability, we will advance our mathematical models through automated calibration and validation workflows. The full calibration process, including datasets used, parameter adjustments, and resulting validation metrics, will be captured within the **data-model backbone** to ensure complete traceability. This enables transparent tracking of how models evolve and are applied across projects, supports reproducibility, and provides a clear basis for confidence in model-based decisions.

Ecosystem collaboration

We aim to strengthen the collaboration in the maritime ecosystem by enabling seamless exchange of data and models, and by supporting co-simulation with external partners within a shared and secure digital environment. This environment will allow clients and partners to directly access and interact with our advanced assessment tools, fostering more transparent and efficient collaboration throughout the design and evaluation process. By providing controlled access to our extensive libraries of our models, clients will be able to explore and assess their designs independently while benefiting from our expertise. Standardized interfaces, secure data exchange protocols, and robust access control will ensure that collaboration for data science remains efficient while safeguarding intellectual property and sensitive information.

In addition, we will extend collaboration beyond the design phase into operations by integrating real-time onboard measurements with our dynamic simulation environments. This will create a hybrid physical–virtual ecosystem in which the vessel, the client's office, and MARIN are digitally connected, enabling joint analysis, simulation, and decision-making across locations. Within this setting, we will support clients in collecting operational insights and exploring innovative operational concepts that enhance performance and efficiency, also enabling our capability of **Human-in-the-loop testing environment**.

3.2 Market-specific research and developments

For each of our five market segments, we have defined research project which are summarised below:

Transport & Shipping

Within the Transport & Shipping market we benefit from various subsidised projects, performing research in EU project or projects from the *Sectoragenda Maritieme Maakindustrie*. Furthermore, many research questions related to the transport and shipping market are generic and applicable to other ship types as well. These generic topics have been taken up by the generic research programmes as described in Section 3.3.

Specifically for this market, we want to focus on:

- *Extrapolation of model data to full scale* – Within the sector, there is uncertainty about the accuracy of prediction of performance at laden draught, as trials are performed in a ballasted condition. We want to improve our understanding by analysing monitoring data of vessels.
- *Experimental techniques for underwater radiated noise* – Noise is becoming a major issue in design of transport vessels. It is expected that IMO will implement regulations in the coming

decade. We will perform noise measurement on various vessels during cavitation test for customers to gather data and start building up a noise database, and to verify our numerical prediction methods.

- *Experimental techniques for powering prediction* – based on the results from the Tripping JIP, we will update our procedures and perform shadow runs alongside our normal test procedure. We will also take the initiative to continue the Tripping JIP in a follow-up JIP.



Hybrid powered short-sea vessel (Source: <https://corvusenergy.com/>)

Passenger & Yachting

Within the Passenger & Yachting market, we have relatively few subsidized collaborative projects. Work for this market obviously profits from the generic research performed in the research programmes. Results and knowledge from subsidized work in the Transport & Shipping market can be transferred to passenger vessels and yachts.



Electro pod by ABB (Source: <https://new.abb.com>)

Specifically for this market, we want to perform the following research projects:

- *Stern slamming* – Stern slamming can significantly reduce the comfort onboard. We will perform a validation study of our CFD tools in predicting slamming loads, including the effect of air entrapment.

- *New electro pods* – With the growing popularity of electro-pods in this maritime segment, we need to be able to perform model testing on various scales. We will develop smaller model scale electro pods to better follow the trends in the market.

Defence

Under the market Defence, MARIN conducts research for the Royal Netherlands Navy and the Command for Materiel and IT (COMMIT, formerly DMO). In recent years, the budget for defence-related research has increased significantly, and it is expected to continue growing in the coming years. As a result, more research topics can be addressed for the Navy. Below is a brief overview of the main lines of defence research. Due to the confidential nature of this work, only the key themes are presented here.

MARIN's defence research is tailored to the needs of the Netherlands Ministry of Defence and complements our civil maritime expertise. The research topics are aligned with the Ministry's *Defence Strategy for Industry and Innovation* (2026) and Innovation Calendar 2021–2026 and *Defence Vision 2035*, which outline the future direction of naval operations and associated research priorities. Our goal is to maximise the military-maritime operational capacity of the Royal Netherlands Navy. We aim to enhance operational effectiveness, ensure safety, and support the sustainability of naval operations.

The Royal Netherlands Navy (RNLN) is undergoing a strategic transformation in response to evolving operational environments. With a renewed emphasis on firepower, operational readiness and effectiveness, the RNLN is preparing to operate in contested environments with significantly greater transparency than in previous conflicts. This shift necessitates a broader and more integrated knowledge base to support future naval operations.

Following the increase in national defence spending in 2022, MARIN has redefined and expanded its strategic defence research and development programme. Besides continued hydrodynamic support for existing and new naval platforms, the updated portfolio includes new research themes such as advanced simulation techniques for manning concepts and training, data science and decision support, and energy transition in naval operations. A dedicated budget has been allocated for international research collaboration, emerging research topics, and European Defence Fund co-funded projects.

End of 2027 some of the current research programmes will conclude. The formulation of new programmes to replace them has already begun in September 2026. MARIN is actively contributing to this process and will seek to align its research priorities with the updated Knowledge Plan Sea (KPZ) roadmap and effectively exploit synergies with the civil knowledge base at MARIN, as well as at NLR and TNO by developing roadmaps and propositions.

The Defence Strategic Innovation Initiative (DSII) calls upon MARIN, NLR, and TNO to strengthen ties with academia. In response, MARIN will more actively pursue opportunities to define PhD positions in cooperation with Dutch universities and the Netherlands Defence Academy (NLDA) and integrate academic research into defence programmes. A first pilot PhD position is planned within the new VM2629 – Flexible Energy Systems programme.

The ongoing programmes for the ministry of Defence are considering the hydrodynamic of surface vessels and submarines; the control of autonomous vehicles; the transition to new energy carriers and systems; and the use of AI in coordination of operations within a fleet. New proposals focus on the expansion of our knowledge on autonomous vehicles, launch & recovery, and damaged stability.

Finally, MARIN conducts exploratory research into innovations that are still far from practical application. These include for example biomimetic propulsion, alternative control systems for autonomous underwater vehicles, and the potential for a digital ship's bridge using augmented reality.

International collaborations

MARIN participates in various collaborative programmes on behalf of or alongside the Navy. Within the European Defence Fund, MARIN is involved in several projects with the Navy and the Dutch defence industry. In five different consortia, we are developing new energy systems for naval vessels, working on a standard for digitalisation, enhancing safety by monitoring the structural integrity of ship structures, exploring AI techniques, and supporting the development of autonomous vessels.

Within the CRNavies programme, further work is being done on the simulation of extreme motions and manoeuvres. In addition, knowledge is exchanged in NATO Applied Vehicle Technology working groups on the analysis of advanced vessels. MARIN is represented in nine working groups.

Offshore Energy & Blue Growth

The market programme for *Offshore Energy & Blue Growth* combines the previous markets *Oil & Gas*, *Life@Sea* and *Renewables* and the previous research programme *Blue Growth* as they share many research aspects, clients and technologies. In this market several Joint Industry Projects and RVO funded research projects are in progress and being initiated around solar energy, wind energy and floating infrastructure. Examples include the ScaleWind JIP for floating and fixed wind turbines, the EU funded projects BAMBOO and Surewave for floating solar energy and the NWO funded research project HybridLabs for testing of offshore renewable systems including software-in-the-loop. Furthermore, the NWA funded research project Floating Future is in progress which is aimed at achieving upscaling of floating infrastructure to offer a viable and climate-proof solution for space limitations in the Dutch Delta.



Floating solar panels (Source: <https://www.tno.nl/>)

Specifically for this market, we want to perform the following research projects:

- *Floating wind numerical simulations* - We will consolidate our procedures for the simulation of floating wind structures in time-domain tools and in CFD. Furthermore, we will use the latest data from the new wind set-up in or Offshore basin to validate the numerical predictions.
- *Low-fidelity monitoring system* – New activities at sea, such as floating solar panels or aquafarming, are often quickly put at sea without model testing. This leads to the need for systems to monitor their behaviour. These systems must be low weight, and low cost. Therefore, we will initiate the development of low-fidelity monitoring systems to be applied on these new light structures.

Marine infrastructure & Spatial planning

Within our market programme Marine Infrastructure & Spatial planning we combined studies for new infrastructure like ports, safety of navigation in this infrastructure, and issues related to maritime spatial planning such as safety around planned wind farms at sea or navigational corridors. Given the nature

of this market, there is a close link with work being done for the Ministry of Infrastructure and Watermanagement, and Rijkswaterstaat.

We will perform the following projects in 2027:

- We will continue with the re-implementation and development of the safety model SAMSON. This model is used for predicting risks at the North Sea in future scenarios. We will focus on improving the workflow for the new SAMSON tool.
- We will start the re-implementation of SHIPMA, our simulation tool for ship manoeuvrings in harbours. Similar to SAMSON, this new tool will be based on our generic time-domain simulation framework XMF.
- We will support the Ministry of Infrastructure and Watermanagement with various policy support. This includes participating in relevant meetings of the International Maritime Organization and helping to prepare submissions for these meetings.
- We will participate in the MariSens JIP which focuses on autonomous underwater vehicles for inspection of marine infrastructure; in Smart ShoreTension JIP to improve safety of harbour mooring operations; and in the EMPOWER EU project to monitor emissions in during harbour operations.
- As spatial planning is a relatively new market for us, we will investigate the state of the art and tools used in this market segment, to draft our own development roadmap.

3.3 MARIN generic research and developments

In the following sections we summarise the RD&I projects defined for our knowledge development, our key-enabling technologies, our facilities, and our digital infrastructure. Projects for our programme on *Implementation of Improved Generic Processes* are funded from our internal revenue and are not listed in this document describing our work subsidised by the Dutch government.

3.3.1 Generic Process Improvement

The Generic Process Improvement programme focuses on creating coherent and scalable frameworks and workflows that connect diverse tools from the generic research programmes into integrated ways of working. At the core of this development are three key elements: a standardised scenario simulation environment, an expanded framework for multi-objective optimisation, and a structured design exploration environment. Together, these form the foundation for a consistent and efficient process that supports MARIN's core capabilities across research and client work.

For 2027, we foresee two main developments that will be funded from our own investments:

- *Multi-domain scenario analysis framework* – We have already developed various scenario analysis tools of the years, but it is difficult to integrate them in new upcoming scenario analyses. Therefore, we want to develop a standardized framework for scenario analysis based on the existing tools, which facilitates the development of multi-domain scenario analysis.
- *Design and optimisation framework* – We are developing a design and optimisation framework for early concept design and concept optimisation. We initially focused this development on the optimisation of resistance and propulsion and gradually included on-board power systems as well. We now aim to enhance the framework with other aspects such as seakeeping and manoeuvring and make the framework suitable for the design of non-ship structures.

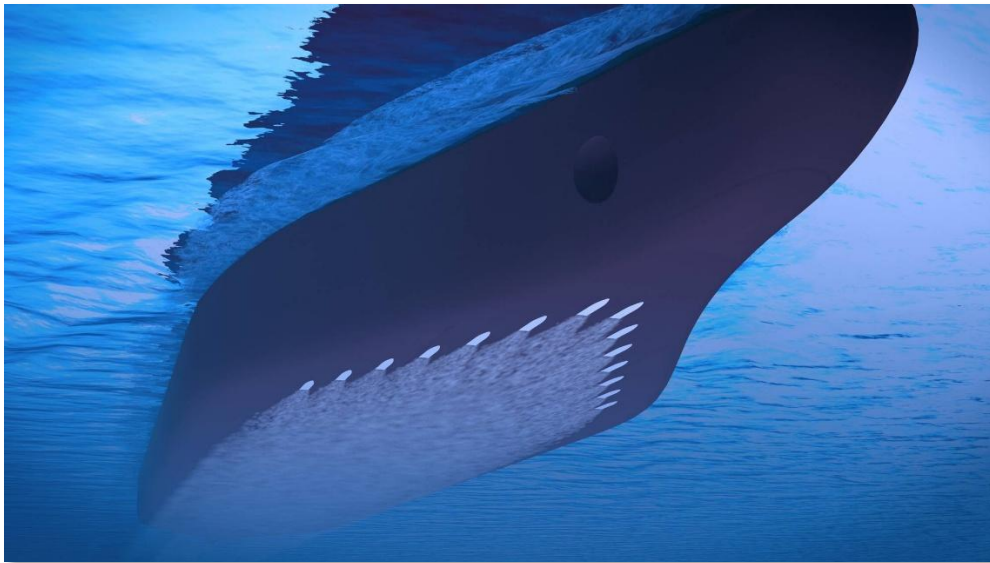
3.3.2 Knowledge development

Sustainable propulsion

The programme's objective is to help the maritime sector realise ships with the lowest practicable environmental impact, while remaining efficient, reliable and fit for purpose throughout their operational life. It brings together MARIN's knowledge of ship hydrodynamics, propulsion performance, wind-assisted propulsion, cavitation, underwater radiated noise, Marine Powering Systems, emissions, and ship operation.

For the coming year, we have defined the following key projects:

- *Multi-disciplinary design* – We will integrate different aspects of a ship design into one design and optimisation environment. Focus will be on the integration of resistance, propulsion and power systems both in optimisation and in early design. First tests will also be performed with the integration of other aspects, such as seakeeping and manoeuvring, in the early-design stage.
- *Verification, Validation and Performance Prediction* – In the coming year we will focus on consolidation. Research from earlier years will be brought together and demonstrated through three large test cases, requiring strong collaboration across departments and disciplines. These test cases will be used to assess how the different methods perform as part of a complete prediction and validation chain, from numerical simulations and model tests to full-scale performance.
- *Operational data and full-scale performance* – Through a collaboration with a large ship owner, we will get long-term access to operational data from a new vessel. We will install additional measurement equipment on the vessel to eliminate uncertainties related to wind and waves. We will use the data to derive calm-water speed-power performance and support the determination of correlation coefficients. Furthermore, we will continue with our collaborative projects on the standardisation of speed trials for newbuild ships. Finally, we aim to perform tests on a ship with an air-lubrication system to objectively determine the efficacy of such as system.



Air-lubrication system (Source: <https://www.marinelink.com>)

Manoeuvring & Control

We will enable reliable, efficient, and scalable assessment and optimisation of ship manoeuvring performance and control across concept, design, and operational phases. We will develop validated time-domain hydrodynamic and manoeuvring models, forming the backbone for credible simulation-based services. Fast, data-driven capabilities will provide rapid access to manoeuvring insights in early design stages, leveraging existing datasets from model tests, CFD, and full-scale observations.

For the coming year, we have chosen the following focal projects:

- *Time-Domain Modelling Backbone* – We will strengthen the reliability, applicability, and scalability of our manoeuvring simulation capabilities. We will perform verification and validation of manoeuvring-in-waves prediction methods, integrate CFD and time-domain simulation approaches, and improve fitting and calibration procedures.

- *Rapid Manoeuvring Insight* – We aim to develop a structured and easily accessible database by integrating captive model tests, CFD simulations, free-running simulations, and validation datasets, further developing the manoeuvring knowledge base.
- *Integrated Multi-Fidelity Workflows* – We will further development an operational manoeuvrability assessment framework. In addition, we will establish integrated calibration workflows linking model tests, CFD, numerical simulations, and simulator applications, enabling more efficient generation, validation, and deployment of vessel models.
- *Effective Control and Navigation* – We will address a broad range of applications, including autonomous harbour navigation, cooperative and multi-vessel operations, optimal crabbing manoeuvres, and trajectory planning under operational constraints.



Historically low water levels in Dutch rivers, leading to one-way traffic in the IJssel river in fall 2026
(Source: <https://www.destentor.nl/>)

An important focus area for several years has been to strengthen the knowledge about ship navigation in extremely shallow water. Fundamental research on this topic is being conducted within the Manoeuvring programme. In collaboration with Rijkswaterstaat, we will explore how this research can be enhanced. The models will also be integrated into existing software programmes to study the effects on traffic flow and safety. We are participating in the international SHINING workshop to compare simulation models for ships in shallow water.

Waves & Motions

This research programme aims to deliver a comprehensive, scientifically grounded framework that enables clients to effectively design, analyse, and operate maritime systems under complex and demanding conditions and ensure safe design and operations.

For 2027, we will focus on the following topics:

- *Fast-track model calibration* – Building on our ambition to perform automatic model testing, we aim to automatically calibrate a numerical model with the measured data. This numerical model can be used in desk studies but should also allow for use in our simulators.
- *Validity of time-domain seakeeping prediction methods* – Within MARIN we have developed several prediction tools for seakeeping characteristics, each with different fidelity. Following the

structured validation of the frequency domain tools, we will now focus on verification and validation of our time-domain tools for a wide variety of ship types.

- *Development of extreme event assessment methodology for slamming applications* – Extreme events are fortunately rare, but this makes it difficult to build up meaningful statistical data. For fixed structures, we have developed a methodology to assess these rare extreme events for structures without forward speed. We now aim to extend this methodology to bow or stern slamming of sailing ships.
- *Wave generation* – We want to further improve the efficiency of our wave generation software and extend its capabilities to include active reflection compensation of basin modes on shallow water. We will also investigate wind-wave interaction, now that the new wind-generation system in our Offshore basin can generate much stronger wind fields. Furthermore, the numerical generation of short-crested waves in our simulators is often very time-consuming and introduced a bottleneck in the real-time environment. We will investigate alternative method to increase the efficiency while balancing the accuracy.



Vessel slamming into a wave (Source: [Veen \(2010\)](#))

Maritime Safety

MARIN is committed to keep and make the maritime sector safe; this means making the ship and the operation safe for all people working within the sector. For this we need to further increase our own awareness, knowledge, and capabilities regarding maritime safety.

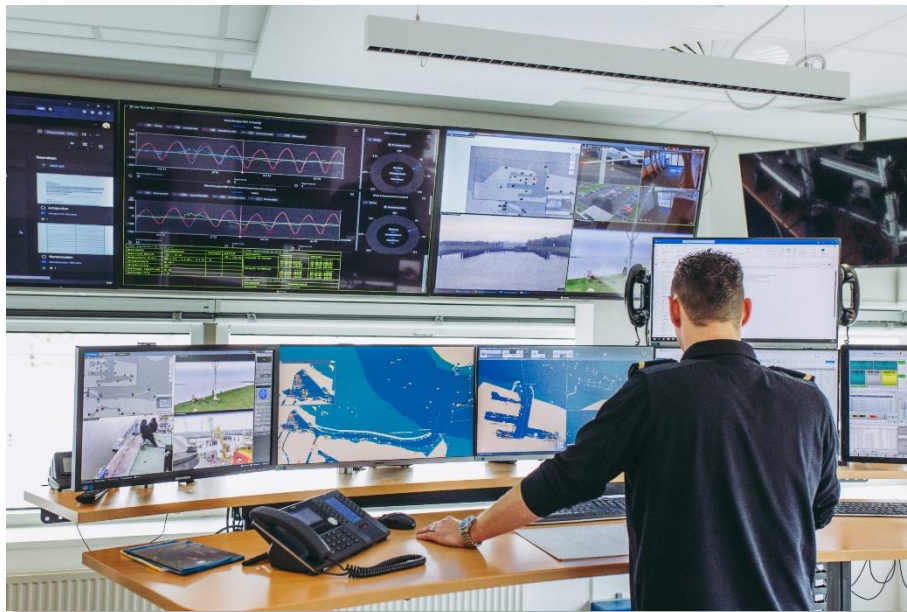
Within the programme of the ministry of Infrastructure & Water management, we propose to work on among others:

- The further development of the SAMSON tool for studying scenarios and risks;
- The dynamic stability of ships in extreme and critical conditions, including ships with wind assisted propulsion
- Risks of oil spills, anchor dragging and other rare events
- Training for emergency response

The final scope of work will be determined in close consultation with the ministry and Rijkswaterstaat during a workshop at the end of 2026.

Supporting the safety related work for the ministry, we foresee the following research projects:

- Safety science – We will extend our knowledge of safety as a science and of the existing regulatory frameworks.
- Risk assessment – Over the years we have developed several methodologies to identify and assess risks in various scenarios. We want to establish a structured framework with well-documented workflows which spans the various use cases.
- IMO SGISC – Based on the validation study of 2026, we will use our time-domain simulation tools for the full probabilistic direct long-term analysis for key failure modes.
- Future VTS – We will investigate the use of AI agents in the management of traffic on inland rivers, supporting the human operators in times of low manning.



VTS operator in action in the Groningen area (Source: <https://www.schuttevaer.nl/>)

For Rijkswaterstaat, MARIN maintains several software programmes. These programmes predict traffic flow and safety on the North Sea, inland waterways, and at locks. In consultation with Rijkswaterstaat, new functionalities will be added to the programmes.

Human-centric design of ships and operations

The human operator is in many maritime operations of vital importance. How to make sure that the human operator remains being able to play this vital role when innovative technologies are introduced? Human centred design ensures that technology is designed from an operational perspective in which the human operator is supported by technology rather than to satisfying the needs of this technology.

For 2027 we foresee the following research projects:

- *Human factors guidelines* – We will develop an overview of existing methodologies and past experiences as a guideline for maritime colleagues that need to include human factors into their technical projects.
- *Human-machine interfacing* – Over the past years, we have developed several HMI prototypes which resulted in a systematic approach. We will now test this approach in onboard situations, and we will further extend it to include human interfaces to AI controllers and systems.
- *IMO MASS code* – The upcoming IMO MASS code for autonomous systems is goal-based rather than rule based. Therefore, we will investigate what modes of operations and contingency plans

need to be considered in evaluating autonomous systems. Furthermore, we will study how to evaluate systems with respect to non-quantifiable measures such as reliability and robustness.

- *Motion cueing* – We will continue our work into motion cueing for our moving simulator platforms. Given the limitations of the platforms, motions need to be simulated in a way that they allow for correct human experience in realistic ship motions.



Large motions simulator with a moving platform

3.3.3 Key-enabling technologies

Data science and Artificial Intelligence

We combine the strength of domain knowledge and tools and data-driven approaches to develop strong, reliable methods. Data science supports quick ship design iterations by exploring many design options efficiently. Surrogate models and machine learning augment expensive simulations for inexpensive early-stage performance prediction. Deep learning helps interpret complex operational data and extract key insights in real-world conditions. And with the maturing of data science methods, we will ensure that these models are reliable, traceable, and integrated into engineering workflows.

Increasingly, the developments within this research programme are taken up by other research programmes for application. However, in this rapidly developing research field, the continuous development of our tools is necessary. Therefore, we foresee the following projects for the coming year:

- *Data-driven optimisation* – we will continue with our development of a tool for automatically generate feasible hull shapes based on limited input. This tool is integrated with our design and optimisation framework NEXUS. Furthermore, we will explore the use of machine learning in the speed-up of CFD computations.
- *Deep-learning data analysis* - Deep learning models can be used as very capable surrogates but require large quantities of data. A common pitfall is to only include happy-flow data, bringing mostly desirable data points to the machine learning model. This often happens by accident, when bad data is eliminated from the work process by human intervention. However, these deep learning models need undesirable data just as much. Various strategies will be explored to improve full coverage of design and operation and adjacent less likely datapoints, without venturing too much into unrealistic scenarios.
- *Real-time data* - Using machine learning models in a (real-time) interactive environments comes with specific challenges related to the stability of the signals to work with. Data from these real-time environments is often sparse. Synthetic data from simulation environments can be used, but these data are too smooth. Additional realism must be created by adding noise, faulty sensors, etc. We will expand our platform for synthetic data generation with sensor malfunctions.

- *MLOps* – Machine Learning Operations (MLOps) is the equivalent of DevOps for software engineering. Machine learning models do not only consist of software, but also of data that was used to train the model. When this training data changes, the model changes without any specific software change. This leads to the need for version control of software, model and data together, and appropriate testing protocols similar to software testing. We will set up the version control system for MLOps in the coming year.

Simulation & Digital twinning technologies

The programme's objective is to provide our internal and external clients with the best time domain simulation and visualisation solution tools available and to develop and apply those tools in a professional, efficient, and reliable manner. This programme focuses on the development of generic tools for running simulations. In recent years, significant effort has been invested in creating a unified framework for simulations. This XMF framework is used for large simulators in the SOSc and for desktop simulations. The simulator centre SOSc offers the possibility to apply Virtual Reality (VR) technologies. These VR technologies have been integrated with the simulator software, enabling a person to perform a virtual operation on a moving virtual ship. Finally, this programme studies the technologies needed to create true digital twins: simulation models that adapt to changing circumstances in real life.

For 2027, we foresee the following developments:

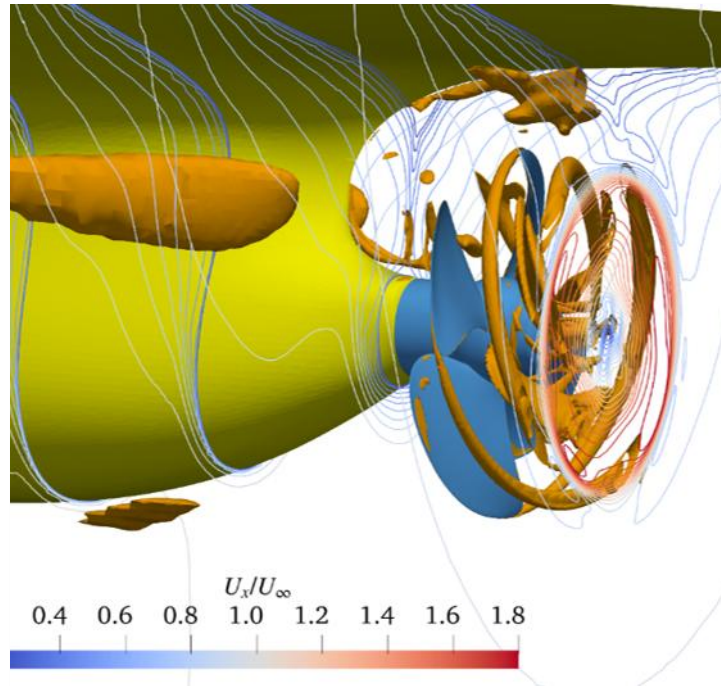
- *Improving XR Infrastructure for Human Machine Test Environments* - We aim to strengthen MARIN's XR ecosystem as a reliable, usable and portable platform for human-machine testing. The work focuses on tighter integration of XR functionality with our simulator environment, improved locomotion and interaction within moving vessel environments, and portable VR configurations.
- *Simulation framework* – We will invest in our simulation framework by improving the modelling of short-crested waves in real-time environment, a better visualization of waves in the simulator, and collision mechanics. Furthermore, we will study the motion cueing of the LMS and FSSS simulators to improve the realism of motions while remaining within the safe limits of the simulator platform.
- *Digital twinning* – For different applications we have developed workflows to tune a numerical model to basin experiments. We want to integrate all these developments into an integrated calibration framework and standardize the modelling approach across users. We will further model the degradation of sensors in our digital twins and study the effect on decision making in autonomous systems.
- *SHIPMA replacement* – we will initiate the replacement of SHIPMA with a new tool based on our time-domain simulation framework XMF, by reusing existing functionality in XMF as much as possible.

CFD development

The CFD development research programme aims to provide reliable tools for computational fluid dynamics (CFD) analysis that support applied research programmes and market activities in hydrodynamics, aerodynamics, and hydro-acoustics.

The work planned for 2027 places particular emphasis on reducing the cost of dynamic simulations by lowering the computational expense of individual time steps and improving the robustness of complex grid manipulation techniques.

- *Future tools* - Developments will focus on technologies with the potential to deliver step changes in capability or efficiency. We will work on a generalised CFD-machine learning coupling framework, targeting routine use of machine learning within ReFRESKO. Research into wall-modelled large-eddy simulation will address the gap between conventional RANS or hybrid RANS-LES approaches.



Unsteady computation of a cavitating propeller behind a ship

- **Core capabilities** - A major focus will be the further development of advanced time-integration methods and coupled solution techniques. A second project will strengthen ReFRESCO's overset grid capability by reducing domain connectivity computation costs, mitigation of unphysical pressure oscillations and convergence problems, and lower grid-density requirements.
- **Robustness & interoperability** – This project focuses on extending CFD capabilities into operational workflows and improving interaction with other MARIN software frameworks. A significant activity for 2027 is the support of extreme-wave manoeuvring simulations in ComFLOW. Furthermore, developments include extensions to manoeuvring and autopilot functionality, improvements to restart procedures using disturbed three-dimensional wave fields reconstructed from coarse-grid simulations, and increased automation of event detection and restart selection.
- **Development & deployment process** – This project addresses the infrastructure and practical support required to sustain reliable software delivery and user adoption. Continued maintenance of the ReFRESCO development environment, including build-farm operations, automated testing, deployment procedures, and management of external dependencies, remains essential for ensuring continuity of development and release activities.

Human factors

This research programme focuses on strengthening the human perspective within maritime design and operations by developing methods, tools, and insights that explicitly account for human performance, safety, and wellbeing. As vessels become more complex and increasingly incorporate automation and new technologies, the role of the human operator remains critical. To ensure safe and effective operations, it is essential to better understand how environmental conditions, system behaviour, and design choices influence human capabilities, limitations, and performance.

In the coming year, we want to expand our capabilities through the following projects:

- **Trust in AI systems** - We will investigate how people develop, lose, and regain trust in AI systems when those systems make mistakes. The study will be conducted in a simulation where operators use an AI-based object detection system during realistic operational tasks, while the AI intentionally makes both obvious and subtle errors.

- *Human control in autonomous systems* – In many autonomous system, human control take-over is the fallback mode. To achieve this, well thought-out operator-focused procedural, regulatory, and system requirements are needed. In the ALERT JIP we will focus on the navigational aspect; in internal research on other operations.
- *Development of a Maritime Workload Task for Applied research* - We will develop a standardized maritime workload task to realistically simulate the demands of ship bridge operations in a controlled research environment. The project will create a prototype task that reflects key bridge activities such as monitoring, communication, decision-making, and managing multiple tasks simultaneously. An existing workload task developed by NASA for the aviation industry will be used as inspiration for the development of a maritime workload task.

3.3.4 Model basins, simulators and on-board test facilities

Large-scale facilities are essential to fulfilling our mission and realizing the future outlook outlined in this strategy: solutions for zero-emission vessels and operations, preventing maritime accidents, and accelerating sustainability and climate adaptation at sea. This involves not only physical infrastructure, but also digital facilities. These are crucial for becoming a global leader in maritime AI and for simulating maritime operations on an integrated digital platform.

SeaLab

MARIN's offshore measurement facilities are vital to our research. To remain a world-leading institute in a rapidly evolving maritime sector, MARIN aims to develop SeaLab: the sea as a digital laboratory. SeaLab will support field labs during real-life operations at sea by measuring and observing the behaviour and interactions between maritime structures, the environment, and humans at sea. It will be a measurement facility built around a modular system, enabling rapid integration of observation and measurement modules into a network tailored to specific operations.

With SeaLab, we enhance the quality of our research in the field of Artificial Intelligence (AI) and increase our impact for innovative companies and governments. The modular concept of SeaLab will help reduce project preparation time ahead of measurement campaigns, shorten the installation time of the measurement system on board, and increase flexibility to add additional ship-based sensors or data sources to the campaign—allowing us to better respond to the specific needs of our clients.

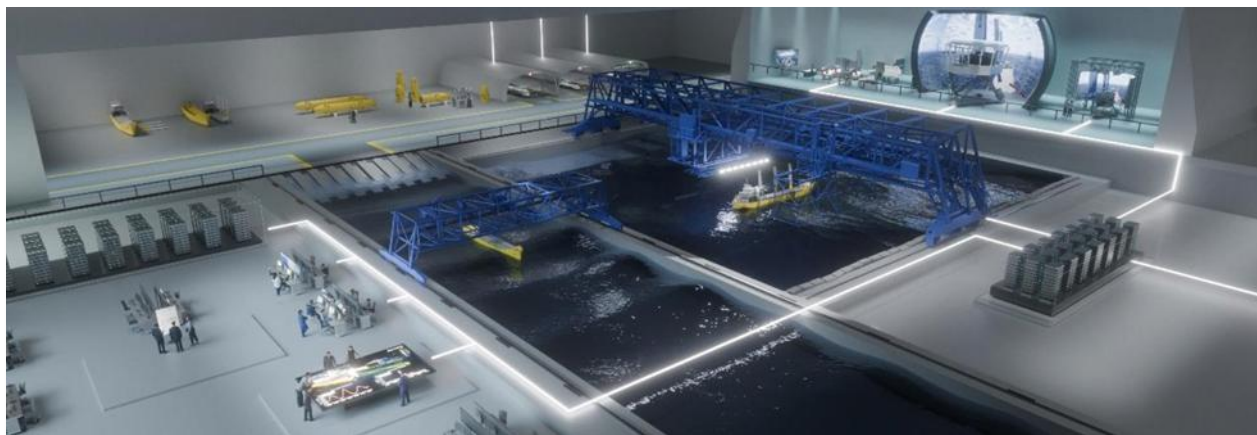
In 2027, the project will conclude. We will focus on implementing the new systems in practice, while consolidating the software and wrap up all documentation. Developments will continue after the project in internal projects and JIPs.

Maritime Innovation Lab

MARIN intends to upgrade its current Inland Shipping Tank and Concept Basin into the Maritime Innovation Lab. In this renewed facility, maritime innovations will be developed and immediately translated into realistic user experiences in the Seven Oceans Simulator Centre or the Zero Emission Lab.

Both the European Union and the Netherlands have set highly ambitious goals to address societal challenges related to the energy transition and safety. Maritime innovations play a crucial role in this effort, including clean and safe transport of people and goods, offshore production of renewable energy, defence applications, inland shipping, and climate-adaptive floating infrastructure. Through its strategy, MARIN aims to accelerate these innovations in close collaboration with the maritime sector.

The Maritime Innovation Lab accelerates innovation by creating an environment in which the maritime industry—from startups and SMEs to large companies—works intensively with government, TO2 institutions, universities, universities of applied sciences, and MARIN specialists. During the day, we use fast numerical tools and exploratory tests in our basins to explore ideas. At night, we seamlessly switch to automated testing to collect structured data for training numerical models. The following day, we bring innovations to life using these models in our simulators and further develop them in collaboration with future users.



Artist impression of the combination of all MARIN facilities in an integrated way

Development of measurement equipment and procedures

Within MARIN we maintain an overview of prioritised updates or renewals of our measurement equipment and procedures, and our simulators. As stipulated in our strategy, we focus on the implementation of automated model testing in our basins, and the use of this data for tuning of numerical models and training of AI.

Many of the prioritised updates require access to our basins and dedicated specialist staff. Therefore, we plan these updates on a quarterly basis when more insight is available on availability.

3.3.5 Digital competencies, IT-, data- and computational infrastructure

DigiLab

The TO2 organisations and several leading public research institutions in the Netherlands are jointly developing a federated digital infrastructure called DigiLab for Applied Knowledge. This initiative responds to increasingly complex societal challenges—such as climate change, public health, food and water security, and safety—by enabling closer collaboration between research bodies, government, and industry. DigiLab provides access to vast datasets and models, enhanced by computing power and advanced visualisation tools, supporting technologies like Artificial Intelligence and Digital Twinning.

Digital collaboration often faces barriers due to the need for organisations to retain control over their data and algorithms. Fragmentation and lack of transparency can hinder reproducibility and public trust. DigiLab addresses these issues by offering a secure, scalable ecosystem for co-creation and shared use of data and models. The project started in 2026. A major upgrade to our computing infrastructure was planned for 2026 but had to be postponed due to problems in delivery of the required hardware. The upgrade is now scheduled for 2027. Furthermore, we will lay the foundation for a research data management system (RDMS) as similarly used at universities, and for federative data sharing.

Internal developments

Alongside the developments in DigiLab, we will establish databases for AIS data and our own hydrodynamic data. These databases will be used as initial input to the new RDMS. Furthermore, we will streamline the software development on our compute clusters and external clusters. We will also identify which numerical algorithms may benefit from future quantum computing capabilities. Finally, we will extend our version control of software and provenance of data, with a combined version control of AI models and their training data.

3.3.6 Pilot projects

The pilot projects component of our RD&I agenda is introduced to accelerate exploratory ventures while keeping our overall developments streamlined. The pilot projects are of relatively short duration to demonstrate an idea or technology. After the demonstration, we decide whether to continue development within one of our other components of the RD&I agenda being MARIN generic RD&I or Market-specific RD&I.

Pilot projects for 2027 will be selected based upon an internal call for proposals at the end of 2026.

3.4 Public Private Partnerships (PPP)

The table below lists the initiatives and ongoing JIPs and JRPs that will contribute to the implementation of the RD&I agenda in 2027.

RD&I Programme	PPP initiatives
Transport & Shipping	• HyUse • EU-projects SeaStars and Awesome • Calm JIP
Defence	• CR Navies • Various EDF projects
Offshore Energy & Blue Growth	• TKI-projects Offset, ScaleWind • NWA Floating Future, HybridLabs • EU project SPARK • WindAUV, Towin' JIPs
Marine Infrastructure & Spatial Planning	• MariSens JIP • EU project Empower
Sustainable Propulsion	• STA2 JIP • CRS working groups • NWO CISCON
Manoeuvring & Control	• CRS working groups • NATO working groups • Shining cooperation on shallow water hydrodynamics
Waves & Motions	• CR Navies • CRS working groups • ComFlow Usergroup, MetaShip JIP, Fready JIP
Maritime Safety	• ALERT JIP
Data science & AI	• CRS working groups • AI Maritime Innovation Lab
Simulation & Digital twinning technologies	• CR Navies
CFD development	• NATO working groups

More detailed information about MARIN's Joint Industry Projects (JIPs) can be found at: <https://www.marin.nl/jips>.

4 BUDGET

In 2027, the *Instituutssubsidie* will be €8.553 million, after deduction of the pre-financing for the new simulator centre. This pre-financing is compensated by a budget of €6.0 million, which can be used over a period of 5 years. In the coming year, we plan to use €0.645 million of this additional budget. This leaves a budget of €1.9 million for the coming three years.

Based on the objectives formulated by the government regarding the use of the institutional subsidy and the MARIN Strategy, MARIN has chosen the following allocation of the institutional subsidy:

- €7.3 million for the Knowledge Base
- €1.9 million for MARIN's contribution to Public-Private Partnerships (Matching Fund/PPP)

In addition to this *Instituutssubsidie*, in 2027 there will be additional funding from the relevant ministries for knowledge development specifically aimed at policy (based on programmes agreed with the ministries), such as the programmes from the Ministry of Defence and the Ministry of Infrastructure and Water Management, amounting to €9.867 million.

We also expect to use €3 to €4 million from previously awarded subsidies for the development of SeaLab, DigiLab, and Maritime Innovation Lab.

The division of our *Instituutssubsidie* over the various programmes is budgeted as follows:

Programmes	Public-Private Partnerships (JIPs)	Knowledge Development	Total
All amounts in k€			
Market-oriented research	1,450	725	2,175
Transport & Shipping			-
Passenger & Yachting			-
Defence			-
Offshore Energy & Blue Growth			-
Maritime Infrastructure & Spatial planning			-
Generic Process Improvements	-	-	-
Maritime themes	450	2,850	3,300
Sustainable Propulsion			-
Waves & Motions			-
Manoeuvring			-
Maritime Safety			-
Human-centric design of ships and operations			-
Key-enabling technologies	-	2,300	2,300
Data Science & Artificial Intelligence			-
Simulation Technologies & Digital Twinning			-
Computational Fluid Dynamics			-
Human Factors			-
Facilities	-	300	300
Digital Infrastructure	-	200	200
Pilot projects	-	600	600
Cooperation	-	323	323
Total	1,900	7,298	9,198

With respect to previous years, the budget for matching in Public-Private Partnerships has been reduced. The reason behind this reduction is the lower number of PPP projects that have been awarded last year, and the finalisation of several large projects in the RDM scheme.

The *Programmasubsidie* by the various ministries is built up from:

- € 2,2 million for knowledge development on safety in the North Sea, zero-emission shipping, and inland shipping.
- € 7.3 million for knowledge development for the Ministry of Defence.
- € 0.3 million for the development of a zero-emission fishing vessel for the Ministry of LNV.

We also receive (partial) co-financing for European defence projects and Horizon Europe projects, which is determined based on the approved proposals.

In 2027, we will use part of our governmental funding as *Instandhoudingsbijdrage*, a contribution to the maintenance of our large facilities. We have allocated a budget of €0.859 million for this goal.

5 ADVISORY BOARD

MARIN's research plans are reviewed by an Advisory Board, composed of representatives from universities, government, and industry. The Advisory Board is chaired independently.

Name	Affiliation
Chair	
Mr. K. Visser	
Universities	
Mr. B.J. Boersma	TU Delft
Mr. R. van de Ketterij	Netherlands Defence Academy
Mr. M. van Koningsveld	TU Delft
Mr. K. Venner	University Twente
Mr. G. Waymouth	TU Delft
TO2 institutes	
Mr. W. de Boer	Deltares
Mr. A. van der Hout	Deltares
Mr. R. Pijpers	TNO
Mr. A. de Reus	NLR
Industry	
Mr. J. van Bekkum	RH Marine Netherlands B.V.
Mr. J. Bokhorst	Heerema Marine Contractors Nederland B.V.
Mr. J. van den Boomgaard	SBM Offshore
Mr. F. van den Broek	Koninklijke Van Oord N.V.
Mr. W. Duursema	Wagenborg Shipping B.V.
Mr. G.-J. van Goch	Wärtsilä Propulsion Netherlands
Mr. R. Agema	Royal IHC / MTI Holland B.V.
Mr. P. Huyskens	Damen Shipyard Group
Mr. J. van Kessel	Shell International Exploration And Production B.V.
Mr. R. Leeuwenburgh	Bluewater Energy Services B.V.
Mr. M. Levadou	De Voogt Naval Architects B.V.
Mr. M. Nijland	A.P. Møller-Maersk A/S
Mr. P.M. Nordbeck	Havenbedrijf Rotterdam N.V.
Mr. A.C. Steenbrink	Koninklijke Boskalis N.V.
Mr. M. Stofregen	Huisman Special Lifting Equipment B.V.
Government	
Mr. A. Boersma	Ministry of I&W
Mr. M. Jansen	Ministry of Defence
Mr. R. Hekkenberg	Ministry of I&W
Mr. O.C. Koedijk	Rijkswaterstaat
Mr. R. Sharpe	Ministry of Economic Affairs
Mr. W. de Vries	Rijksrederij

6 ABBREVIATIONS

AI	Artificial Intelligence
AIS	Automatic Identification System
AR	Augmented Reality
AUV	Autonomous Underwater Vehicle
CFD	Computational Fluid Dynamics
COMMIT	Commando Materieel en IT
CRNavies	Cooperative Research Navies
CRS	Cooperative Research for Ships
CZSK	Commando Zeestrijdkrachten
DWB	Depressurised Wave Basin
EMTO	Evaluatie en Monitoring Toegepast Onderzoek
EU	European Union
EZ	Ministry of Economic Affairs
FER	Floating Energy Research
FPSO	Floating Production, Storage & Offloading
FRISC	Fast Raiding Interception Special Forces Craft
FSSS	Fast Small Ship Simulator
FTO	Faciliteiten voor Toegepast Onderzoek
HMI	Human-Machine Interface
HPC	High-performance computing
IMO	International Maritime Organisation
IMSF	International Marine Simulator Forum
ISSC	International Ship and Offshore Structures Congress
ITTC	International Towing Tank Conference
JIP	Joint Industry Project
JMDP	Joint Maritime Digital Platform
JRP	Joint Research Project
KGG	Ministerie van “Klimaat en Groene Groei”
KPZ	Kennisplan Zee
LES	Large Eddy Simulation
LMS	Large Motion Simulator
LVVN	Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur
MASS	Maritime Autonomous Surface Ships
MKC	Maritiem Kenniscentrum
MLOps	Machine Learning Operations
NATO	North Atlantic Treaty Organisation
NIOZ	Koninklijk Nederlands Instituut voor Onderzoek der Zee
NLDA	Nederlandse Defensie Academie
NLR	Koninklijk Nederlands Lucht- en Ruimtevaartcentrum
NML	Nederland Maritiem Land
NWA	Nederlandse Wetenschapsagenda
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek
PPP	Public-Private Partnership (Publiek-Private Samenwerking)
RANS	Reynolds-Averaged Navier-Stokes
RDM	R&D regeling voor de mobiliteitssectoren
RDMS	Research Data Management System
RNLN	Royal Netherlands Navy
RVO	Rijksdienst Voor Ondernemend Nederland
SGISC	Second-Generation Intact Stability Criteria
SITO	Subsidieregeling voor Instituten voor Toegepast Onderzoek
SME	Small or Medium Enterprise
SOSc	Seven Oceans Simulator centre

TKI	Topconsortium voor Kennis en Innovatie
TNO	Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek
TO2	Toegepast Onderzoek Organisaties
VR	Virtual Reality
VTs	Vessel Traffic Services
WUR	Wageningen University & Research
XR	Extended Reality

