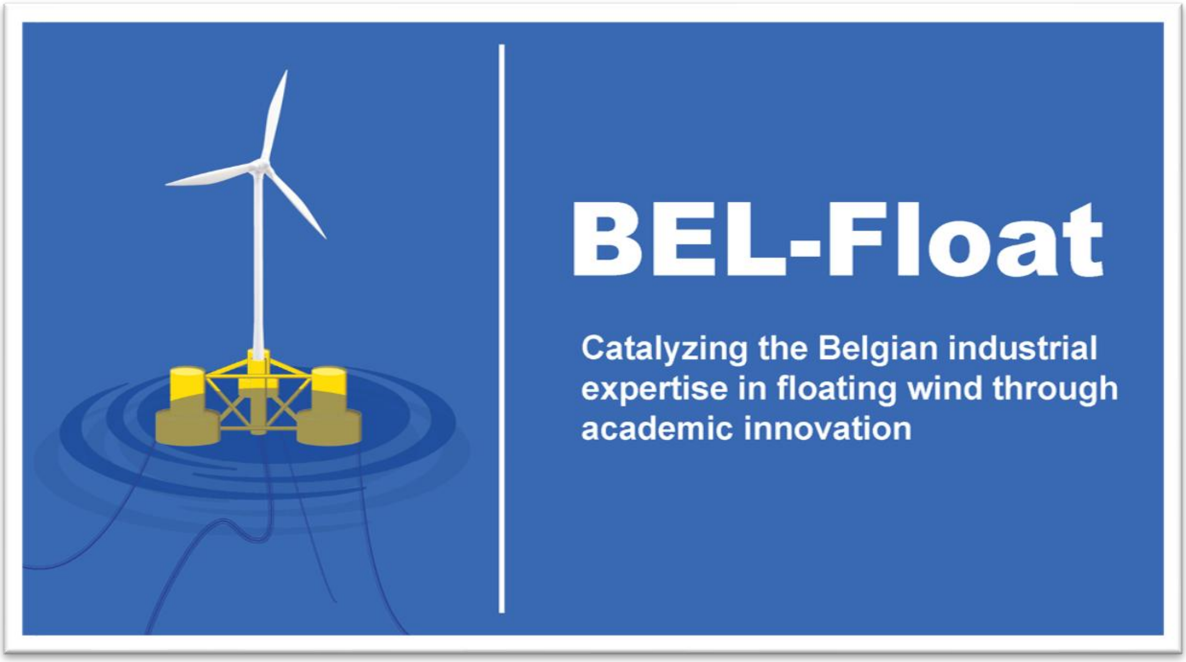

BEL-Float Innovation Agenda

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1. Purpose of the Innovation Agenda

Floating offshore wind (FOW) is emerging as one of the most promising growth markets within the global offshore renewable energy sector. While Belgium has established a strong international reputation in bottom-fixed offshore wind and developed a highly competitive offshore supply chain, maintaining this leading position will require active engagement in the rapidly expanding floating wind market. To support this transition, the BEL-Float project was established with the ambition of strengthening the Belgian knowledge base, fostering collaboration between academia and industry, and developing the expertise needed to address the technological challenges associated with floating offshore wind.

One of the objectives of the BEL-Float project is to develop a shared Innovation Agenda for floating offshore wind, building on the expertise generated within the project and the needs identified by industry. The purpose of this Innovation Agenda is to capture the main technological challenges, knowledge gaps and research needs that are considered relevant by stakeholders in the Belgian offshore wind ecosystem. By consolidating these insights, the agenda provides an overview of priority topics that may benefit from further research, innovation and collaboration in the coming years.

The Innovation Agenda builds on the unique collaborative approach of the BEL-Float project. The six BEL-Float research topics were defined through close interaction between Belgian universities, Norwegian research partners and industrial stakeholders active throughout the offshore wind value chain. The Innovation Agenda brings together lessons learned within BEL-Float and perspectives gathered from (mainly) industry representatives and research partners. As such, it aims to support dialogue between academia and industry and to stimulate future initiatives that can strengthen the Belgian position in the emerging floating offshore wind sector.

The BEL-Float Innovation Agenda should also be viewed in the context of existing strategic initiatives in floating offshore wind, most notably the i3FLOAT Strategic Research and Innovation Agenda. While the i3FLOAT agenda provides a broad European perspective on the key technological challenges and innovation priorities for floating offshore wind, the BEL-Float Innovation Agenda offers a complementary and more detailed view from the perspective of the Belgian ecosystem. Through the BEL-Float research activities and stakeholder consultations, specific research needs, technological barriers and industrial priorities were identified and further elaborated. As such, this Innovation Agenda does not seek to replace existing strategic agendas, but rather to deepen and contextualise selected priority themes by linking them to concrete research experiences, industrial feedback and opportunities relevant to Belgian stakeholders.

Furthermore, the BEL-FLOAT Innovation Agenda should be viewed as a living strategic document. As floating offshore wind technologies continue to evolve and the sector matures, the priorities identified in this agenda can help align future research and innovation efforts with emerging industrial needs and opportunities, ultimately contributing to a strong and competitive Belgian role in the global floating offshore wind value chain.

2. Methodology

The BEL-Float innovation agenda was developed through a **stakeholder consultation process** centred around the **BEL-Float Mini-Symposium**, organised on June 2nd at the NH Hotel Brugge. The stakeholder group included representatives from Blue Cluster, FPS Economy, Elicio, HAEDES, Multi-engineering, Smulders, Jan De Nul, DEME, Von Karman Institute (VKI), JERA Nex bp, and 24SEA, in addition to the BEL-Float researchers and project partners. The objective was twofold: to disseminate the results generated within the BEL-Float project and to gather stakeholder perspectives on future research and innovation priorities for the Belgian floating offshore wind sector.

Prior to the mini-symposium, the BEL-Float researchers reviewed the outcomes of the six project research topics and analysed their relevance within the broader floating offshore wind innovation landscape. As part of this exercise, primary and secondary links were identified between the BEL-Float research topics and the priorities described in the i3FLOAT Strategic Research and Innovation Agenda (***Figure 1***). This mapping exercise helped position the BEL-Float research within a wider European context and provided a basis for discussions during the workshop. The identified links were visualised and presented to the participants during the event.

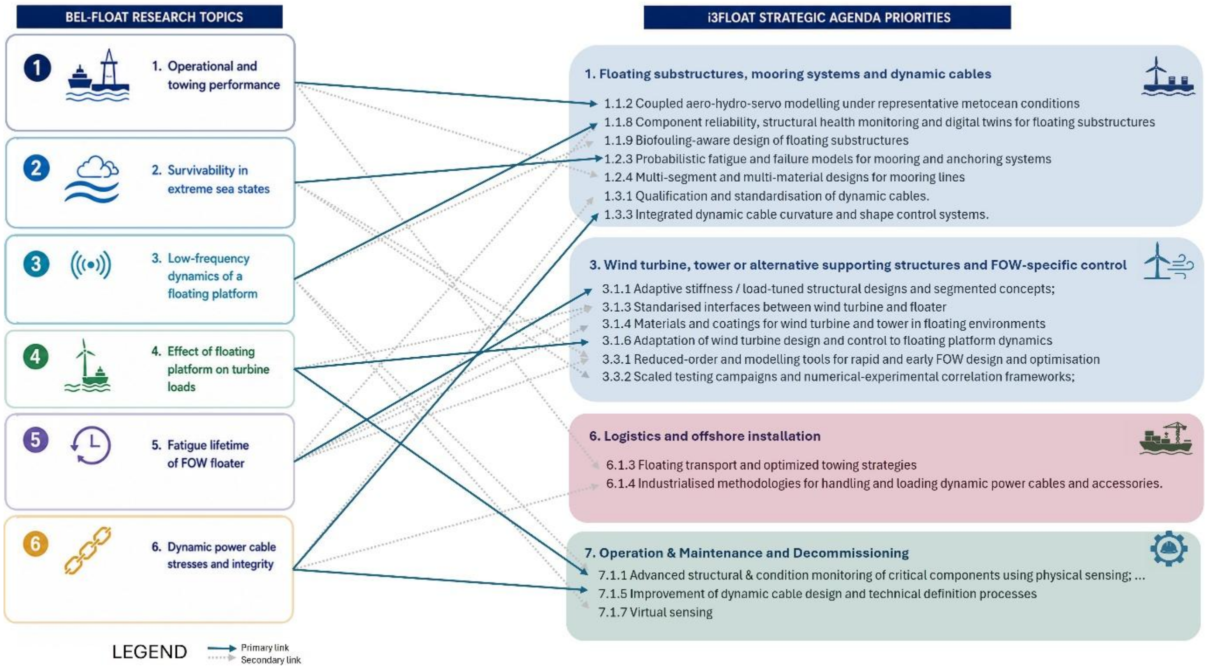

Figure 1. BEL-FLOAT research topics are linked (primary and secondary) to subtopics of the i3float Strategic and Innovation Agenda.

The first part of the mini-symposium consisted of presentations of the six BEL-Float research topics and their key valorisable results. Following the presentations, participants were invited to take part in an interactive stakeholder workshop organised around three round-table discussions. Each table focused on one research domain and therefore covered two related BEL-Float research topics.

Participants were free to join the discussion table that best matched their expertise and interests:

- **Hydrodynamics and integrated design**
  - Operational performance, towing and mooring system assessment
  - Extreme response, mooring integrity and survivability
- **Field monitoring and data**
  - Low-frequency dynamics, monitoring & virtual sensing of floating platforms
  - Effect of floating platform on turbine loads
- **Exploitation and lifetime**
  - Floater structural integrity, fatigue and lifetime
  - Dynamic power cable loads, integrity and lifecycle performance

To ensure consistency across the discussions, each table addressed the same three guiding questions:

- *What is most interesting for industry – from each BEL-FLOAT research topic?*
- *What are the barriers for industrial uptake?*
- *What should be the research priorities for future work?*

The discussions were moderated by members of the BEL-Float consortium, and the feedback from each table was documented and consolidated after the event. The outcomes of the round-table discussions were analysed and structured according to the six BEL-Float research topics (see section 3). For each topic, the stakeholder feedback was synthesised into three categories: industrial relevance, barriers for uptake, and future research priorities. The Innovation Agenda retains the six BEL-FLOAT research topics as its organising structure to preserve traceability with the project activities and stakeholder discussions. As several challenges in floating offshore wind are inherently cross-cutting, some overlap between topics is expected; the identified priorities should therefore not be interpreted as six independent future research workstreams. Where relevant, the identified priorities were linked to corresponding themes in the i3FLOAT Strategic Research and Innovation Agenda and supported with guiding notes from the discussions. A draft version of the resulting Innovation Agenda was subsequently shared with the workshop participants, allowing them to review the findings, provide additional comments and validate that the documented priorities accurately reflected the discussions held during the workshop.

3. BEL-Float Innovation Agenda

This section presents the BEL-Float Innovation Agenda resulting from the stakeholder consultations. The identified opportunities, barriers and research priorities are presented for each of the six BEL-Float research topics.

RESEARCH TOPIC #1	Operational performance, towing and mooring system assessment
What is most interesting for industry?	
• Improved assessment of operational platform and mooring system performance, including hybrid and synthetic mooring configurations that are increasingly considered by industry as alternatives to conventional chain-based systems. • Computationally efficient modelling of FOWT towing operations, including towing configurations, vessel–floater response and environmental operability limits. • Practical modelling tools that can support early-stage engineering studies, tendering activities and decision-making processes where large numbers of simulations are required. • Open-access datasets and validated modelling approaches that increase confidence in design tools and facilitate benchmarking between different modelling approaches.	
Barriers for uptake	
• Lack of publicly available validation data from laboratory and full-scale floating wind projects. • Limited towing datasets, especially for high-speed towing operations. • Remaining uncertainty regarding modelling approaches and design assumptions. • Difficulty reproducing realistic environmental conditions and mooring behaviour in experiments.	
Research priorities for future work	
• Further development and validation of reduced-order and computationally efficient modelling approaches for towing and operability assessments. • Improved modelling of low-frequency platform motions, second-order wave effects and their influence on mooring loads. • Development of operability and workability assessment methodologies to optimise installation windows and reduce offshore campaign costs. • Expanded experimental and full-scale validation datasets to improve confidence in coupled numerical models and support model benchmarking. • Continued research on hybrid and synthetic mooring systems, including their dynamic behaviour, stiffness characteristics and long-term performance. • Better integration between high-fidelity and low-fidelity modelling approaches to combine computational efficiency with sufficient engineering accuracy.	

Link(s) to i3float strategic agenda

1.1.2 "Coupled aero-hydro-servo modelling under representative metocean conditions" 1.2.4 "Multi-segment and multi-material designs for mooring lines" 6.1.3 "Floating transport and optimised towing strategies"	Participants repeatedly highlighted the importance of practical engineering tools that can support towing operations, installation planning and operability assessments. Industry representatives noted that project development often requires very large numbers of simulations, creating a strong need for reduced-order models that are sufficiently accurate while remaining computationally efficient. Considerable discussion focused on low-frequency platform motions, second-order wave effects and their influence on mooring loads. Participants also stressed the growing industrial relevance of hybrid and synthetic mooring systems and the need to better understand their behaviour. Across nearly all discussion points, validation emerged as a key theme, with participants emphasising the importance of experimental datasets, full-scale measurements and benchmarking activities to increase confidence in modelling approaches.

RESEARCH TOPIC #2	Extreme response, mooring integrity and survivability
What is most interesting for industry?	
• Improved understanding of mooring system behaviour under extreme environmental conditions and the mechanisms leading to excessive loads or failure. • Investigation of second-order wave loads, low-frequency platform responses and their contribution to extreme mooring tensions. • Experimental and numerical assessment of survivability, including nonlinear mooring behaviour, slack-snap events and tension spikes. • Better understanding of the behaviour of synthetic and hybrid mooring systems under extreme loading conditions. • Improved capability to predict failure risks and support safer and more cost-effective mooring system design.	
Barriers for uptake	
• Lack of full-scale measurements for extreme events. • Challenges in scaling mooring systems correctly in laboratory experiments. • Limited understanding of the behaviour of emerging synthetic and hybrid mooring concepts under extreme loading. • Uncertainty in prediction of nonlinear mooring responses. • Limited field data linking specific wave events to observed platform and mooring responses, partly due to the difficulty of accurately measuring local sea states during offshore operations.	
Research priorities for future work	
• Validation of mooring scaling approaches through dedicated physical model testing and improved numerical-experimental correlation. • Further investigation of second-order wave effects, low-frequency response and coupled loading mechanisms that drive extreme platform and mooring responses. • Improved understanding of nonlinear mooring behaviour, including slack-snap events, large-offset conditions and transient tension peaks. • Assessment of degradation, failure mechanisms and reliability of synthetic and hybrid mooring systems under extreme and cyclic loading. • Development of probabilistic and reliability-based approaches to quantify uncertainty in extreme response and failure assessments of mooring and anchoring systems. • Collection of additional field and experimental data to support model validation and improve confidence in survivability predictions.	

Link(s) to i3float strategic agenda

1.2.3 "Probabilistic fatigue and failure models for mooring and anchoring systems" 3.3.1 " Reduced-order and modelling tools for rapid and early FOW design and optimisation" 3.3.2 "Scaled testing campaigns and numerical-experimental correlation frameworks"	Participants emphasized the importance of understanding extreme mooring loads and the nonlinear phenomena that govern mooring behaviour under severe sea states. Particular attention was given to slack-snap events, tension spikes, large platform offsets and the influence of second-order wave loads. Several participants questioned how accurately current laboratory testing approaches represent full-scale behaviour and stressed the need for improved scaling methodologies and validation frameworks. The discussion also highlighted growing industrial interest in synthetic and hybrid mooring concepts, while recognising that their long-term reliability, fatigue behaviour and failure mechanisms remain insufficiently understood. Validation through both experimental testing and field measurements was consistently identified as a prerequisite for industrial uptake.

RESEARCH TOPIC #3	Low-frequency dynamics, monitoring & virtual sensing of floating platforms

What is most interesting for industry?

Advanced monitoring and virtual sensing integration.

- Further implement virtual sensing and advanced monitoring solutions to optimise operational performance while minimising O&M costs.
- Enhance mooring line monitoring and early damage detection.

Design optimisation and concept selection

- Learn from in-field data and continuously integrate in-field operational data into structural design validation and modelling assumptions.
- Leverage lessons learned from monopile standardization to improve scalability of floating wind solutions.

Cost reduction across the floating wind value chain

- Prioritize strategies that reduce and simplify floater design[1] and construction costs, without compromising structural integrity or performance. For instance, by improving accuracy of data-driven design optimisation, a reduction of conservatism might be achieved which will ultimately contribute to a reduction of floating wind costs.
- Use advanced monitoring and virtual sensing to strengthen bankability and increase investor and governmental confidence in floating wind technologies, by demonstrating long-term reliability and reduced uncertainty.

[1]Recognize that mooring systems materials are not the primary driver of the elevated floating wind costs.

Barriers for uptake

- Insufficient validation of monitoring and virtual sensing methods using full-scale operational data.
- Limited availability of combined laboratory and field datasets for benchmarking and model validation.
- Detailed cable and floating concept models to improve accuracy.
- Need for reliable and robust sensor technologies for measuring mooring-line tension and generating high-fidelity data for model validation..
- Lack of integration and collaboration across disciplines, including limited knowledge sharing between turbine and floater designers and limited access to controller strategies.
- Understanding the dominant design drivers and failure modes – Ultimate Limit State (ULS) vs Fatigue Limit State (FLS) – of mooring lines.
- Need for experimental prototype/research pilot for research validation.

Research priorities for future work

- Conduct laboratory testing in ocean basins or pilot project in pre-commercial stage to validate monitoring and virtual sensing approaches and benchmark model predictions against existing design codes.
- Enable research on realistic integrated systems with sufficient access to design data and controller insights.
- Increase TRL through operational validation of monitoring and virtual sensing solutions.
- Improve fatigue models for mooring lines, supported where possible by monitoring and virtual sensing data.
- Develop innovative virtual sensing monitoring strategies.

Link(s) to i3float strategic agenda

1.1.8 "Component reliability, structural health monitoring and digital twins for floating substructures" 1.1.9 "Biofouling-aware design of floating substructures" 7.1.1 "Advanced structural & condition monitoring of critical components using physical sensing" 7.1.7 "Virtual sensing"	The Floating Offshore Wind (FOW) Strategic Innovation agenda characterizes the development and integration of reliability and structural health monitoring (SHM) solutions for floating substructures, as one of the innovation drivers to increase floater availability and lifetime. BEL-Float enabled the development of an SHM system that captures the dynamics of FOWT using vibration-based monitoring and virtual sensing techniques. It also investigates how SHM indicators can translate into practical O&M decisions. Ultimately, contributing, e.g. to the strategic result of reducing inspection cost and downtime via risk-based inspection planning and digital evidence for decision-making.

RESEARCH TOPIC #4	Effect of floating platform on turbine loads

What is most interesting for industry?

<u>Advanced monitoring and virtual sensing integration.</u>

- Further develop advanced monitoring solutions to optimise operational performance and reduce turbine and mooring loads associated with metocean conditions.
- Enhance mooring line monitoring and early damage detection.

<u>Design optimisation and concept selection</u>

- Learn from in-field data and continuously use in-field operational data to update and benchmark field and design loads.
- Use in-field data to update and improve metocean condition assessments.

<u>Cost reduction across the floating wind value chain</u>

- Prioritize strategies that reduce and simplify floater design and construction costs, by having a better understanding the long-term characteristic of the metocean conditions and their impact on the design.
- Use advanced monitoring to strengthen bankability and increase investor and governmental confidence in floating wind technologies, by demonstrating long-term reliability and reduced uncertainty.

Barriers for uptake

- Insufficient modelling validation through in-field operational data.
- Limited availability of combined field and laboratory-scale datasets for model validation.
- Detailed cable, turbine and floating concept models to improve accuracy.
- Need for reliable and robust sensor technologies for measuring mooring-line tension and generating high-fidelity data for model validation.
- Lack of integration and collaboration across disciplines, including limited knowledge sharing between turbine and floater designers and limited access to controller strategies. Understanding the dominant design drivers and failure modes – Ultimate Limit State (ULS) vs Fatigue Limit State (FLS) – of mooring lines.
- Need for experimental prototype/research pilot for research validation.

Research priorities for future work

- Improve understanding of the interaction between turbine operation, platform dynamics and mooring loads.
- Develop innovative monitoring strategies that combine metocean conditions, turbine performance and structural load information.
- Conduct laboratory or pilot-scale validation to benchmark integrated turbine–floater load models and design assumptions.
- Enable research on realistic integrated systems with sufficient access to design data and turbine controller insights.
- Increase TRL through operational validation of integrated load and performance assessment methodologies.
- Improve understanding of wind farm interactions and advanced turbine and farm-level control strategies, including trade-offs between power production and structural loads.

Link(s) to i3float strategic agenda

3.1.6 "Adaptation of wind turbine design and control to floating platform dynamics" ***7.1.1 "Advanced structural and condition monitoring of critical equipment and components using physical sensing and model-based approaches"***	The FOW Strategic agenda characterizes the adaptation of turbine design and control strategies to platform-induced motions and dynamics (3.1.6), as one of the innovation drivers to ensure stable and efficient operation of wind turbines installed on floating platforms. Moreover, another key technological objective (7.1.1) is to enable more accurate condition assessment and improved O&M planning by integrating advanced sensing technologies, metocean data and model-based monitoring approaches into floating wind farm operations.
3.1.3 "Standarised interfaces between wind turbine and floater"	BEL-Float targets the characterization of the long-term metocean conditions at the envisaged site by satellite reanalysis data and extracts the corresponding design load cases as well as their probabilities. This is part of an integrated approach that applies these conditions to turbine aero-elastic hydro-dynamic models to assess the impacts on turbine and mooring line loads and damages over the lifetime of the machine. This framework allows to assess impacts of updates in the design of turbine, mooring line and controller. During O&M a corresponding monitoring strategy is determined to compare true loads to design to update impact on turbine usage as well as create update metocean conditions.

RESEARCH TOPIC #5	Floater structural integrity, fatigue and lifetime

What is most interesting for industry?

- Concrete floaters are of high interest for industry. Current literature and research largely focus on steel floaters, while there is very limited publicly available information on concrete designs. Yet concrete floaters may become particularly relevant for Europe due to limitations in the European steel supply chain and the desire for European manufacturing.
- For concrete floaters: while the fundamental principles remain similar to steel floaters, the parameters differ due to the larger mass and different fatigue behaviour of concrete structures. The methods and concepts developed for steel floaters, including shell-element modelling approaches, remain therefore highly relevant.
- The tower–floater interface is a critical connection, yet towers and floaters are commonly designed independently. Detailed analysis and potential co-design of this interface are therefore important.
- There is a need for generic open-access reference designs for concrete floaters that can be used by researchers and industry. Existing data (e.g. specific demonstrator concepts) are often locked behind IP restrictions.
- Load-mapping methods are currently an active area of research, as also reflected in IEA Task 56.. It would be interesting to have an open-source software package of the BEL-Float load mapping method. If a company needs to analyse a new design, this software could be used. The method is computationally expensive, but this will be improved timewise.

Barriers for uptake

- Computational feasibility vs. model fidelity: High-fidelity models are needed to accurately capture floater behaviour and fatigue loading, but they are computationally expensive and require specialist expertise, limiting their industrial applicability. Companies do not have such specialists to work on these models, but rather outsource to dedicated engineering companies or are suggesting internships/secondments/…
- Research often relies on reference models of floaters, while the specific floater configurations likely to be deployed industrially are not yet fully reflected in publicly available R&D models. This creates uncertainty when translating research findings to future commercial projects, particularly for concrete floaters, designs suitable for intermediate water depths (80–100 m), and realistic station keeping systems with redundancy requirements.
- Unclear view on O&M activities: If you must tow the floater back to port for O&M, it ruins the business case (too time-consuming, costly). Testing of installation logistics could be done at the Coastal and Ocean Basin in Ostend but hasn't been initiated yet.
- From the Belgian government perspective, floating offshore wind is not considered a feasible option in Belgian waters due to the limited water depth. As a result, attention is directed more towards other floating technologies, such as floating solar, where relevant.

Research priorities for future work

- Extend R&D to more (concrete) floater types, including the development of generic reference designs that can serve as common research platforms across academia and industry.
- Encourage research into concrete floater behavior, including fatigue, loading and mooring systems, to address current knowledge gaps and support a European floating wind supply chain.

- Improve transferability of research results across different floater concepts to avoid concept-specific studies only. Focus on open-source data and models. This helps innovation in general, and can allow us to build different models, to build layers on layers. Do more effort to distribute results, data and models (also to companies). This will facilitate more work on those inputs.
- Integrate O&M considerations into floater design, concept selection and installation planning to reduce lifecycle costs and operational risks.
- Improve integration of floater design with turbine OEM requirements, turbine dynamics and structural interface considerations.
- Advance virtual sensing techniques for monitoring the condition and loads of redundant mooring lines (cfr research topic 3).

Link(s) to i3float strategic agenda

3.1.1. "Adaptive stiffness / Load-tuned structural designs and segmented concepts for floating applications in all phases of the lifecycle" 1.1.8 "Component reliability, SHM and digital twins for floating substructures" 3.1.3 "Standardised interfaces between wind turbine and floater" 3.1.4 "Materials and coatings for wind turbine and tower in floating environments" 3.3.1 "Reduced-order modelling tools for rapid and early FOW design and optimisation"	It was discussed that available literature focuses primarily on steel floaters, with limited information on concrete alternatives. Key differences were highlighted: fatigue behaviour in concrete floaters is significantly different, and their greater mass affects loading and mooring dynamics. Because findings are often strongly tied to the specific floater geometry considered, it was underlined that an open-access concrete reference floater design would be of great value to the research community, as it would provide a common benchmark for comparison. The participants also discussed the relevance of structural stiffness and the connection to the tower. The underlying principles for different floater geometries/material selections remain the same and are very valuable, yet this still requires a lot of R&D.

RESEARCH TOPIC #6	Dynamic power cable loads, integrity and lifecycle performance

What is most interesting for industry?

- Realistic modelling of cable flexibility remains a key challenge and is highly relevant for industry.
- Experimental validation is important, but scaling cable experiments remains difficult, particularly when reproducing realistic electrical and mechanical conditions simultaneously.
- Realistic cable deflections as input for experiments: Experimental setups should accurately reproduce realistic cable motions and deflections to ensure representative loading conditions and reliable validation results.
- Influence of cable protection systems on bending moments: Cable protection systems can significantly affect local bending behaviour and stresses in dynamic cables, making their impact important to assess during design.

Barriers for uptake

- Computational feasibility vs. model fidelity (also see topic 5)
- Larger companies are not yet investing heavily in research because the perceived impact is too limited: Limited clarity on the transferability of cable monitoring and assessment methods across different projects and cable configurations reduces industrial uptake.
- Demonstrator projects are essential for generating real cable behaviour data, but high costs and limited sharing of results (especially failures), due to IP and liability concerns, create a persistent data gap. Greater sharing of relevant operational and failure data across the sector should therefore be encouraged.

Research priorities for future work

- Include extreme excursions and temporary installation, commissioning and maintenance load cases in dynamic cable design, and investigate methods to manage or reduce these loads through cable, station or system design.
- Improve modelling and assessment of temporary cable loads during installation, commissioning and maintenance, including cable dynamics and mechanical load limits under restricted environmental conditions.
- Strengthen collaboration with cable manufacturers to improve access to representative cable and material data and promote a system-level approach to dynamic cable design.
- Focus on open-source algorithms and numerical models (see topic 5)
- Facilitate access to representative dataset of materials and decommissioned cable components for research and testing. Physical specimens with known mechanical properties would reduce modelling uncertainties and enhance the predictive capacity of numerical models.
- Promote collaboration with asset owners and developers to make decommissioned cable sections available for research purposes.

Link(s) to i3float strategic agenda

1.3.3. "Integrated dynamic cable curvature and shape control systems" ***7.1.5. "Improvement of dynamic cable design and technical definition processes"*** 1.3.1 "Qualification and standardisation of dynamic cables." 6.1.4 "Industrialised methodologies for handling and loading dynamic power cables and accessories"	Several participants underlined the importance of researching representative load cases and test conditions for dynamic cables. It was specifically mentioned that extreme excursions should be researched, e.g. via modelling or combined with testing of scaled models in laboratory or basin environments. Participants also emphasised the importance of closer interaction with cable manufacturers, particularly to improve access to material data needed to understand cable behaviour and lifetime. They also highlighted the need to move towards a system-level design approach that considers the complete dynamic cable solution.

4. Conclusion and future collaboration pathways

The BEL-Float Innovation Agenda consolidates the insights gathered from the BEL-Float research activities and stakeholder consultations into a set of concrete research and innovation priorities for floating offshore wind. The resulting Innovation Agenda combines insights from the BEL-Float research activities with feedback gathered from the stakeholders who participated in the BEL-Float Mini-Symposium and round-table discussions. As such, it provides a snapshot of the challenges, opportunities and research needs identified by the participating organisations and researchers, offering valuable input for the future development of floating offshore wind expertise and innovation activities in Belgium.

Across the six research topics, a clear and recurring message emerges: further industrial uptake will depend not only on advancing individual technologies, but also on closing the gap between research-scale knowledge, validated models and operational evidence.

The barriers identified point to several common challenges. A first and central barrier is the **limited availability of representative field data, full-scale measurements and shared validation datasets**. This affects confidence in models for towing operations, survivability under extreme sea states, platform dynamics, turbine loads, floater fatigue and dynamic cable integrity. In several areas, the lack of operational data is reinforced by the difficulty of accurately measuring local sea states, reproducing realistic environmental conditions in experiments, and scaling laboratory results to full-scale floating wind systems. As a result, model validation remains challenging, and uncertainty in design assumptions can hinder industrial confidence.

A second recurring barrier is the **balance between model fidelity and practical applicability**. High-fidelity numerical models are essential to capture complex coupled behaviour, nonlinear mooring responses, fatigue loading and dynamic cable stresses, but they are often computationally demanding and require specialist expertise. At the same time, industry needs robust, efficient and transferable tools that can support early-stage design, tendering, operability assessments, O&M planning and investment decisions. This creates a clear need for modelling approaches that combine sufficient engineering accuracy with computational efficiency and practical usability.

A third cross-cutting challenge is the l**imited availability of open, transferable and integrated knowledge**. Several topics highlighted the need for open-access reference designs, benchmark datasets, transferable modelling frameworks and improved data sharing between academia and industry. This is particularly relevant for emerging concepts such as synthetic and hybrid mooring systems, concrete floaters, integrated turbine-floater design and dynamic cable systems. Intellectual property restrictions, limited sharing of demonstrator results and insufficient interaction between disciplines can slow down innovation and make it harder to build on existing research outcomes.

These barriers also define the most relevant pathways for future work. Priority should be given to the **generation and sharing of experimental, pilot-scale and full-scale datasets that can support model validation and benchmarking**. Dedicated testing campaigns, pre-commercial demonstrators, access to decommissioned components and long-term monitoring of operational systems would provide essential evidence to reduce uncertainty and increase confidence in design tools. In parallel, **further work is needed on reduced-order and computationally efficient models**, numerical-experimental correlation frameworks, open-source modelling approaches and virtual sensing strategies **that can translate complex research outcomes into tools with direct industrial relevance**.

□ Future research should also **strengthen the integration** between floating substructure design, mooring systems, turbine dynamics, dynamic cables, monitoring strategies and O&M considerations. Floating offshore wind systems are highly coupled, and design choices made in one part of the system can strongly affect loads, fatigue, installation, maintenance and lifetime performance elsewhere. Collaboration between floater designers, turbine OEMs, cable and mooring suppliers, asset owners, engineering companies, research institutions and public actors will therefore be essential to develop more reliable, cost-effective and bankable floating wind solutions.

For the Belgian offshore wind ecosystem, the priorities identified in this Innovation Agenda offer clear opportunities for future collaboration. While floating offshore wind deployment may primarily take place in deeper-water markets outside Belgium, Belgian actors can contribute through their strong offshore expertise, engineering capabilities, testing infrastructure, a capable fleet of offshore installation vessels, monitoring technologies and international industrial networks. By focusing future initiatives on validation, data sharing, transferable modelling, integrated design and demonstrator-based learning, Belgium can strengthen its role as a relevant knowledge and innovation partner in the emerging floating offshore wind value chain. Knowledge exchange with complementary European and international initiatives can further support this ambition, particularly in areas such as integrated floating wind design, technology qualification, open reference models and datasets, mooring systems, dynamic cables, installation and O&M. Relevant opportunities may include initiatives such as AMS-FLOW and IEA Wind Task 49.

The six BEL-FLOAT research topics should not necessarily be interpreted as separate future workstreams. Several of the identified challenges are cross-cutting and may be addressed most effectively through broader collaborative themes. When translating the identified research priorities into future activities, their expected industrial impact — particularly in terms of cost reduction, risk reduction, bankability and scalability — as well as their complementarity with existing European and international initiatives should be considered.

As such, the BEL-Float Innovation Agenda should be seen as a starting point for continued dialogue and targeted collaboration. The research priorities identified here provide concrete entry points for follow-up projects, joint industry-academia initiatives and international partnerships aimed at reducing uncertainty, improving design confidence and accelerating the responsible industrial uptake of floating offshore wind technologies.