BETTER SHIPS, BLUE OCEANS

Activity plan SITO 2026

Datum : September 2025
Versie : 1.0
Draft report

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Version	Date	Description	Checked by	Released by
1.0	30-09-2025	Draft for public consultation	H.J. Prins	

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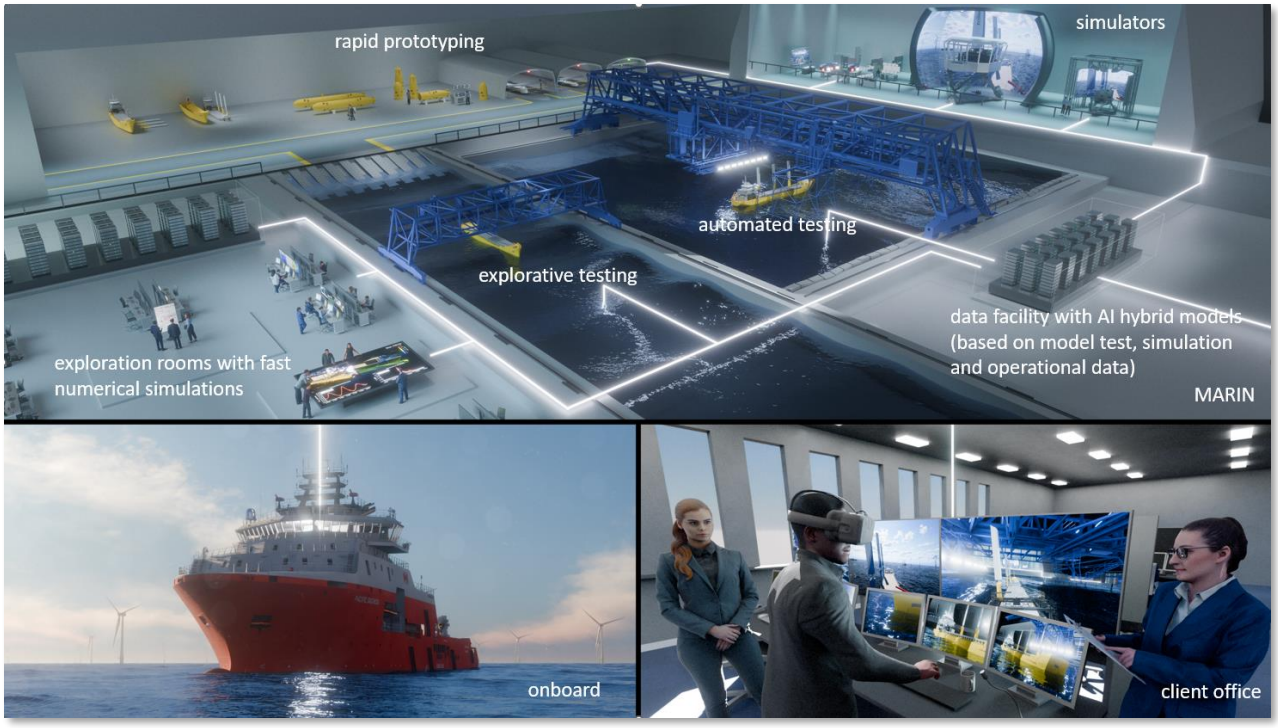
1 INTRODUCTION

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, and *Infrastructuursubsidie* for the renewal of 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 2026, the *Instituutssubsidie* will be €8.173 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 €1.3 million of this additional budget.



The funding for defence-specific knowledge development will be €6.429 million in 2026, 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.

There is a ministry-wide agreement between I&W and MARIN. We have established a broader research programme for shipping safety in the North Sea. In addition, there are smaller programs for making shipping more sustainable and for knowledge development regarding wet infrastructure such as bridges and locks. In 2026, the ministry has allocated a budget of €2.0 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, more and more research is being included in the programme.

In 2026, *Programmasubsidie* will start from the ministries of LVVN and KGG. For these two ministries, we are working on the development of a zero-emission shrimp cutter.

MARIN has been awarded three large projects in the past FTO calls: BlueLabs, SeaLab and DigiLab. In BlueLabs the wind-generation capabilities in our Offshore Basin have been improved. This project is expected to be completed at the end of 2025. 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. These projects are funded through *Infrastructuursubsidie.*

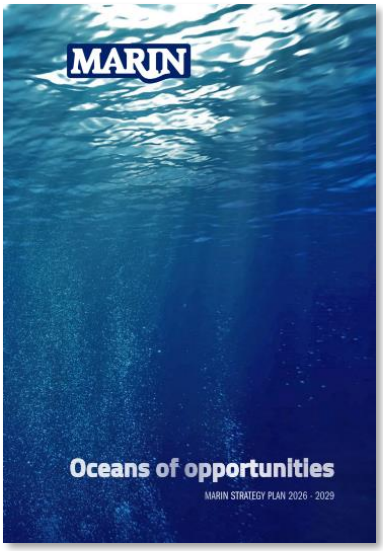
This MARIN Activities Plan SITO provides a brief overview of MARIN's role in the maritime sector and gives highlights of the planned research for 2026. In addition, there is a more detailed appendix to this Activity Plan: the MARIN RD&I Agenda 2026. This appendix goes into more detail about the plans and also 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. Similar to 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 oceans[1] *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.

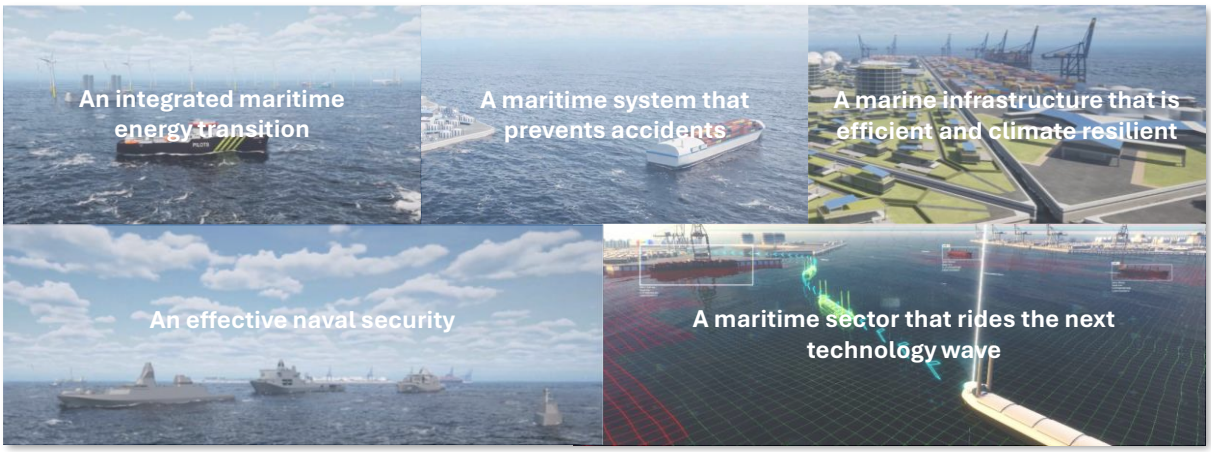
protecting human life, nature and economic value are key aspects. And also vice versa, a thriving maritime sector is needed to achieve sustainable, safe and secure use of the oceans.

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 wat 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:

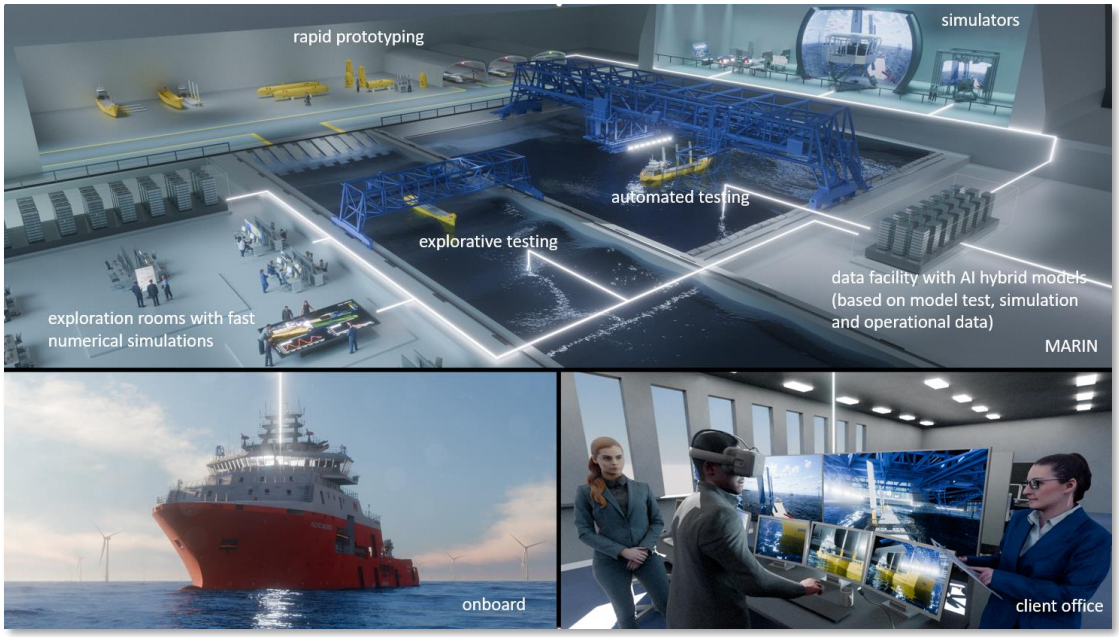
1. **We create impact across the entire maritime sector by engaging across five markets.**
   We are committed to achieving our vision with the maritime industry and governments across the entire spectrum of the maritime markets. That is why we are actively involved in five important market segments: 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 infrastruc-ture 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 actually 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 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. 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.

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).

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 2025: "*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 a number of 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.

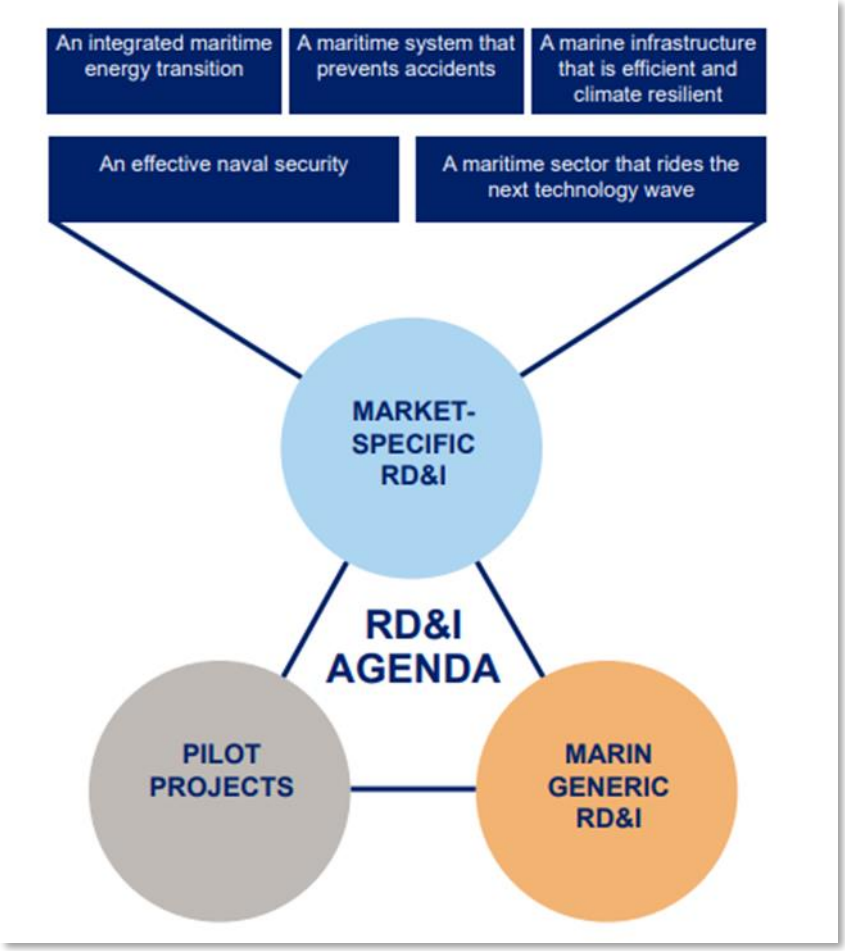
3 RD&I AGENDA IN 2026

3.1 Introduction

Our RD&I agenda broadens the past focus on R&D by incorporating the critical steps required to implement knowledge into services and into the maritime sector. It goes beyond the development of knowledge and technology, encompassing enhancements to our basins, simulation centre, digital services, infrastructure, and operational processes.

We strive to support our clients from concept to operation. The five market groups within MARIN will work in close collaboration with the maritime sector to develop market roadmaps aimed at achieving our five strategic visions. These roadmaps will be aligned with the RD&I agenda and will highlight new initiatives for collaborative projects. We will build on our existing strengths while also fostering new knowledge and technologies.

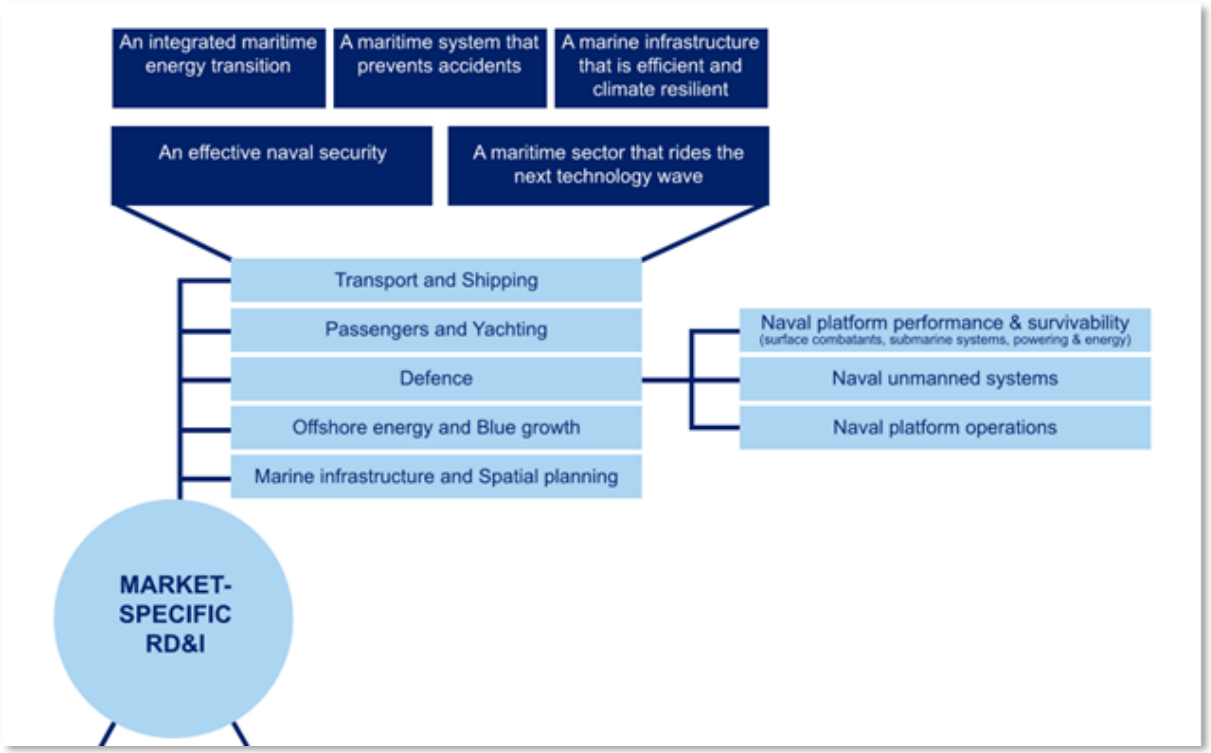
In the following paragraphs we will introduce the new organisation of our RD&I agenda. The actual research is described from section 3.2 onwards.



3.1.1 Market-specific RD&I

The market-specific component of the RD&I agenda includes a programme for each market. It encompasses research, development or implementation that is not generic to multiple markets. For example, consider a research project on a topic specific to Defence. We want to emphasise that this does not mean that the entire research project is market specific. Such a project can still include developments that are valuable to other markets or contribute financially to future generic developments

by paying for the use of our generic foundation. The market-specific RD&I can range from fundamental research to very specific implementation in services. It can be external or internally funded.



We have distinguished five separate markets

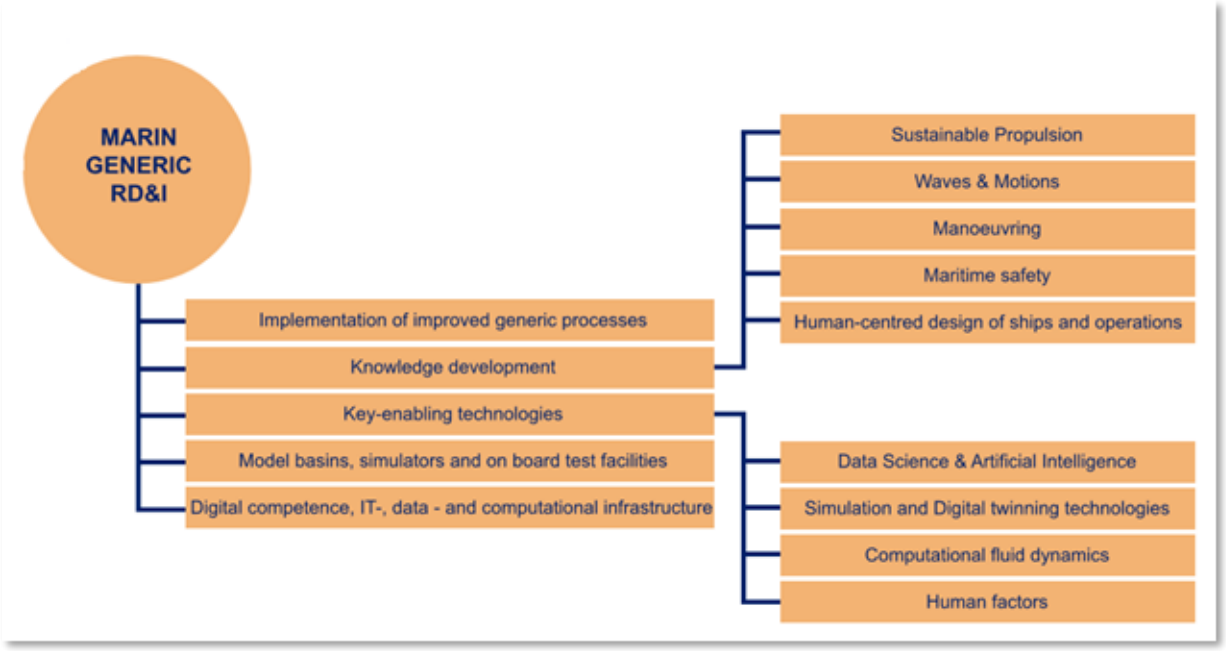
- Transport & Shipping
- Passenger & Yachting
- Defence
- Offshore Energy & Blue Growth
- Marine infrastructure & Spatial planning

Tailored programs are developed for each market. In the Defence sector, several programs are designed to support the Ministry of Defence's targeted knowledge development.

3.1.2 MARIN generic RD&I

From our market-specific roadmaps we strive to derive generic research as much as possible. This is in line with our strategy to develop generic knowledge where possible, and market specific knowledge where needed.

Within our generic knowledge development, we have distinguished programmes on knowledge development on maritime areas, and on key enabling technologies. Furthermore, we added in our RD&I agenda programmes on implementation of generic improved processes, on the developments of our facilities and simulators, and on the development of our digital infrastructure and competences.



Implementation of improved generic processes
The backbone of the MARIN generic RD&I is the programme 'Implementation of improved generic processes'. Each of the other programmes is actively involved in this backbone to realise generic implementations together. It also focusses on improving and automating the workflow around our research methods. The programme also manages our MARIN-wide modular library with data and models. We introduce stewardship for data and models. It is a crucial role to govern the quality, integrity, and security of our library.

Knowledge development
Each knowledge development programme covers fundamental research, tool development, and implementation in efficient processes and services. Implementation is done in collaboration with the 'Implementation of improved generic processes' programme or market-specific programmes. The knowledge development programmes use the latest technologies from key-enabling technologies and advancements in facilities and measurement techniques, supported by IT infrastructure for large computations and data availability.

The *Sustainable Propulsion* programme focuses on all steps needed to reach zero-emission shipping. Starting with hull and propeller designs, it extends to innovative propulsion methods such as wind propulsion and includes modelling the propulsion train and its interaction with the propeller. It also covers the modelling of ship powering in digital twins. This programme combines past research on Zero emission shipping and Resistance & Propulsion.

The *Waves & Motions* programme studies the behaviour of ships and structures in waves, combining seakeeping and offshore hydrodynamics and structural (flexible) response. It includes the hydrodynamic safety aspects of individual ships in a seaway and the modelling of seakeeping in digital twins. It is extended by the relevant hydrodynamical parts of the past research programmes on Blue growth and Safe operations & Human factors. Aspects of these past programmes that were market-specific will be included in the relevant market-specific RD&I.

The *Manoeuvring* programme focuses on ship behaviour during manoeuvres and offshore structures in current or during dynamic positioning. It includes the hydrodynamic safety aspects of individual ships during manoeuvres and the modelling of manoeuvring of ships in digital twins. It takes on board the relevant hydrodynamical research of the past Safe operations & Human factors programme, and of the Autonomy & Decision support programme.

These three maritime research programmes will develop exploration tools for design and operation. They will do this by utilising data science and artificial intelligence techniques based on the ample data generated in our basins and from simulations.

The programme *Maritime safety* is focussing on the safety of operations in multi-vessel situations or in nautical traffic. Safety science is an important part of this. The programme incorporates part of the past research programme on Safe operations & Human factors. A significant part of the research will be performed within the *Programmasubsidie* of the Ministry of Infrastructure & Water management within the programme of Safety at the North Sea.

The programme *Human-centred design of ships and operations* integrates technical aspects (Technology Readiness Level), human factors (Adoption Readiness Level) and operational considerations. It provides workable solutions for the design or innovation process for ships, marine structures, operations, onboard automation and decision support systems, including those based on artificial intelligence. The programme adopts a human-centred design approach, which is a proven methodology for problems with complex user interactions and advanced technologies. The iterative process facilitates multidisciplinary collaboration and early involvement of end users. The programme takes on board the relevant aspects of the past Autonomy & Decision support programme. It will use the work of the key-enabling programmes and the digital twins developed by the maritime programmes.

Key-enabling technologies
We consider four key-enabling technologies programmes:

- Data Science & Artificial Intelligence
- Simulation and Digital Twinning technologies
- Computational Fluid Dynamics
- Human Factors

The *Data science & Artificial intelligence* programme focusses on the adaptation of artificial intelligence and data science techniques to maritime use cases. The application of the algorithms is foreseen in the knowledge development programmes. We believe that combining our domain knowledge with data science and artificial intelligence is key. To create our own data sets, we will use the free time of our basins as well as numerical simulations. Data science will be used to determine what additional measurements or simulations are required to enhance our algorithms and datasets. A significant part of the research programme will be dedicated to onboarding new technologies emerging in this rapidly developing research field.

The *Simulation and Digital twinning technologies* programme will enhance our capabilities in the simulation of multiple objects in all environments. The simulation technologies consist of a simulation framework (XMF), simulation models, and visualisation and user interaction. The techniques are used throughout MARIN in the simulators, in desktop studies and in the basins. A coupling with our CFD code and finite element packages exists to stimulate the reuse of models and technologies. New developments are foreseen in the field of co-simulation to facilitate the interaction with simulation models from third parties or customers. Additional work is needed to further improve our capabilities in virtual and augmented reality since the technological developments in these fields are fast moving. Also, the capability for digital twinning is addressed here, by integration data science and AI into our simulation framework.

The *Computational fluid dynamics* programme develops the core of CFD software to simulate the flow around a ship, propeller or offshore structure. The software has been developed for many years now and is used in market and research projects alike. Key enhancements that are necessary are the speed up of the code for time-dependent simulations in waves, and of cavitation, bubbles and related noise.

The *Human factors* programme deals with measuring and analysing the human performance on board or in simulator studies. This is a basic technology needed for the improvement of safety of operations, the efficacy of simulator trainings, and the development of human centred designs.

Model basins, simulators and on-board test facilities
Our basins, equipped with all necessary measurement tools, simulators, and onboard measurement equipment, are a cornerstone of MARIN. We are developing a dedicated programme to enhance these facilities.

A key focus is to achieve automatic model testing. Our basins currently operate with one manned shift per basin, and occasionally double manned shifts during periods of high demand. This leaves many hours without operation and hence without data generation. In our projects, we often conduct only those experiments necessary to address our customer's immediate questions. However, this approach results in a limited dataset and biases the data towards specific conditions. We will change our operations and therefore, our basins need to operate automatically or remotely for a large class of experiments. In customer projects, we will start to generate the data we need for our own research and use part of this data to answer the questions of our customers.

Digital competencies, IT-, data- and computational infrastructure
We continue our digital transformation. In addition to strengthening our digital competencies as part of our human relations plan, we are focusing on the following main initiatives.

Digital collaboration and workplace: Ensuring accessible digital resources for internal and external collaboration without compromising security and sovereignty. We aim to share, provide, and access data, models, and digital services. An approach is federated data sharing whereby data and models stay at their source, with access and use controlled by their owner. This approach is crucial for maintaining sovereignty, for our clients and ourselves, and ensures the trusts needed to collaborate on data and models. Our on-premises infrastructure remains a key foundation. The upgrade of our computational infrastructure (High Performance Computing) and the improvement of our research data management are important developments. We complement our on-premises infrastructure with strategically chosen MARIN-managed cloud solutions and collaboration environments such as DigiLab and JMDP.

Data, models and knowledge: Streamlining our digital process to transform data into knowledge is strategically important. Key components include data collection, storage, organisation, sharing, and preservation. Effective use of research data is vital for our internal processes and external services. Therefore, we continue to invest in AI applications for these areas. This supports the stewardship in the MARIN generic RD&I.

Security, business continuity and compliance: Information security in accordance with risk levels, privacy, and compliance are essential to our digital transformation. Risk management is the foundation of all our decisions, including those related to digital developments and dependencies.

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. Explorative projects may be related to the latest knowledge in academia, or to for example the latest IT or measurement technology. Also, good ideas to develop new services or to improve processes outside the scope of our market roadmaps may be awarded.

Pilot projects for 2026 will be selected based upon an internal call for proposals at the end of 2025.

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.

Container vessels are crucial for international trade (Source: https://www.ronsped.it/)

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 the various model basin institutes. We want to improve and demonstrate our accuracy and reliability.
- *Experimental techniques for underwater radiated noise* – Noise is becoming a major issue in design of transport vessels. We have submitted an FTO proposal for the upgrade of our model basin (AcousticLab). In anticipation of this project, we want to improve our measurement techniques by incorporating the latest sensors.

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.

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

- *Extrapolation of cycloidal propellers* – With the market introduction of the ABB Dynafin, next to the existing Voith-Schneider propulsion system, cycloidal propellers have gained renewed attention in the market. We will study the extrapolation from model scale to full scale to help the industry to analyse the benefits of these propellers.
- *Fishtailing and anchoring operations* – Yachts at anchor often experience fishtailing motions. This is similar to large FPSOs or shuttle tankers in the offshore industry. We want to transfer knowledge from the offshore industry to the yacht sector to enhance safety of anchoring operations.

- *Unconventional hulls: planing and foiling hulls* – In this market, small fast ships are becoming increasingly popular. New hull shapes are necessary, like multi-hulls or foiling vessels. Together with the industry, we want to build up experience with these alternative hull forms to support the industry with design challenges.

Multi-hull yacht (Source: https://www.yachtbuyer.com)

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* (DSII, 2025) and Innovation Calendar 2021–2025 and *Defence Vision 2035*, which outline the future direction of naval operations and associated research priorities. Our goal to maximise the military-maritime operational capacity of the Royal Netherlands Navy (RNLN). 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.

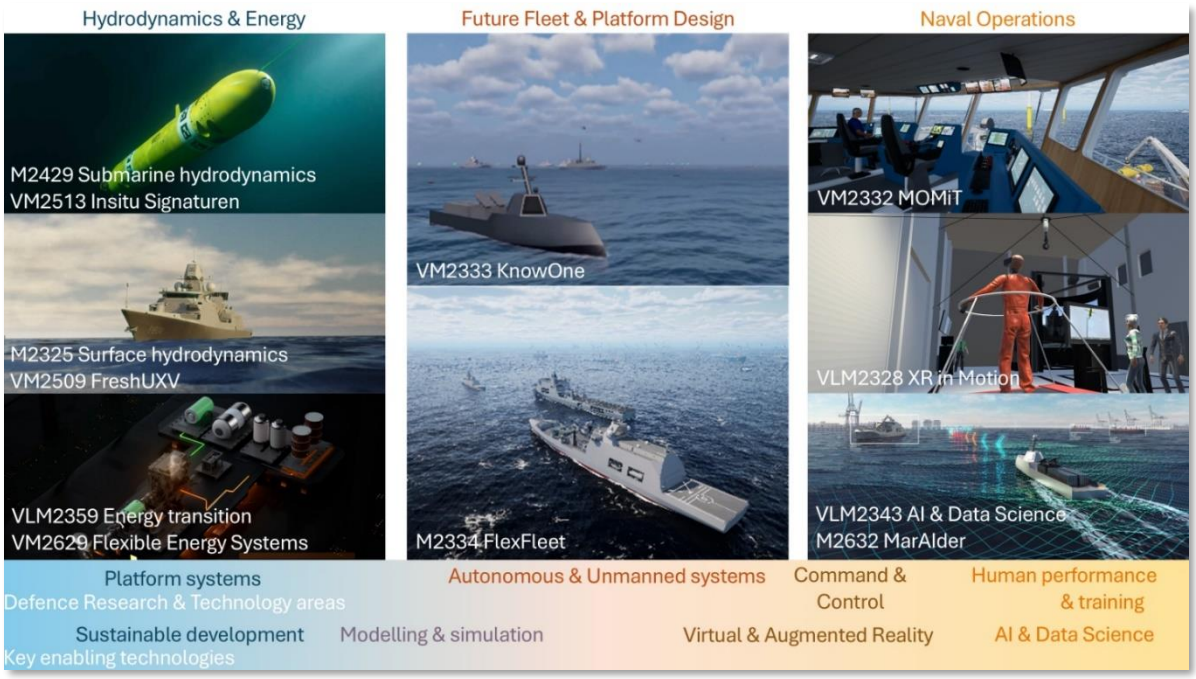
Following the increase in national defence spending in 2022, MARIN has redefined and expanded its strategic defence research and development programme. Besides continued hydrodynamic support for existing and new naval platforms, the updated portfolio includes new research themes such as advanced simulation 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.

As the new research programmes mature, there is a growing need to better align the defence and civil research agendas at MARIN to maximise synergy and impact. To improve integration between civil and defence research, we will organize joint thematic sessions in which researchers and coordinators can exchange knowledge and align future work. We will integrate the budgeting, where we will be reserving

budget and scope within new defence programmes to contribute to MARIN-wide research priorities that overlap with defence needs. Finally, we will be continuing to involve personnel from outside the Defence department in defence research programmes, particularly where dual-use expertise is relevant.

In 2026, some of the current research programmes will conclude. The formulation of new programmes to replace them has already begun in September 2025. This renewal coincides with the reformulation of the Knowledge Plan Sea (KPZ) by the Knowledge Network Sea, the governing body for CZSK[2] research. MARIN is actively contributing to this process and will seek to align its research priorities with the updated 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. To support this strategic alignment, MARIN is establishing an advisory group composed of the heads of the several departments at the Ministry of Defence.

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. The first pilot PhD position is already planned within the new VM2629 – Flexible Energy Systems programme.



Overview of the research programmes for the Ministry of Defence

Fundamental knowledge
Research is conducted across four programme lines to build foundational knowledge for defence applications. This includes traditional programmes on ship and submarine hydrodynamics, as well as new research into emission reduction. Key topics include deployment and retrieval of unmanned vessels from submarines, ship signature (acoustic emissions that reveal a vessel's presence), silent propulsion systems, and interaction between large and small vessels, e.g. motherships and fast craft. Emission reduction is also critical for naval vessels. MARIN investigates the energy transition of current and future assets, addressing not only civilian challenges but also military-specific issues such as fuel logistics and vulnerability during attacks.

[2] Commando Zeestrijdkrachten

Fleet design
Designing autonomous naval vessels raises additional questions: what tasks can autonomous vessels perform, can tasks be combined, and how can control systems be made as effective as possible? In collaboration with TNO, MARIN is developing a simulation environment for autonomous vessels and their interaction with crew aboard the mothership. Verification and validation of this environment are essential to ensure future designs can be reliably tested.

Operational aspects
The Navy possesses vast datasets on its vessels. Its ambition is to leverage this data to improve operational efficiency and safety. MARIN supports this by developing machine-learning algorithms for optimised long-range routing and advisory systems for FRISC control. Together with TNO and NLR, MARIN is working on integrating data from various systems—ships, onboard equipment, and potentially drones or helicopters. This includes accurate data collection, cleaning, and storage; controlled access to sensitive data; systematic training of algorithms; and training personnel to understand AI systems.

Human performance
To enhance crew performance aboard naval vessels, the Navy aims to maximise the use of simulators. However, replicating a ship's bridge or command centre is costly. MARIN is exploring how Virtual Reality (VR) and Augmented Reality (AR) can supplement simulations while maintaining realism. Research topics include simulating tactile feedback in VR, preventing cyber sickness, and designing onboard systems that align with human perception using VR technologies.

Exploratory research
Finally, MARIN conducts exploratory research into innovations that are still far from practical application. These include 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 (EDF), 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 constructions, 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 a number of Joint Industry Projects and RVO funded research projects are in progress and being initiated around Oil & Gas, solar energy, wind energy and floating infrastructure. Examples include the ScaleWind and RunWAVE JIPs 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.

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

- *Numerical and physical modelling of servo-elastic (floating) structures* – To accurately include structural flexibility in combination with actuators and controllers for the assessment of fixed and

floating wind turbines, the current numerical and model testing expertise and capabilities should be expanded further. The ambition is to validate the numerical models including structural flexibility against model test results from the running ScaleWind and RunWAVE JIPs.
- *Shallow water hydrodynamics* – In the recently finished HAWA-III Joint Industry Project a general applicable numerical method has been developed for the hydrodynamic analysis of permanently moored floating structures in shallow water conditions. Further research and development are needed to be able to include more relevant complex applications, such as a moored vessel with and without a breakwater positioned in an area with complex ocean bathymetry.

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 collaboration with the research programmes on Maritime Safety and Manoeuvring:
- 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 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.
- In collaboration with our Flemish and German colleagues, we will study the effect of extremely shallow water on the manoeuvrability of inland ships.
- Finally, we support Rijkswaterstaat through the maintenance of several older models and software tools currently in use for safety analysis of inland shipping.

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 Knowledge development

Sustainable propulsion
The research programme Sustainable Propulsion combines research on the resistance and propulsion of ships with research on power generation and the use of sustainable fuels. For the coming year, we have defined the following key projects:
- *Multi-fidelity optimisation of the total ship system and of the prolusion configuration* – We want to be able to optimise the total ship energy systems and propulsion configuration in an early design phase. We want to perform multi-objective optimisation with multi-fidelity methods.
- *Improving model test accuracy and CFD predictions for resistance and propulsion at full scale* – In recent years we have made several improvements to model-scale experiments on propellers. We want to apply this new methodology to all resistance and propulsion tests. We will also study the influence of residual flow in the basins.
- *Refined model test procedures for cavitation observations* – Scaling of the wake is critical for cavitation similarity between model scale and full scale. We will improve our procedures by including numerical simulations of cavitation at different scales.

- *Underwater-radiated noise* – We have submitted a proposal for subsidy for an upgrade of our facility DWB to better measure underwater radiated noise. In preparation for this project, we will start a JIP: the CALM JIP. The aim is to develop validated simplified prediction methods for ship underwater radiated noise at an early design stage or during through-life sustainability improvements.
- *Full-scale observations of fouling, air lubrication* – We will collaborate with industry on the development of a new observation system to monitor fouling and air lubrication at full scale.
- *Extending our modelling of power generation systems* – Over the recent years we have developed a set of models for power generation systems. In the coming year we want to extend this set with models for the degradation of battery systems, and of engine emission.
- *Zero-emission sustainable fishing vessels* – For the Ministry of LVVN we will work with partners on the design of a standard design for zero-emission shrimp fishing vessels.
- *Wind-assisted ships* – In several collaborative projects we will be working on the design of wind-assisted ships. We will also assist the Ministry of Infrastructure and Watermanagement and the industry with regulatory affairs at for example IMO.

Wind-assisted ship propulsion

Waves & Motions

The research programme *Waves & Motions* aims to accurately predict motions of ships and platforms in waves. These predictions will be used to assess the safety and operability of ships and operations. Therefore, there is a clear link with the research programme on Maritime Safety.

When dealing with safety at sea, waves and the resulting motions and responses are a key aspect to investigate. Consequently, it is important to model these waves realistically and accurately in our numerical tools and experimental facilities and to quantify the response of these structures in both operational and extreme wave conditions. Operations with two or more marine structures can be extremely challenging and safe operations require careful preparations and planning. When the structures are in close proximity, the interactions between the structures need to be properly considered. For large structures, their flexibility could significantly influence their response, so this needs to be taken into account and investigated as well.

Bow of a frigate slamming into a wave

For 2026, we will focus on the following topics:

- *Efficient higher-order wave event generation* – For the study of extreme, violent events such as slamming, an accurate prediction of individual waves is necessary. These extreme waves are very non-linear, and therefore difficult to predict. We want to extend our work on machine learning for wave calibration.
- *Validity of frequency domain seakeeping prediction methods* – Within MARIN we have developed several prediction tools for seakeeping characteristics, each with different fidelity. The underlying methodologies are used throughout the maritime sector. We want to establish the accuracy and reliability of each method for the different seakeeping characteristics and share these insights with the maritime sector.
- *Assessment of applying non-linear hydro-structural simulations for fatigue assessment* – Within the industry the common practice for the assessment of structural fatigue is based on linear hydrodynamic and linear structural analysis. We want to assess whether the inclusion of non-linear hydrodynamics affects the outcome of the fatigue analysis.
- *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. We now aim to apply this methodology to bow or stern slamming of sailing ships.
- *Second generation intact stability IMO code* – New IMO regulations on stability of ships will come into place within a few years. IMO is requesting feedback on the proposed regulations. We aim to study the regulations and the suitability of various computational tools.

Manoeuvring

The research programme *Manoeuvring* supports the maritime sector with the assessment and improvement of safety and efficiency of nautical operations and traffic flows and provides reliable and accurate hydrodynamic models. These models can be used in concept, design and operation. The programme also includes research on control methodologies in combination with the on-board control devices.

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

- *Advanced Manoeuvring Simulations* – We will investigate the latest capabilities of CFD for manoeuvring simulations on complex geometries. This includes simulations with active control devices, simulations for shallow or confined water, and ship-ship interaction.
- *Integrated Manoeuvring & Control System* – This project aims to enhance robust control methods in maritime simulations by integrating optimized autopilot gains and dynamic wind/current field modelling into time-domain simulation environments. Key activities include managing complex hydrodynamic transitions, and developing control for operations like crabbing and dynamic positioning.
- *Unified Manoeuvring Data & Workflows* – This is fundamentally a data-driven initiative. The project focuses on learning from data, developing new methodologies, and integrating insights into predictive models—core research activities. Workflow improvements will be funded from MARIN's reserves.
- *Manoeuvrability Scoring Framework* – This project aims to develop and implement a standardized scoring system to assess the manoeuvrability of ships, similar to an energy label or a 5-star rating. The goal is to provide an intuitive and comparative performance metric that can be used across the maritime sector.

Ship manoeuvring in calm water (Source: https://www.marineinsight.com/)

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.

Maritime Safety

For the Ministry of Infrastructure and Water Management, MARIN is working on the knowledge agenda for safety in the North Sea. This work began in 2024 and will continue into next year. The activities are divided into three main areas:

- The definition of safety and the methodologies used to calculate it. We aim to investigate how the risk at sea increases as more people work offshore. We will also review existing safety measures to assess their effectiveness. The safety model SAMSON will be modernised in light of new developments at sea.
- The mathematical models required to predict safety. This part of the programme focuses on models for sailing cargo vessels, which behave differently from conventional cargo ships. We also examine the impact of using alternative fuels in shipping on safety.

- Policy support based on this research. We will assist the ministry with policy-related matters for the IMO and the Dutch Parliament. In particular, we will explore the possibility of reducing the mandatory sailing time for nautical students through the use of simulators.

Flinterstar sinking at the North Sea after a collision (Source: Louwe Nentjes onboard mv 'Schokland')

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. In 2024, the modernisation of SAMSON began. The architecture has been established, and the main computational models were transferred during 2025. In the coming year, the re-implementation of all core functionality will be finished, and focus will shift to improving the user experience.

The final scope of work will be determined in close consultation with the ministry and Rijkswaterstaat during a workshop at the end of 2025.

Furthermore, we will study the IMO Second Generation Intact Stability Guidelines. We will study the capabilities of different simulation techniques to predict the intact stability criteria. Based on this work we will use the opportunity given by IMO to give feedback on the proposed regulations.

Human-centric design of ships and operations

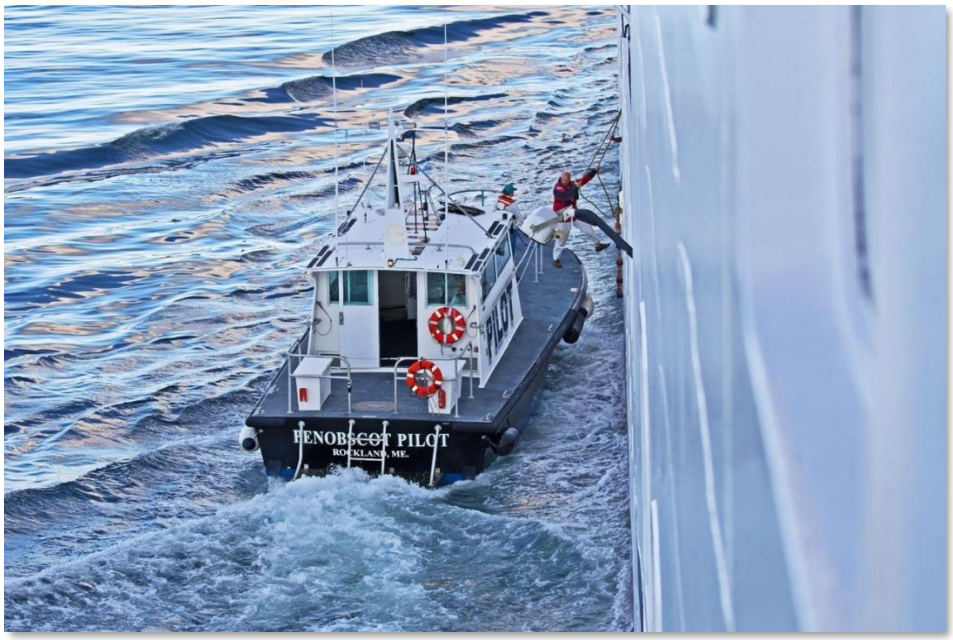
The programme *Human-centred design of ships and operations* integrates technical aspects, human factors and operational considerations. The programme adopts a human-centred design approach, which is a proven methodology for problems with complex user interactions and advanced technologies.

For 2026 we foresee the following research projects:

- *Quick prototyping of human interfaces* – Over the years we have developed several decision support systems in collaboration with industry. One of the key points to address in the coming year is to develop a system in which we can quickly build a prototype user interface for testing the human interaction with the decision support system. This user interface should also be capable of collecting data of prototypes on board.
- *Temporary unattended navigation spaces* – As maritime systems become increasingly autonomous, the “human-out-of-the-loop” effect poses serious safety risk. The human operator

may be attending other systems or may even not be on the bridge for a period of time. Operators may have to intervene during critical moments without prior situational context. We will study the effects of the time to become situational aware on the design of ship systems.

- *Parametric Roll Awareness* – Building upon our earlier TopTier JIP, we will initiate a new JIP on the risk of parametric rolling. In this JIP we want to develop tools and procedures to make crew aware of the risks of parametric rolling at sea.
- *Crew or pilot transfer* – In the LEAP JIP we want to study the safety of transfer of crew or pilots from one vessel to another. We will compare the perceived safety of the transfer with objective measures. Based on this comparison, we aim to redesign transfer operation and develop a support system that indicates the safety to the transferring crew.



Pilot transferring to a large vessel (Source: https://maritime-mutual.com/risk-bulletins)

3.3.2 Key-enabling technologies

Data science and Artificial Intelligence

The research programme Data Science & AI focuses on developing knowledge and tools that can later be applied within maritime themes or other key technologies. Over the past few years, we have built a solid foundation for the application of data science and artificial intelligence. Gradually, we have reached a point where market interest is increasing—driven both by greater external awareness and an improved knowledge base within MARIN.

More and more, 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:

- *Efficient data gathering* – We aim to study Active Learning, in which AI predicts which data points need to be added to the data set to improve the predictions of AI models. This can directly be applied to numerical optimisations where reduced-order models are used. This also has the potential to be used in measurement campaigns in our basins, where time is valuable and optimal use of the basin time can be achieved.
- *Generalizing performance models* – Over the past years we have studied various data science models for the evaluation of the performance of a ship in a seaway or while manoeuvring. We want to combine and generalize these methods to get a coherent set for application in applied research programmes.
- *Early warning system for mooring failure* – Within a collaborative project, we have studied the detection of mooring failure by means of data science on floater motion data. This has been

successful using synthetic data coming from simulations, but has not yet been applied in real life. Before making the step to floaters at sea, we will make the intermediate step to apply the failure detection to our model basins. While still being a controlled environment, this step includes the domain shift by move from synthetic data to real data.

- *Unlocked data* – We aim to unlock the large potential of the information stored in reports by using Large Language Models. We want to apply this technique to efficiently search in our public reports, as well as in reports from collaborations such as the CRS.

Simulation & Digital twinning technologies

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 with tools such as ANYSIM and FREDYN. We also aim to develop several generic innovations that can be used across all other research programmes. For example, we would like to further expand the use of GPUs in simulations and make more models available on these high-speed processors. The new 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.

Virtual reality combined with interaction with moving physical systems

For 2026, we foresee the following developments:

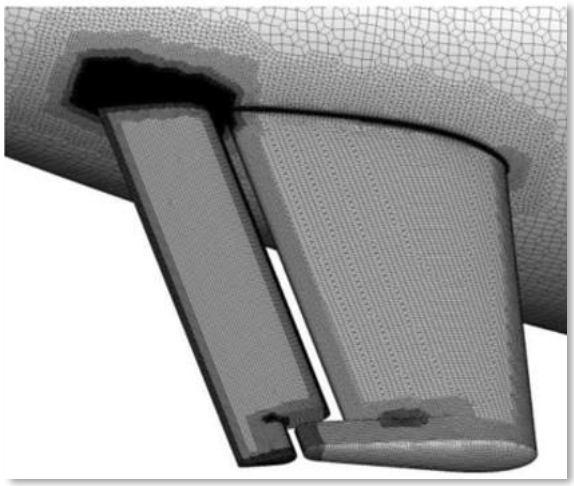
- *Consolidating XR as a MARIN product* – We aim to consolidate the developments of the past four years into a standardised MARIN product available in our different simulators. To this end, we need to extend the motion realism by combining XR with the motion systems in the simulator.
- *Improvement of Simulations using Constraint Dynamics* – Within many of our simulations, the flexibility of the structure plays a role in the hydrodynamic response. To model this, the flexibility is modelled using constrained dynamics. This is of lower fidelity than the hydro-structural coupling studied in the research programme on Waves & Motions but is serves as a quick check on hydrodynamic and structural interactions. We want to extend our hydrodynamical models with this new structural analysis technique.
- *Digital Twin technologies* – We aim to extend our knowledge on the twinning of numerical models and their physical counterparts. Numerical models need to adapt to changing environments of a ship, but at the same time should raise alarms if the changes are too large to

be explained by changes in the environment. We will deploy our framework in two collaborative projects to test the advantages and disadvantages.

- *Numerical model calibration* – In a similar effort to the digital twinning, we want to automatically tune numerical models based on experimental data. So far, this calibration process remains manual and user dependent, and thus the results may vary from user to user. We aim to use our optimisation framework for automatic tuning of numerical models, with the aim to significantly reduce the time between experiments and simulator studies.

CFD development

The CFD development research programme aims at the development of Computational Fluid Dynamics (CFD) software that can be applied in other research programmes and in services to simulate the flow around ships and offshore structures.



Complex geometry of a ship's rudder requiring special attention in CFD

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

- *Consolidation turbulence and free-surface modelling* – This project aims to make advanced turbulence and free-surface models available for practical applications. In 2026 we will focus on turbulence and free-surface modelling as both are essential in hydrodynamics.
- *Higher speed against lower costs* – This project aims to make complex CFD simulations faster and thereby more feasible. Although ReFRESCO can be used for many applications, its research and success depend on the computational speed and costs. In many contexts HPC costs can quickly dominate the project, particularly in design optimization studies due to the large number of cases or in unsteady simulations due to the large number of time steps required.
- *Object motions - handling geometry and motions of objects in the fluid* – This project aims to provide direct support for users with complex simulations and thereby improve the robustness of ReFRESCO in a targeted way. Recent developments in ReFRESCO such as freely moving objects combined with hybrid, sliding and overset meshes have increased the number of possible applications so strongly that not every application can be tested up-front.

IT related issues like performance on massively parallel compute clusters and the interaction with other software packages, is handled in internally funded projects.

Human factors

The Human factors programme deals with measuring and analysing the human performance on board or in simulator studies. This is a basic technology needed for the improvement of safety of operations, the efficacy of simulator trainings, and the development of human centred designs.

Over the last five years, we have built a set of measurement techniques and analysis tools for human factor research. In the coming year, we want to expand our capabilities through the following projects:

- *Human Performance: methodologies and measurement suite* – We will further develop our suite of measurement techniques. We will extend our eye-tracking capabilities with the automatic recognition of objects in a simulator environment. This enables us to determine what the human was focussing on.
- *Measuring Time to Build Situational Awareness* – The more autonomous a system becomes, and the more the navigation officer assumes the role of a monitor, the harder it becomes to recognize when things go wrong—and to intervene effectively. This initiative focuses on measuring how much time operators require to develop sufficient situational awareness from a baseline of no prior information.
- *Human-Machine Interface (HMI) Design and Prototyping* – The HMI design methodology and prototype implementation approach was initiated in 2025, and further development is desired. This work will align with the international Open Bridge initiative led by the University of Bergen in Norway.

3.3.3 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.

BlueLabs
MARIN has developed BlueLabs, a new facility aimed at accelerating sustainable developments at sea. The Netherlands and Europe are increasingly reliant on the sea for a sustainable and energy-independent future. Maritime innovations—such as offshore renewable energy production, sustainable food production, floating infrastructure, and zero-emission shipping—play a vital role in addressing these urgent societal challenges.
Over the past years, MARIN has played a key role in these developments, but its facilities were reaching their limits. With BlueLabs, MARIN was able to generate new knowledge that contributes to the key technologies required to realise sustainability at sea more effectively. To support research into major sustainable transitions at sea, we expanded our facilities with the following capabilities:

- Advanced wind generation in the Offshore Basin: focused on the development of floating wind turbines, floating solar panels, and floating infrastructure.
- Modelling of wind forces and complex systems using computer-controlled actuators: aimed at wind-assisted ship propulsion and research to enable future robotisation of offshore wind turbine installation and maintenance.
- Wireless measurement technologies: to enable data collection from ultra-light and wind-sensitive structures such as floating wind turbines, solar panels, and sailing cargo vessels.
- Optical measurement systems: to capture the deformation of flexible structures, such as solar panels, nets, and plastic collection systems.

New wind fans ready for installation in the Offshore Basin

Most of the upgrade of the facility has been realised in 2025. In 2026 the final testing of the new equipment will be performed, and minor improvements are expected.

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 Q2 of 2024, a team began exploring SeaLab use cases and established a development environment to support structured, documented, and traceable module creation. By the end of 2024, the environment was operational, with general requirements for the backbone and modules defined, and initial modules—such as sensor interfaces and standardized data storage—were developed. In 2025, development continued with modules like communication layers, data logging, crew interfaces, and vessel system integration, aiming for first operational use in MARIN projects by year-end. In 2026, the focus shifts to integrating SeaLab with other MARIN facilities, including external data storage and analysis tools. SeaLab also supports digital twin research by linking real vessels to simulation models. Modules for remote sensing and direct contact measurement will be expanded and integrated with data acquisition systems. A pilot project will be executed in 2026 to test SeaLab on a research vessel, enabling live monitoring and data-driven research to enhance vessel operations.

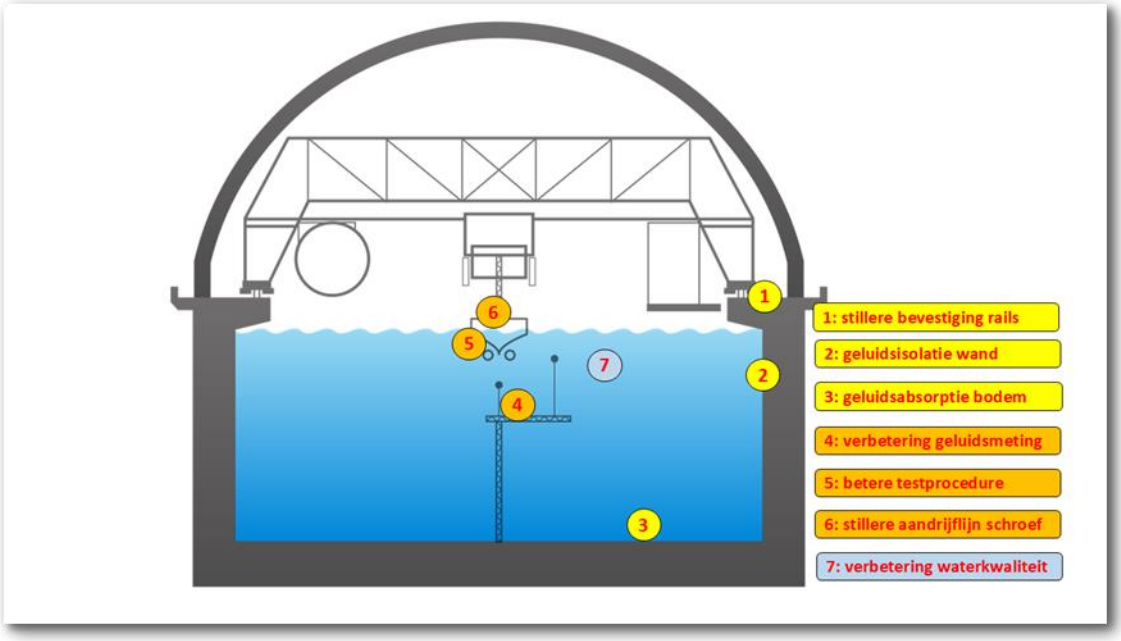
AcousticLab
In AcousticLab, we will expand MARIN's existing facility, the Depressurised Wave Basin (DWB), with the capability to accurately measure underwater sound. Underwater sound is important for two key reasons:

- Due to increasing human activity at sea, more noise is being produced by ships and installations such as wind turbines, which can be harmful to marine mammals and fish. The Netherlands has committed to protecting marine life (United Nations Sustainable Development Goal 14 and EU

MSFD Good Environmental Status descriptor 11). Within the UN organisation IMO, regulations are being prepared concerning noise generated by shipping.
- For the Royal Netherlands Navy, it is essential to develop vessels that produce minimal noise, while also being able to detect and identify the noise of hostile ships.

The Depressurised Wave Basin is already used for research into propeller cavitation, the onboard disturbances it causes, and high-frequency underwater noise. However, to make accurate predictions of underwater sound across all relevant frequencies, the facility needs to be upgraded. Currently, there is too much interference from sound reflections, noise from the towing carriage, and ambient noise entering the facility.

In collaboration with TNO, we have initiated a process to upgrade the facility. A proposal has been submitted to RVO. The decision on this proposal will be announced in the fall of 2025.



Proposed improvements to the DWB facility for acoustic measurements

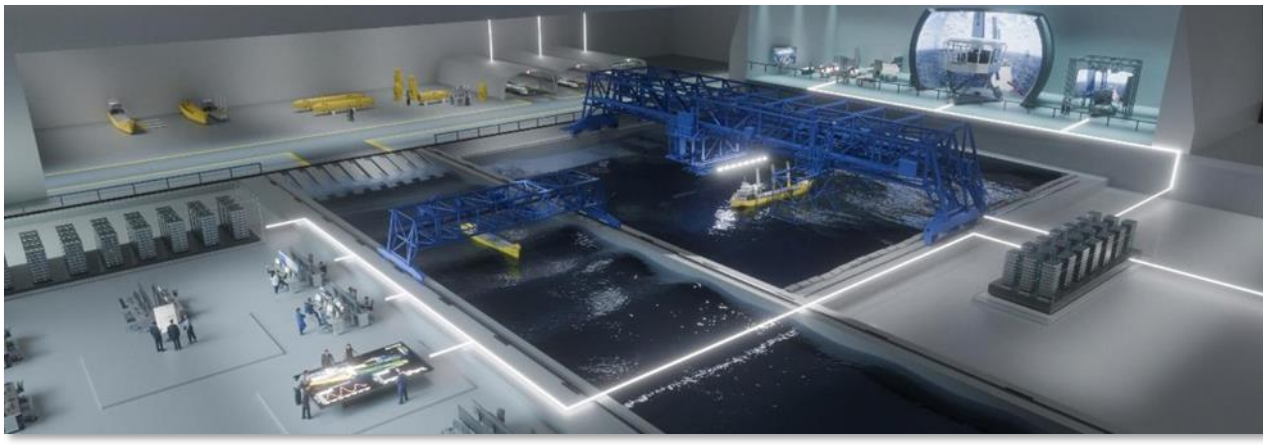
Maritime Innovation Lab

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.

A proposal has been submitted to RVO. The decision on this proposal will be announced in the fall of 2025.



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

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

DigiLab
To boost innovation, the TO2 organisations and several leading public research institutions in the Netherlands are jointly developing a federated digital infrastructure called the 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 contract was finalised in early 2025, with implementation beginning in autumn. A major upgrade to our computing infrastructure is planned for 2026 to support the initiative's long-term goals.

Joint Maritime Data Platform (JMDP)
The JMDP is a network, not a centralized data platform. Within JMDP the aim is to make data from various parties securely and accessibly available, enabling data analysis and reuse. This set of agreements, with guidelines and sector-wide arrangements, ensures safe and efficient data exchange. JMDP is part of the Maritime Master Plan.

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 2026.

RD&I Programme	PPP initiatives
Transport & Shipping	• EU-projects Synergetics, SeaStars • Calm JIP • Nav-Amaz JIP
Defence	• CR Navies • Various EDF projects
Offshore Energy & Blue Growth	• EU-project Bamboo • TKI-projects Offset, RunWave, ScaleWind • NWA Floating Future, HybridLabs • Riser Balcony JIP, Towin JIP, LifeLine II
Sustainable Propulsion	• RDM – Sh2ipDrive • HyUse • Calm JIP • ShipAirGo JIP • CRS projects Certify, K2+, PropNoise, Transom
Waves & Motions	• CR Navies • CRS projects CTRL-LIFT, GoodVibes, SEACAL-2, SPEC, Reliable • ComFlow Usergroup, MetaShip JIP
Manoeuvring	• CRS CTRL-LIFT, Mambo • NATO working groups • Shining cooperation on shallow water hydrodynamics
Human-centric design of ships and operations	• ALERT JIP
Data science & AI	• CRS-project Terminator
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 2026, the *Instituutssubsidie* will be €8.173 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 €1.3 million of this additional budget. This leaves a budget of €2.56 million for the coming two 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:

- €7.8 million for the Knowledge Base
- €1.6 million for MARIN's contribution to Public-Private Partnerships (Matching Fund/PPS)

In addition to this *Instituutssubsidie*, in 2026 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 €8.429 million.
We also expect to convert €3 to €4 million from previously awarded subsidies for the development of SeaLab and DigiLab. Furthermore, we may receive additional funding for one or two proposals for investment in our facilities.

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

Programmes All amounts in k€	Public-Private Partnerships (JIPs)	Knowledge Development	Total
Mission-oriented research	**830**	**870**	**1,700**
Transport & Shipping			
Passenger & Yachting			
Defence			
Offshore Energy & Blue Growth			
Maritime Infrastructure & Spatial planning			
Generic Process Improvements	**-**	**-**	**-**
Maritime themes	**815**	**3,405**	**4,220**
Sustainable Propulsion			
Waves & Motions			
Manoeuvring			
Maritime Safety			
Human-centric design of ships and operations			
Key-enabling technologies	**-**	**1,950**	**1,950**
Data Science & Artificial Intelligence			
Simulation Technologies & Digital Twinning			
Computational Fluid Dynamics			
Human Factors			
Facilities	**-**	**350**	**350**
Digital Infrastructure	**-**	**300**	**300**
Pilot projects	**-**	**600**	**600**
Cooperation	**-**	**300**	**300**
Total	**1,645**	**7,775**	**9,420**

With respect to previous years, the budget for matching in Public-Prive 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:

- € 1,5 million for knowledge development on safety in the North Sea.
- € 6.4 million for knowledge development for the Ministry of Defence.
- € 0.5 million for maintenance of software for Rijkswaterstaat.

In 2026, *Programmasubsidie* will start from the ministries of LVVN and KGG. For these two ministries, we are working on the development of a zero-emission shrimp cutter. Exact budgets will be determined in fall 2025.

We also receive co-financing from European defence projects, which is determined based on the approved proposals.

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. P.J. Keuning	
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. P. van der Hoek	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.
Mr. S. Woltheus	Shell Nederland Verkoopmaatschappij 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
AR	Augmented Reality
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
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
KGG	Ministerie van “Klimaat en Groene Groei”
KPZ	Kennisplan Zee
LVVN	Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur
MKC	Maritiem Kenniscentrum
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)
RDM	R&D regeling voor de mobiliteitssectoren
RVO	Rijksdienst Voor Ondernemend Nederland
SITO	Subsidieregeling voor Instituten voor Toegepast Onderzoek
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
WUR	Wageningen University & Research

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