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Roadmap Report

KETmaritime |Setting course to energise maritime uptake of Key Enabling Technologies

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Abbreviations and Glossary

KET	Key Enabled Technologies
EU	European Union
ICT	Information and Communications Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
MaREI	Marine and Renewable Energy Ireland
RRI	Responsible Research and Innovation
SME	Small and Medium-sized Enterprises
UN	United Nations

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Finally, we would like to acknowledge the inputs of Karen O’ Callaghan in the communications team in the SFI MaREI centre for Marine, Climate and Energy communications team, for her advice and guidance, and design efforts on the policy briefs.

Executive Summary

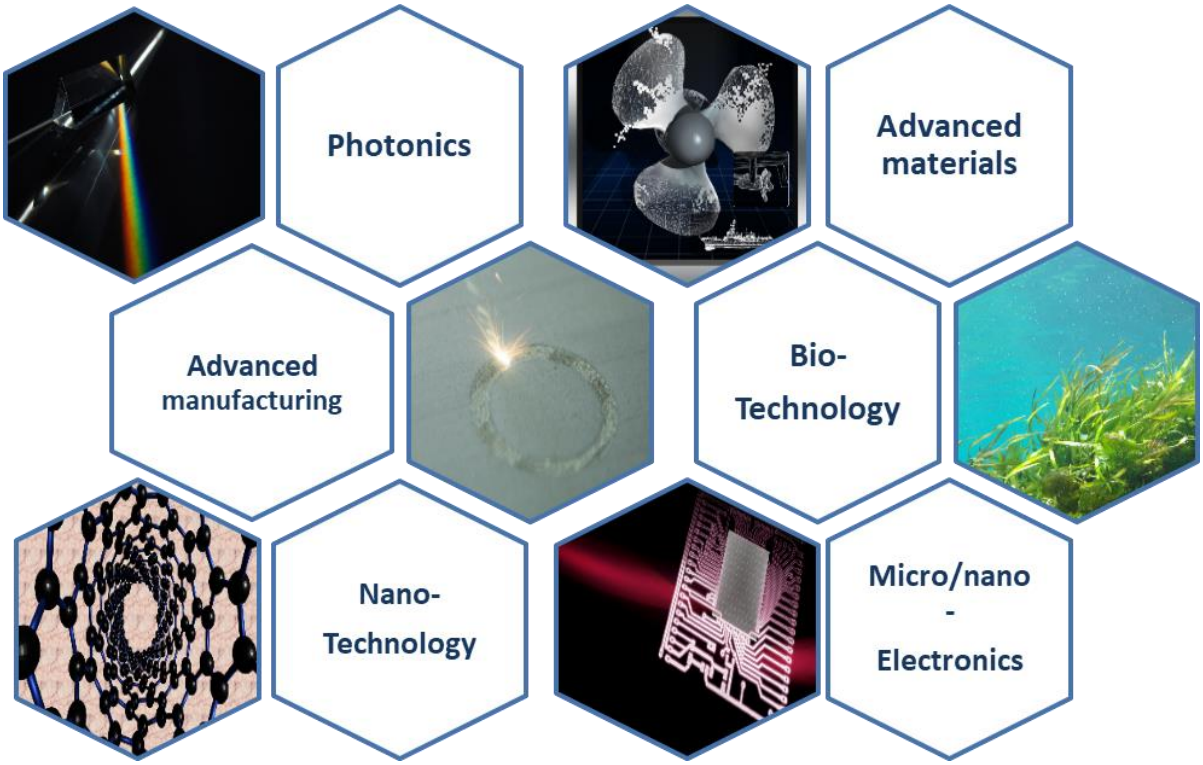


Figure 1: The six Key Enabling Technology areas which offer opportunities to maritime business and societies.

Key Enabled Technologies(KETs) have the potential to impact on many aspects of society, whilst transforming European industrial competitiveness at the local, national, and global scales. Studies funded by the European Commission have shown that European advances in six technology areas (figure 1) would not only enhance the leadership and competitiveness of European business, but also drive advances across Europe's business sectors and society.

Despite their applicability across sectors, KETs represent a change, and a new manner of moving forward. Business and society view change both positively, welcoming advances in technology and new tools and products to make life somewhat easier for citizens, and negatively, recognising that with change comes risk and a reticence to change. Like society, different industrial sectors will view innovation and new technology differently. As such, each sector requires a slightly different approach to energise KET uptake into their daily operations and lives.

Recognition of this reality underpinned the development of this roadmap. Stakeholders have been engaged across the Atlantic Area, through the use of online surveying, face-to-face workshops, and one-to-one interviews conducted virtually. This has enabled the authors to develop an awareness of the maritime scene and community which offers such opportunities and potential for KETs. It also provided insights into the reality of energising this uptake when framed in the context of social, financial and governance realities.

Over the course of the project, the team conducted an analysis of the maritime sector, to identify and map out any KET applications that were in development. In parallel, a diverse pool of academic and commercial stakeholders identified the opportunities they could see for KET applications in the maritime sector. They also identified factors which restrict uptake, and restrain viable trans-disciplinary innovations from effectively making it to market. Stakeholder perspectives were combined with the investigative findings to develop a vision for a KET-maritime innovation ecosystem. The barriers and challenges shaped a range of proposed actions, which target different facets of the innovation ecosystem to ease growth and shape development. These actors were iteratively reviewed by stakeholders, and amended accordingly.

These actions form the basis of this roadmap, a proposed path towards realising a vibrant growing KET-maritime innovation ecosystem. It contains a suite of 60 inter-linked, systemic actions, framed within 35 action areas to achieve 9 core goals, spread across 5 thematic agendas (policy, funding, building a sustainable innovation ecosystem, capacity building, and awareness raising). This envisioned KET-maritime innovation ecosystem fosters application-led innovation, and advances societal and market benefits for all. Each of the 5 thematic agendas are summarised as a policy brief, provided in the Appendices. The actions applicable to each policy brief are detailed in this report, alongside a proposed timeframe for implementation. Each action is codified, and can be traced through the iterative review process using the provenance table supplied.

The potential for KET applications across the Blue Economy is extensive, and all sectors offer at least some opportunities for KETs. Within this landscape, the following sectors are identified as having strong growth potential where KET's can help to drive that growth:

- Fisheries and aquaculture,
- Blue biotechnology,
- Maritime surveillance,
- Marine renewable energy,
- Ship and boat building.

Within these sectors, four specific KET-maritime applications research priorities are highlighted:

- Advanced materials application in marine renewable energy,
- Photonics application in maritime surveillance,
- Micro- and nano-electronics in maritime surveillance,
- Advanced manufacturing techniques in ship and boat building.

Finally, the project team would like to take this opportunity to thank all stakeholders who participated in the workshops, interviews, and review activities which culminated in this roadmap.

Developing the roadmap

The actions suggested in this roadmap are based on qualitative data – surveys, workshop data, and review by stakeholders – and desk-based literature review. The KETmaritime research team do not aim to make generalisations from our sample to the wider population, but used literature to supplement our findings, and to verify the findings are more than anecdotal. A dedicated validation exercise was also implemented on the draft recommendations to further verify that the findings were meaningful.

Consulted stakeholders

Consultee confidentiality was a core principal of the KETmaritime approach, and was deemed crucial to maximising the participation of consultees. The majority of consultees agreed to be acknowledged in the reports generated from their pool of interview data. However, the data, recommendations made in each report, and actions are not linked to the consultees themselves.

The consultees who shaped and drove the recommendations reported here, were a heterogeneous group, consisting of top levels in the consulted enterprises, alongside representatives drawn from research institutes, government agencies, and relevant actors from the business support system. SMEs and larger companies were represented, as well as established companies and new start-up companies. They were supplemented by insights from academia, particularly those with expertise in entrepreneurship and innovation management. The selection of consultees was based on their relevance for the study, and they were identified on the basis of knowledge and network. A combination of the KETmaritime consortium's network and knowledge was used, along with the consultees' knowledge and network. This sampling method has some similarities with respondent driven sampling; one of the disadvantages of this form of approach to sampling is the risk of strong bias and lack of control of the sample.

Addressing bias

Bias is a challenge the consultation team encountered. Strong participation from some regional groups (e.g. those from Ireland) and absence of others raised the risk of bias in workshop and survey data. Furthermore, the expertise areas being sampled also featured a bias, whereby confusion surrounding the nature and timing of BREXIT, rendered it impossible to schedule consultation meetings with a number of government agencies involved in business and technology transfer support. By using supplementary data from the literature, the authors have explored possible bias, and found that the consultee data supplements the findings. The consultee data does show that literature-derived findings are more than anecdotal. Furthermore, efforts implemented to address the regional bias (during the Validation Exercise portion of the Roadmapping process) are deemed to have successfully ensured this roadmap represents Atlantic Area stakeholder perspectives on barriers and opportunities for KET maritime innovation.

Analysis and drafting recommendations

To maximise harmonisation across different national pools of interviewees, guidance on the nature of questions to be asked was developed from data gathered by survey and at the Cork workshop. Key questions to be asked were highlighted and distributed to the KETmaritime team members hosting a contributory workshop. This semi-structured approach to workshop discussions ensured that critical information points were broached during the conversation. Meanwhile, it maximised opportunities for following up relevant and useful topics that arose, allowing for questions which were not of relevance for the consultee to be omitted. Analysis of recommendations arising from the survey and workshop data formed the basis of the validation exercise methodology, which served to verify the findings were more than anecdotal, and reduce known geographic biases in the data.

The overall process to derive actions is shown in Figure 2. Guidance to access the full details of the analysis are in Annex B (upon request). Consultees were first surveyed online, with the results reported in the KETmaritime Survey Report[1]. Folowing this, workshops gathered further data. The survey and workshop data were analysed alongside existing literature to extract identifiable opportunities and barriers to KET-martime innovation.

Stakeholder Review

The draft actions (Version 1.0) were first reviewed by the KETmaritime partners, amended accordingly, and then grouped under common thematic areas (in this case "*Policy*", "*Funding*", "*Awareness Building and an Enabled Innovation Community*", and "*Maintaining Focus on Impactful Markets*"). Following this, a validation exercise was conducted whereby the partner-reviewed (Version 2.0) actions were passed by key stakeholders who either (i) accepted each action in full, (ii) had the action amended in response to their feedback, or (iii) rejected an action. Furthermore, this feedback obtained from the Validation Exercise (iv) initiated new actions, to address gaps identified by the stakeholders. The full description of the validation exercise can be seen in the KETmaritime Validation Report[2], and in the provenance matrix accompanying this report. No Irish stakeholders were involved in the Validation Exercise, to reduce the initial geographical bias in the data arising from the Cork Workshop, and literature review and recommendation drafting by the MaREI Centre - University College Cork (based in Ireland).

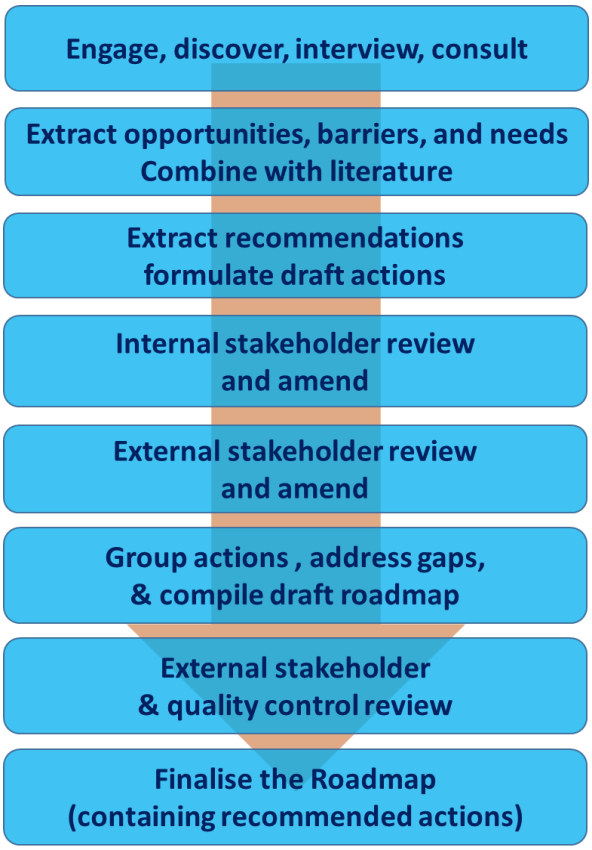


Figure 2: The KETmaritime roadmap development process.

The validated actions (Version 3.0) were then re-grouped and used to define the focus of the policy briefs associated with this roadmap. Each policy brief contains a set of action headlines, which are linked to a set of target actions. The draft document was then presented at the Business2Sea conference[3] (November 17th, 2020). It was then circulated to all consulted stakeholders, and interested parties attending the Business2Sea event who were offered the opportunity to provide final perspectives within a 1-week timeframe. This one week opportunity was granted to all parties to provide feedback. In total, three stakeholders returned feedback at this stage, suggesting grammatical corrections, and expressing agreement with the document. The amendment process, feedback comments and decisions are contained in the provenance matrix accompanying this report. Feedback has been rigorously censored to protect consultee confidentiality.

[1] See the results of the online surveying as reported in: Tuohy, E., Scarrott, R.G., O' Mahony, C., Vila, A. (2019) *Stakeholder Survey Results*. Deliverable report under the INTERREG Atlantic Area KETmaritime project (E.U. Grant no. EAPA_595/2016).

[2] The full description of the exercise approach, results, and analysis are available in: Scarrott, R.G., O' Mahony, C. (2020) *Validation Exercise Report: Parts 1 and 2*. Deliverable report under the INTERREG Atlantic Area KETmaritime project (E.U. Grant no. EAPA_595/2016).

[3] ketmaritime.eu/2020/11/02/ketmaritime-final-event-at-business2sea-digital/ (last accessed 15th December, 2020)

The KET-maritime Vision

This roadmap represents a path forward, informed by and co-developed with stakeholders interested in seeing KETs realise their maritime potential. The roadmap envisions *an innovation ecosystem[4], with knowledge synergies bringing forth ideas, capturing them, testing their viability and commercially realising their potential for the Maritime and Key Enabling Technology communities.*

The roadmap presents concrete, achievable actions, which can realise a KET-maritime innovation ecosystem. It addresses the challenge to envision beyond the current state of the maritime and KET sectors, and chart a course towards opportunities identified by both communities. It addresses the barriers identified by these communities, as they seek to engage and innovate together.

The recommended actions are supported by findings evident in existing scientific literature. Policy briefs summarise the primary focus areas needed to build and animate the KET-maritime innovation ecosystem, with more detailed actions specifying how short to long term efforts can achieve these area goals.

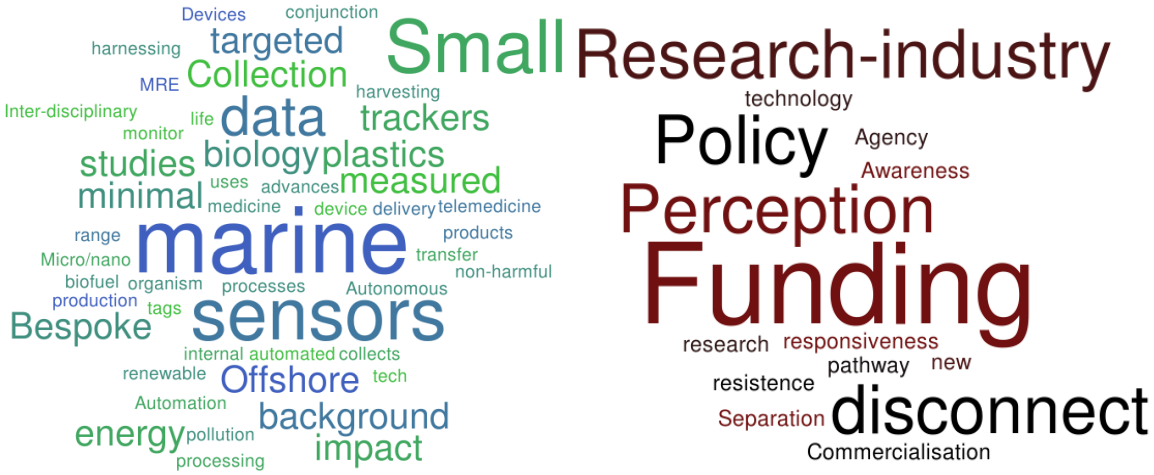


Figure 3: A sample of opportunities (left) and barriers (right) facing maritime and KET innovators, as identified by workshop participants in Cork (26th September 2019).

As such, this document represents a call for assistance by the consulted maritime and KET research and business communities, to enable them to realise KET potential in the maritime sector. With appropriate financial, and knowledge supports, ideas can be carried forward, tested, and in some cases realise their commercial potential. This roadmap seeks to inform, and facilitate this process.

[4] As defined in Granstrand, O., Holgersson, M. (2020) Innovation ecosystems: A conceptual review and a new definition. Technovation, 90-91,102098. DOI: 10.1016/j.technovation.2019.102098.

Actions to foster KET-maritime innovation and uptake

This roadmap presents a range of targeted actions linked to the innovation, economic, and societal potential of KETs in the maritime sector. These accomplish nine goals, encompassing 35 complimentary action areas (Table 1), each containing a range of specific actions. Specific actions are detailed in the following section, and are associated timeframes (short, medium, long) and/or a time span (e.g. short – long). Each action is also associated with a unique identifier (action code), linking it to the range of applicable action areas, and to the provenance matrix associated with this report. Actions target unlocking potential across the innovation ecosystem, and are systemic (Figure 4).

Table 1: System focus, goals, and action areas to foster an animated KET-maritime innovation ecosystem.

	Goals	Action Areas
Shaping Policy	**Adapting Policy Frameworks to foster a technology-uptake environment**	➢ Ground supports in policy ➢ Map existing supports and contributory sectors ➢ Equip and resource public-sector supports ➢ Ensure policy is responsive to an expanding and rapidly innovating sector
Funding	**Fueling Innovation**	➢ Clarify what is available to support development ➢ Synergise with the digital economy ➢ Fund supports to facilitate innovators ➢ Shape funding initiatives to animate the KET-maritime ecosystem
	Ensuring Value for Money	➢ Monitor an advancing maritime landscape ➢ Synergise with education ➢ Ensure supports to adapt to advances ➢ Monitor strategic demonstrations
Building an innovation ecosystem	**Fostering Trust**	➢ Demonstrate KET-maritime successes ➢ Ensure info on KETs is readily available ➢ Develop and support networks of trust ➢ Ensure innovators and supporters are rewarded fairly
	Building an Innovation Ecosystem	➢ Build a community of practice ➢ Facilitate ideas and testing ➢ Match SMEs with partners and collaborators ➢ Promote knowledge transfer
	Ensuring Strategic Innovation	➢ Target short-term priority demonstrators ➢ Identify niches ➢ Embrace Responsible Research and Innovation
Capacity building	**Enhancing capacity for knowledge synergies**	➢ Provide knowledge supports for innovation ➢ Leverage Europe's education systems ➢ Provide staff training for innovation
Awareness raising	**Raising KET and maritime innovation awareness**	➢ Conduct strategic outreach and animation ➢ Ensure factual evidence-based awareness raising
	Demonstrating KET-maritime potential	➢ Facilitate rapid testing for accelerated innovation ➢ Promote long-term innovation ➢ Demonstrate KETs meeting maritime needs ➢ Target key demonstrations

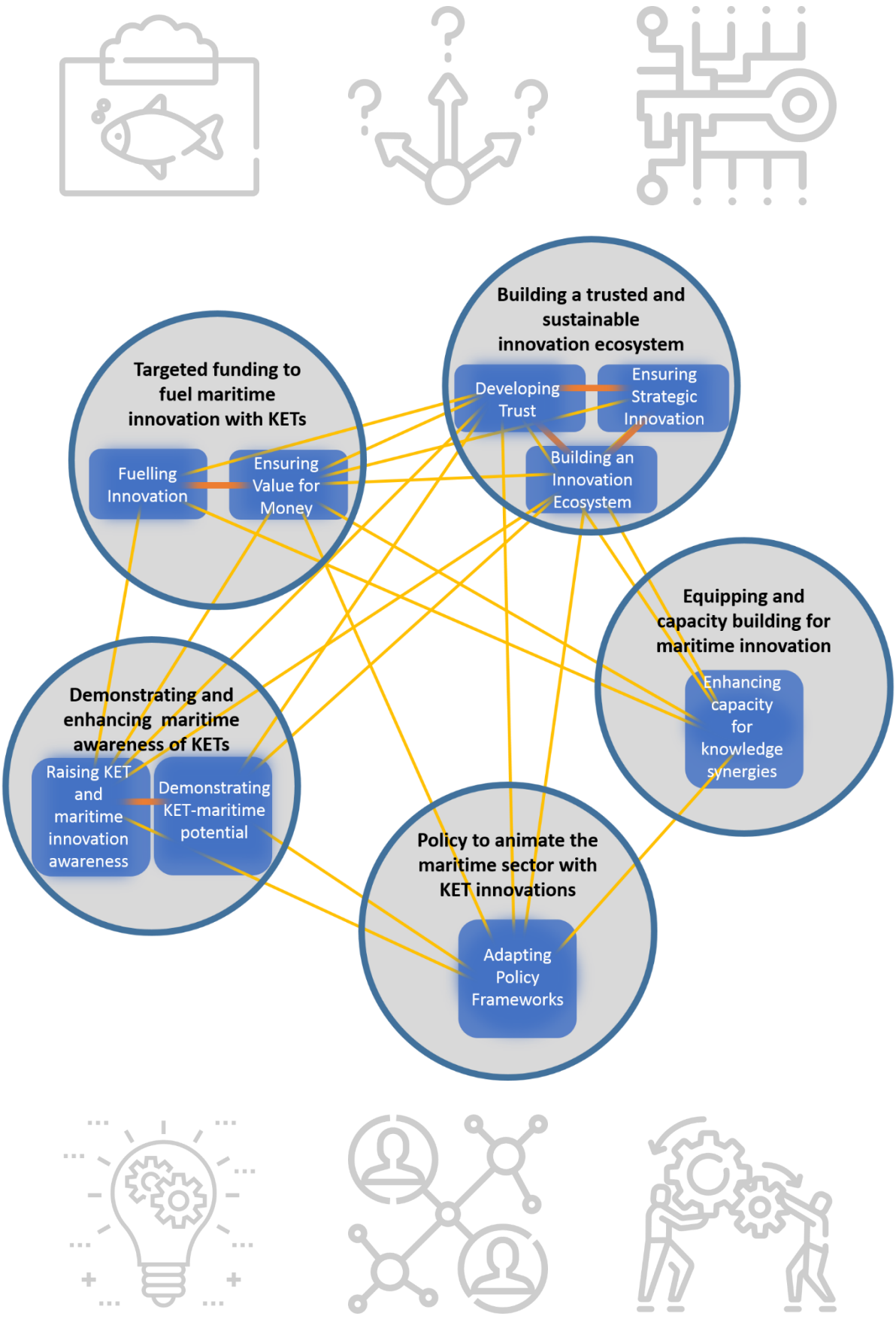


Figure 4: The five systemic focus areas of the KETmaritime roadmap, showing the primary goals, and their interconnected systemic nature.

Policy to animate the maritime sector with KET innovations

A coherent, and supportive policy framework can provide a clear set of principles within which legislation, funding, and activities to support KET uptake into the maritime sector can be accelerated. The implementation of policy principles is often achieved using the targeted application of funding. With this in mind, recommended actions here address the policy-level interventions needed to allow funding applications to be implemented, and take effect. These should be conducted in close coordination with actions outlined in other sections of this roadmap, in particular those in "*Building an Innovation Ecosystem*", as evidenced by the high number of cross-applicable actions. Given the potentially rapid pace of change in priorities, only short and medium term actions are proposed. Development of these actions should continue into the long term to enable refinements in fostering activity.

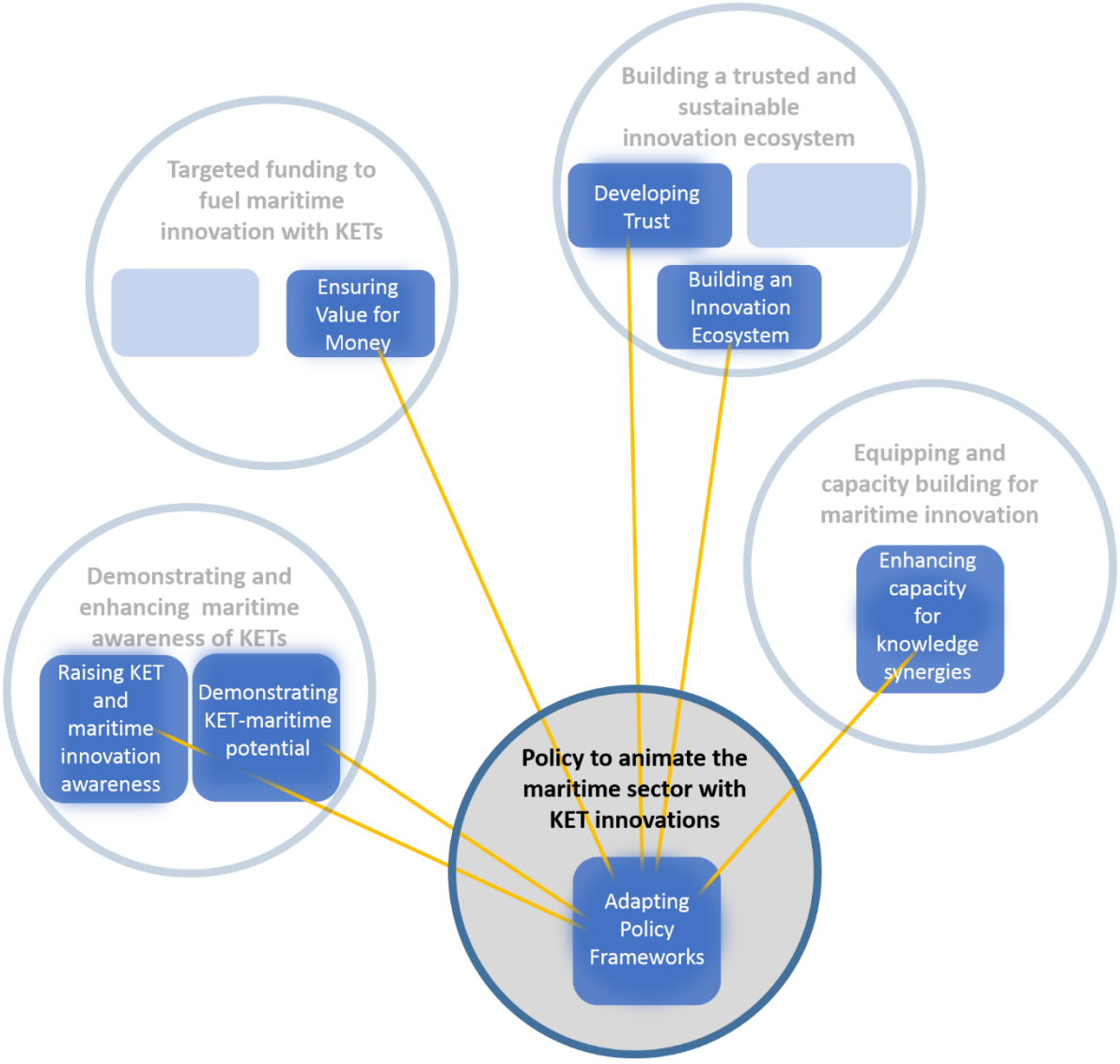


Figure 5: Connections between taking action on regional, national and international policy, and goals across the other 4 roadmap foci.

Adapting Policy Frameworks to foster a technology-uptake environment

The policy environment will determine the boundaries of the KET-maritime innovation ecosystem. It will restrain the extent to which KETs penetrate into the maritime sector, primarily by providing clarity of what is allowed, and certainty for investors.

Grounding supports in policy

Supports for knowledge transfer, capturing innovations and enabling them to be carried to market, can take the form of funding, training, and even the form of guidance. Grounding these supports in policy provides a measure of certainty to innovators and business, reassuring them that this is a regionally-promoted direction to go in, and worthy of longer term investment of time and resources.

Table 2: Policy-targeted actions to provide direction and surety to KET-maritime innovators and developers

Action Code	Action	Timeframe
KETM001	Ensure funding calls targeting KET-maritime animation, specifically link companies with the support of public bodies.	Short
KETM031	Support the implementation of demonstration KET-maritime activities in the following subsectors: Fisheries and Aquaculture; Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Short
KETM032	Promote linking companies to the R&D supports available to public bodies.	Short
KETM033	Ensure efficient and effective supports are available for Innovators, scientists and technology developers to trial KET technology transfers.	Short

Table 3: Complementarities between actions to embed supports in policy, with other action areas.

Action Area		KETM001	KETM031	KETM032	KETM033
Adapting policy frameworks	Grounding supports in policy	✓	✓	✓	✓
	Mapping existing supports and contributory sectors				
	Equipping and resourcing public-sector supports				
	Ensuring responsive policy				
Ensuring value for money: Strategic Monitored Demonstrations			✓		
Building an innovation ecosystem: Promoting knowledge transfer				✓	
Demonstrating KET-maritime potential: Rapid testing for accelerated innovation					✓

Mapping existing supports and contributory sectors

There are a multitude of existing policy, funding and capacity building supports available to innovators and businesses across the Atlantic Area. The KET-maritime innovation area provides a new focus for them to target, with minor amendments to tailor their focus. As such, it is critical that the role of the Atlantic Area's existing economic sectors, in particular the ICT sector, is fully realised to drive innovation in this new area. The full extent of existing supports must also be mapped out, to ensure a systemic approach is taken which is cost effective, efficient, and works with existing frameworks.

Table 4: Actions to identify existing support frameworks and activities, and recognise the role of ICT.

Action Code	Action	Timeframe
KETM034	Recognise the importance of the ICT sector to KET uptake by the maritime sector in marine policy documents and revisions, emphasizing the Value Chain Approach.	Short
KETM035	Map, build upon, amend and supplement existing frameworks and structures which foster trans-disciplinary innovation development, with amendments to specifically target KET-maritime innovation development.	Short

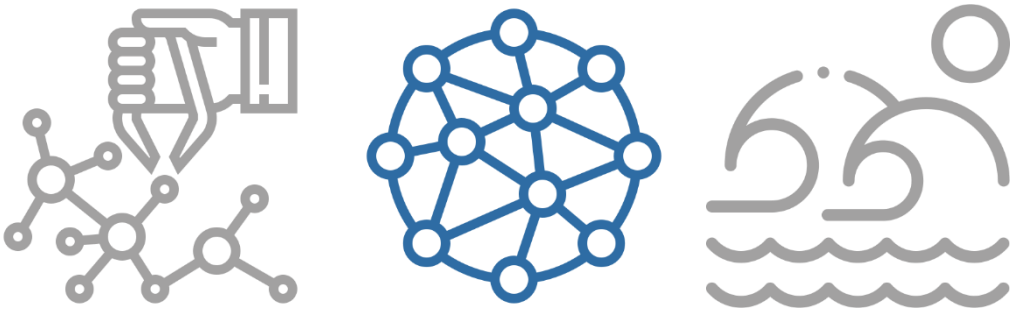


Table 5: Complementarities between actions to map supports and recognise contributory sectors, and other action areas.

Action Area		KETM034	KETM035
Adapting policy frameworks	Grounding supports in policy		
	Mapping existing supports and contributory sectors	✓	✓
	Equipping and resourcing public-sector supports		
	Ensuring responsive policy		
Building an innovation ecosystem: Matching SMEs with partners and collaborators		✓	
Building an innovation ecosystem: Promoting knowledge transfer			✓

Equipping and resourcing public-sector supports

Governance structures in the Atlantic Area can shape and foster the environment within which businesses and innovators conceive, and develop ideas. The actions suggested here recognise the role of state bodies in creating and shaping this environment. They provide guidance on the focus of any public sector engagement, in the event it is tasked with animating the KET-maritime innovation space. The actions also recognise the critical role education plays in the innovation economy, particularly when seeking to build long term sustainable innovation economies.

Table 6: Actions to enable the public sector to foster an animated maritime sector harnessing KET innovations.

Action Code	Action	Timeframe
KETM002	Allocate a responsible agency(s) to: - provide/source the intermediary teams, - identify and promote existing KET companies, - animate the community markets, and - arrange the needed innovation connection opportunities between KET and maritime communities.	Short
KETM036	Enable, equip, and resource key public bodies: - to support companies in their efforts to develop KET-maritime innovations; - to guide and target new societal need opportunities; - to recognise and respond to both direct and indirect impacts of public-body support.	Short - Long
KETM060	Ensure that education sector involvement is: - orientated towards the market, - focuses on the development of innovative and disruptive initiatives considered too risky for smaller private sector companies, - equipped to support both start-ups and traditional companies.	Short-medium

Table 7: Complementarities between actions to align public sector supports with a KET-maritime economy, and other action areas.

Action Area		KETM002	KETM036	KETM060
Adapting policy frameworks	Grounding supports in policy			
	Mapping existing supports and contributory sectors			
	Equipping and resourcing public-sector supports	✓	✓	✓
	Ensuring responsive policy			
Ensuring value for money: Monitoring an advancing maritime landscape				✓
Developing trust: Rewarding innovators and supporters fairly			✓	
Building an innovation ecosystem: Building a community of practice				✓
Enhancing capacity for knowledge synergies: Knowledge supports for innovation				✓

Ensuring responsive policy

A successful KET-maritime innovation economy, is one which grows and instigates changes in the maritime sector. These changes could re-shape how the sector and its communities operate, and function socio-economically. This is especially notable, in light of alignment with the UN Sustainable Development Goals, and potential to contribute to, for example, the delivery of a low-carbon, circular economy and climate resilient society. As such, it is essential that policies remain flexible, to capitalise on any disruptive innovations, and mitigate any unexpected consequences of a thriving maritime sector which is harnessing KET innovations. To ensure policy responds effectively to a potentially rapidly changing sector, frameworks and metrics to efficiently monitor the state of the maritime sector as it changes should be implemented.

Table 8: Actions to ensure policy makers are aware of the state of the maritime sector, and can rapidly respond to changes.

Action Code	Action	Timeframe
KETM037	Adapt the technology support frameworks to changes in both the KET-maritime innovation sector, and the KET sector itself as a result of maritime innovations.	Long
KETM055	Create a long-term adaptable framework for monitoring successes and challenges innovators are facing, with measurable (monitorable) indicators of impact, and aiding the promotion of success stories.	Short

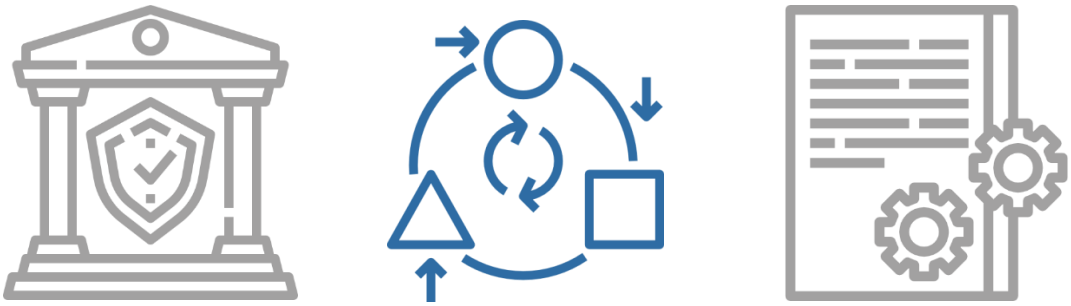


Table 9: Complementarities between actions to ensure responsive policy, and other action areas.

Action Area		KETM037	KETM055
Adapting policy frameworks	Grounding supports in policy		
	Mapping existing supports and contributory sectors		
	Equipping and resourcing public-sector supports		
	Ensuring responsive policy	✓	✓
Ensuring value for money: Ensuring supports to adapt to advances		✓	✓
Raising KET and maritime innovation awareness: Awareness raising with evidence			✓

Targeted funding to fuel maritime innovation with KETs

Dependable and accessible funding is essential for innovators to develop, and ultimately harness, an innovation. Particularly for new innovation sectors, the path from innovation to commercial success is longer, and requires the commitment of longer-term supports. These must recognise the need for risk taking and the potential for ventures to fail. It is evident that for the maritime sector to truly benefit from the European KET ambitions, long term dependable funding streams are needed to nurture those KET-maritime innovations from their typically low Technology Readiness Level. These supports should be available in addition to existing supports for commercialisation and product/business development. The inclusion of terms, and directions in call documents can vastly reshape the solutions proposed in response. These terms must be supported by policy-frameworks as highlighted above.

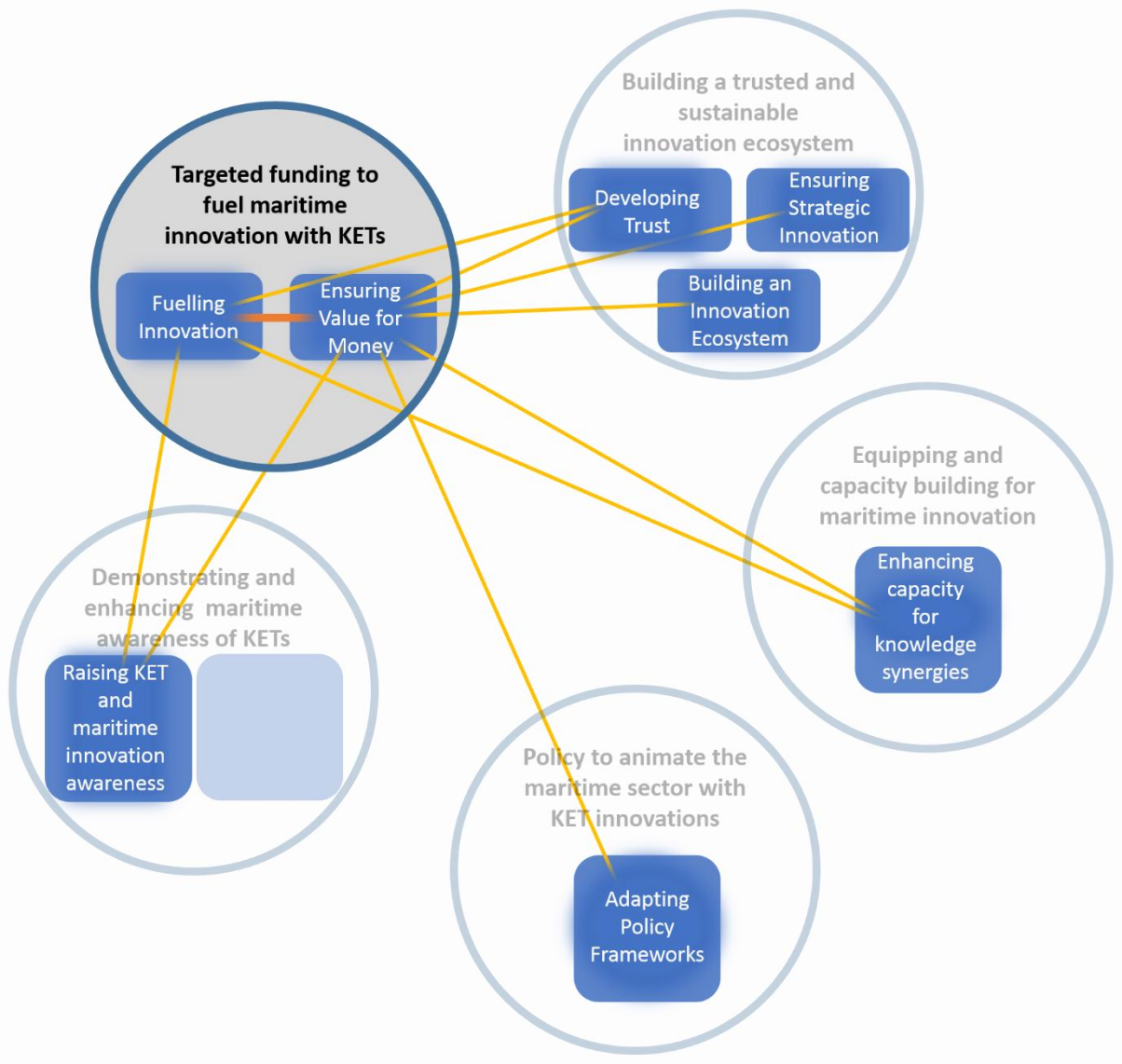


Figure 6: Synergies between tailoring funding approaches, and goals across the other 4 roadmap foci.

Fueling Innovation

A key tool to realise European Atlantic ambitions is the use of strategic targeted investment. With this they can promote activity in desirable sectors of the economy, and reinforce its perceived importance in the private investment community. How the funding is provided, and the characteristics of accessing it, are as important as providing it. Innovation sectors in their infancy require the long-term perspective to be adopted. This provides certainty to the disruptive innovators as they push the boundaries of science and engineering. These disruptors must be supported alongside the application innovators, who can trial innovations in new environments, and connect them to the maritime sector. These application innovators require a different flavour of funding, targeting demonstration and proof of concepts. Another flavour of funding must target SMEs, recognising their need to integrate Science Technology Innovation (STI) into their Doing-Using-Interacting (DUI) mode of innovation[5].



[5] Insights into the characteristic innovation approaches used by SMEs are described in Alhusen & Bennat (2020) Combinatorial innovation modes in SMEs: mechanisms integrating STI processes into DUI mode learning and the role of regional innovation policy, *European Planning Studies*, DOI: 10.1080/09654313.2020.1786009

Clarifying what is available to support development

The Atlantic Area's funding landscape features a diverse range of national and trans-national funding mechanisms. These are targeted towards a range of research institutes, large companies, SMEs, with a wide variety of structures which encourage different approaches and participants. The actions outlined here seek to clarify what financial instruments are currently available across the regions of the Atlantic Area. They also encourage funding agencies to ensure the key actors in animating maritime innovation with KETs are a focus audience of future calls, and the fall-off points for commercialisation are considered in framing the calls. The actions outlined here are not cross-applicable to multiple action areas. This does not diminish their importance, as they ensure implementing policy, funding socio-economic actions is done efficiently, and uses existing support structures.

Table 10: Actions towards clarifying the available supports to maritime innovation using KETs, and streamlining amendments to focus on the KET-maritime opportunity.

Action Code	Action	Timeframe
KETM003	Examine how investment in KET-maritime initiatives could be incentivised. In particular clarify (amongst other aspects): • the potential for pilot projects to animate activity, and how to maximise the animation potential; • how to incentivise high risk developments such as adopting KETs into existing or developing high value products.	Short-medium
KETM004	Map, critically evaluate, build upon, amend and supplement existing funding mechanisms which foster trans-disciplinary innovation development, with amendments to specifically target KET-maritime innovation development (*note this action works in tandem with KETM035*).	Short
KETM005	Clarify the public and non-public supports available to facilitate innovators pathways to manufacturing, critically examining the variety of approaches internationally.	Short

Table 11: The independence of actions KETM003 to KETM005, does not diminish their importance to achieving KET-maritime goals.

Action Area		KETM003	KETM004	KETM005
Fuelling innovation	Clarifying what is available to support development	✓	✓	✓
	Synergising with the digital economy			
	Funding supports to facilitate innovators			
	Shaping funding initiatives to animate the KET-maritime ecosystem			

Synergising with the digital economy

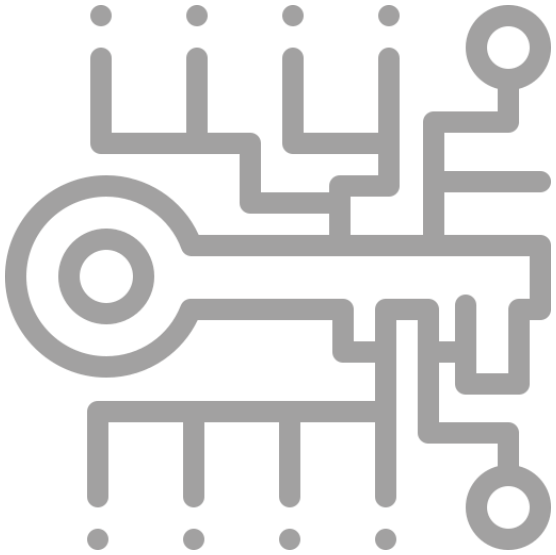
Evidence suggests ICT is to be a true enabler in the marine and maritime industry[6]. The increase in prevalence and availability of satellite imaging and communications, coupled with booming demand for maritime information services, is driving strong growth in areas such as surveillance, asset management and environmental monitoring. The action recommended here provides opportunities for the ICT sector to support maritime innovations using KETs, by directly encouraging the ICT sector to support KET-maritime applications development.

Table 12: Actions enabling the ICT sector to support maritime innovation using KETs.

Action Code	Action	Timeframe
KETM006	Fund ICT-developments (recognising the need to invest further in Big Data collection, processing and analysis) which specifically target enhanced KET uptake by the maritime sector.	Short

Table 13: The independence of actions KETM006 does not diminish its importance to achieving KET-maritime goals.

Action Area		KETM006
Fuelling innovation	Clarifying what is available to support development	
	Synergising with the digital economy	✓
	Funding supports to facilitate innovators	
	Shaping funding initiatives to animate the KET-maritime ecosystem	



[6] This was revealed and highlighted in a mapping exercise of existing commercialising KET-maritime innovations, reported in Williams, J. *et al.* (2020) *Capitalisation: blue growth projects and how these map onto the KET ecosystem*. Deliverable Report (D3.1) under the INTERREG Atlantic Area KETmaritime project (E.U. Grant no. EAPA_595/2016).

Funding supports to facilitate innovators

Accessing funding supports is often a barrier which can discourage innovators from applying for the funding, or knowing it exists. This is also a consideration for companies, who are specialised in their technological area and landscape, but are not familiar with novel application sectors, or existing funding supports for those sectors. Facilitators are needed to help companies learn where the supports lie, and how to access them. This could take the form of an agency, or individual actors, or part of a Community of Practice, tasked with providing that knowledge and experience to guide innovators and companies through the applications processes.

Table 14: Actions to ensure companies and KET innovators new to the maritime sector, can understand and access supports to realise innovations which are applicable to the sector.

Action Code	Action	Timeframe
KETM049	Support maritime and KET companies to engage with financial supports	Short-medium



Table 15: Complementarities between the role of specific financial support facilitators, and other action areas.

Action Area		KETM049
Fuelling innovation	Clarifying what is available to support development	
	Synergising with the digital economy	
	Funding supports to facilitate innovators	✓
	Shaping funding initiatives to animate the KET-maritime ecosystem	
Enhancing capacity for knowledge synergies: Knowledge supports for innovation		✓

Shaping funding initiatives to animate the KET-maritime ecosystem

Realising the ambition of a maritime sector which is actively seeking and implementing KET-based solutions, requires the development of a sustained, long term ecosystem for KET-maritime innovations, and innovation capture. A part of creating this ecosystem involves targeted funding, ensuring the initiatives used address key restrictions, and are framed to address those weaknesses, identified in the context of broadening uptake of KETs. The actions recommended here highlight key features which should be incorporated into the diverse range of available financial supports. They target short to long-term amendments specifically addressing funding weaknesses which restrain maritime uptake of KETs.

Table 16: Actions to tailor funding initiatives to specifically address weaknesses restraining maritime uptake of KETs.

Action Code	Action	Timeframe
KETM007	Ensure a range of KET-maritime-focused funding programmes incorporate the following elements (strategically): • focus on addressing maritime needs, targeting priority and promising maritime subsectors; • framed by, and funded activities iterate with, maritime and industry stakeholders; • help foster and grow a community of practice, focused on supporting the maritime sector to take advantage of KET developments. • include funding with a longer term perspective (with longer-term, 5+ year, funding and development streams); • establish a foundation of secure, core-funding for more risk-enabling, innovative, and fundamental KET-maritime applications research; • promote pilot example demonstrations, prototype development, and case study development as part of the range of supported activities; • include funding to promote business development of demonstrative innovative KET-maritime examples (e.g. with incubation support). • specifically support long-term collaborations between research institutions and private sector actors; • include funding lines ranging from short term innovation accelerators for promising innovations, and longer term open funding for risky yet potentially disruptive innovation development.	Short-long
KETM038	Ensure funding calls adequately resource the addressing of IPR concerns as part of the KET-maritime innovation process.	Short
KETM050	Ensure funding calls specifically promote collaborative opportunities, building long term innovation communities founded on trusted IPR practices.	Short
KETM056	Ensure initiatives examine how KETs perform in boosting maritime economies and commercial activity (e.g. reducing operating costs, or improving productivity), actively raise awareness of it, and factor this into their project strategy.	Medium

Table 17: Complementarities between the suggestions for targeted funding initiative amendments, and other action areas.

Action Area		KETM007	KETM038	KETM050	KETM056
Fuelling innovation	Clarifying what is available to support development				
	Synergising with the digital economy				
	Funding supports to facilitate innovators				
	Shaping funding initiatives to animate the KET-maritime ecosystem	✓	✓	✓	✓
Ensuring value for money: Strategic Monitored Demonstrations					✓
Developing trust: Rewarding innovators and supporters fairly			✓	✓	
Raising KET and maritime innovation awareness: Awareness raising with evidence					✓



Ensuring Value for Money

Investing in innovation is risky, especially when seeking disruptive innovations and sectoral transformation. Particularly when taxpayer-derived funds are deployed, it is essential that value for money is secured, transparency is paramount, and policy makers are clearly informed to determine when the supply of financing is in need of adjustment. This awareness of the state of the growing KET-maritime economy is particularly relevant should the financial applications be successful in animating a rapidly growing sector. In this situation, the rapid growth could alter the needs of the sector, and require a re-allocation of resources, or a strategic reduction in financing as it becomes self-sustaining.



Monitoring an advancing maritime landscape

As with policy implementation and robustness, the financial side of innovation support must also be monitored. The strengths and weaknesses of the various applications must be assessed, feed back into amending the financial instruments, and inform their contribution to responsive policy making. This monitoring capacity must be prepared to function in the event of rapid changes in the maritime economy harnessing KETs. Metrics must be devised to inform funding coordinators, and policy developers, when adaptations to their approach are needed. The actions outlined here are short to medium in nature, and involve a commitment to gathering relevant information on the KET-maritime economy, monitoring the perceptions of KETs in the maritime sector and whether there is or is not a growing pull in the maritime sector for KETs, and finally monitoring the feedback of any successful maritime growth back into the KET sectors. The metrics could also provide guidance to financial markets, towards the goal of a self-sustaining KET-maritime economy.

Table 18: Actions needed to ensure funding coordinators and policy makers are informed to amend their activities and adjust to any changes in the KET-maritime economy.

Action Code	Action	Timeframe
KETM008	Monitor how the development of these KET-maritime technologies affects the original KET technology fields.	Medium
KETM009	Monitor and assess "Market pull" for KET in the maritime, amending or enhancing actions in this roadmap as appropriate.	Medium
KETM039	As the KET-maritime activity increases, gather information to clearly describe the professional and economic advantages which are evident in KET applications to the maritime sector.	Short-medium



Table 19: Complementarities between monitoring the impact of financing measures, and other action areas.

Action Area		KETM008	KETM009	KETM039
Ensuring value for money	Monitoring an advancing maritime landscape	✓	✓	✓
	Synergising with Education			
	Ensuring supports to adapt to advances			
	Strategic Monitored Demonstrations			
Raising KET and maritime innovation awareness: Awareness raising with evidence				✓

Synergising with education

Building any innovation economy requires engagement with, and involvement of, the education sector. The actions suggested here, target the involvement of both secondary and tertiary education in the evolution of KET-maritime innovation. It adopts a long-term perspective, while consisting of both short, and medium term actions which focus on provision of a pipeline of talent and human capital necessary for the growth of KETs and maritime sectors.

Table 20: Actions to ensure the education sector is aligned to support maritime uptake of KETs, and KET innovations.

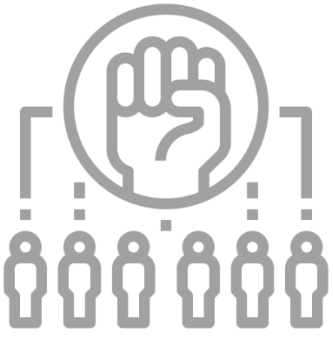
Action Code	Action	Timeframe
KETM040	Explore the potential to integrate education on KET innovation into secondary level education.	Short
KETM060	Ensure that education sector involvement is: • orientated towards the market, • focuses on the development of innovative and disruptive initiatives considered too risky for smaller private sector companies, • equipped to support both start-ups and traditional companies.	Short-medium

Table 21: Complementarities between education sector alignment actions, and other action areas.

Action Area		KETM040	KETM060
Ensuring value for money	Monitoring an advancing maritime landscape		
	Synergising with Education	✓	✓
	Ensuring supports to adapt to advances		
	Strategic Monitored Demonstrations		
Adapting policy frameworks: Equipping and resourcing public-sector supports			✓
Building an innovation ecosystem: Facilitating ideas and testing			✓
Enhancing capacity for knowledge synergies: Leveraging Europe's education systems and resources		✓	✓







Ensuring supports adapt to advances

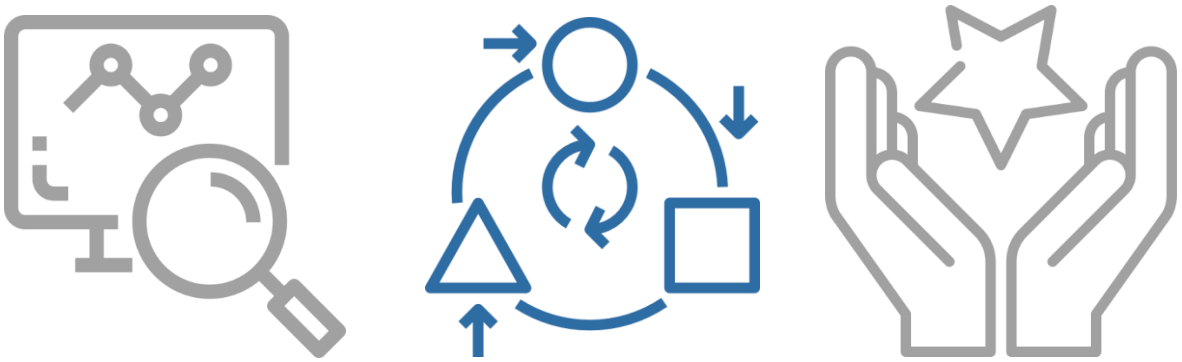
Adaptive policy and financial instruments must be complemented by adaptive knowledge supports. These are education supports needed by KET innovators and companies to discover new opportunities, engage with the maritime sector effectively, and explore niches for novel products or disruptive innovations throughout the maritime sector.

Table 22: Actions to ensure knowledge supports are adaptive and respond to changes in the maritime economy due to KETs.

Action Code	Action	Timeframe
KETM037	Adapt the technology support frameworks to changes in both the KET-maritime innovation sector, and the KET sector itself as a result of maritime innovations.	Long
KETM055	Create a long-term adaptable framework for monitoring successes and challenges innovators are facing, with measurable (monitorable) indicators of impact, and aiding the promotion of success stories.	Short

Table 23: Complementarities between ensuring knowledge supports are adaptive, and other action areas.

Action Area		KETM037	KETM055
Ensuring value for money	Monitoring an advancing maritime landscape		
	Synergising with Education		
	Ensuring supports to adapt to advances	✓	✓
	Strategic Monitored Demonstrations		
Adapting policy frameworks: Ensuring responsive policy		✓	✓
Raising KET and maritime innovation awareness: Awareness raising with evidence			✓



Strategic monitored demonstrations

Introducing new technologies to established sectors requires demonstrating their viability and robustness. Particularly in the maritime sector, safety is a priority concern. Mistakes can have a high cost, both in terms of money, and in lives. Maritime stakeholders need to: see proof that KETs are worth considering; feel confident in engaging with innovations; and have opportunity to guide their refinement. The need for demonstrations featured strongly across the stakeholder perspectives gathered over the course of this roadmap's development. The actions suggested here refer to financing, specifically recommending a subset of financial initiatives targeted at demonstrating maritime advancements using KET techologies. They seek to ensure the advances meet the real needs of the current maritime community, and that lessons learned can be built upon, and provide opportunities for greater engagement by maritime stakeholders and markets.

Table 24: Actions to ensure targeted proof of concepts and demonstrations are implemented which are needs-driven, and framed to foster further maritime sectoral engagement.

Action Code	Action	Timeframe
KETM031	Support the implementation of demonstration KET-maritime activities in the following subsectors: Fisheries and Aquaculture; Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Short
KETM056	Ensure initiatives examine how KETs perform in boosting maritime economies and commercial activity (e.g. reducing operating costs, or improving productivity), actively raise awareness of it, and factor this into their project strategy.	Medium
KETM046	Ensure innovative KET-maritime applications development is within areas of maritime needs, framed iteratively by maritime stakeholders (e.g. Maritime company associations, sectoral stakeholders) by gathering information on specific maritime issues and maritime industry problems.	Short-medium

Table 25: Complementarities between framing funding for demonstrators and other action areas.

Action Area		KETM031	KETM056	KETM046
Ensuring value for money	Monitoring an advancing maritime landscape			
	Synergising with Education			
	Ensuring supports to adapt to advances			
	Strategic Monitored Demonstrations	✓	✓	✓
Adapting policy frameworks: Grounding supports in policy		✓		
Fuelling innovation: Shaping funding initiatives to animate the KET-maritime ecosystem			✓	
Developing trust: Demonstrating KET-maritime successes				✓
Ensuring strategic innovation: Responsible research and innovation				✓
Raising KET and maritime innovation awareness: Awareness raising with evidence			✓	

Building a trusted and sustainable innovation ecosystem

This roadmap envisions the development of a vibrant trans-national innovation ecosystem, across which knowledge flows, and innovators conceive and seize KET-maritime opportunities. Currently, the potential for this ecosystem has been recognised, and is grassroots in nature. However, these pioneers, who have contributed to shaping this roadmap, have laid the foundations of this ecosystem, and identified the path forward. Building this transnational system requires investment in building trust, laying the networking pathways for knowledge transfer and innovation capture, and strategically maximising the impact of investments.

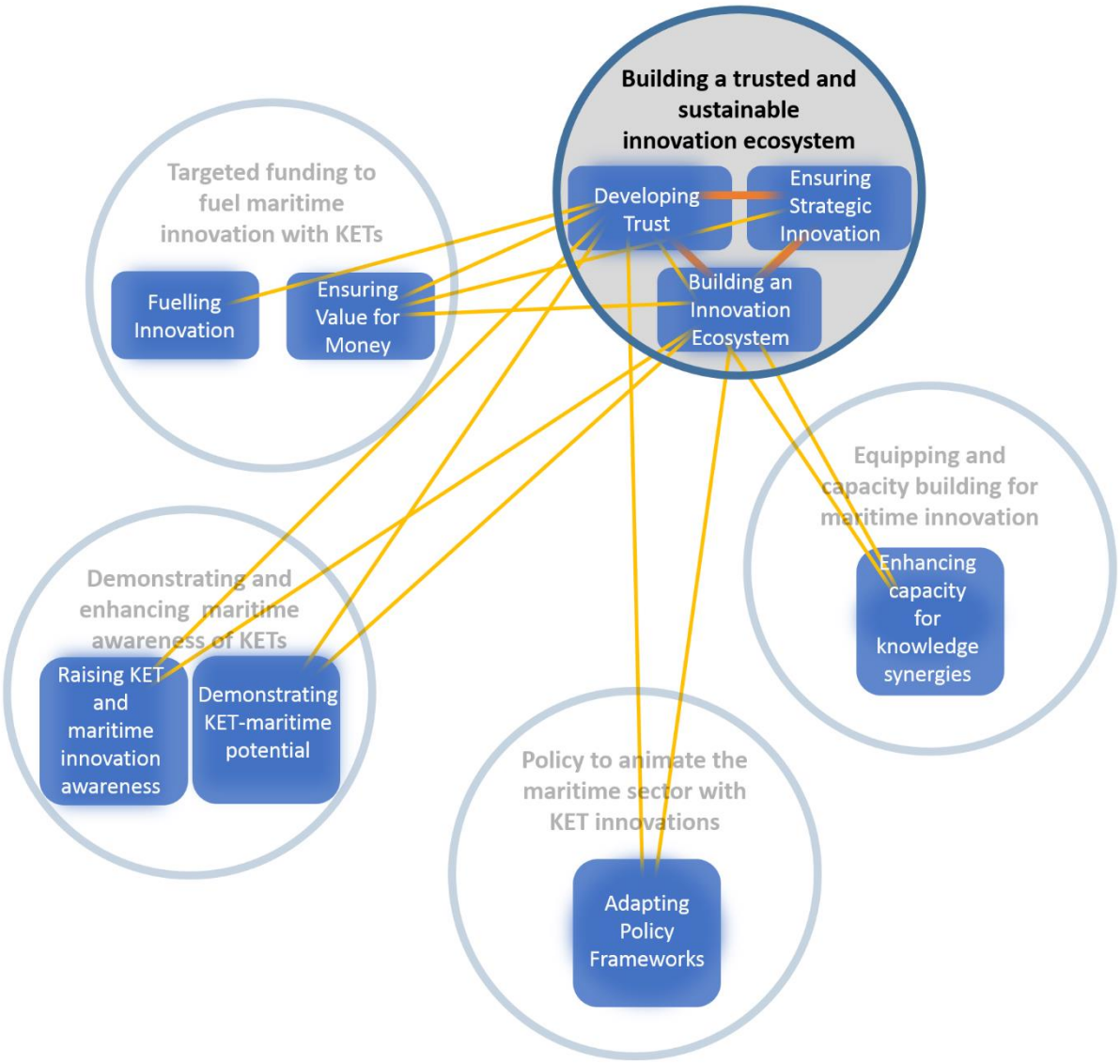
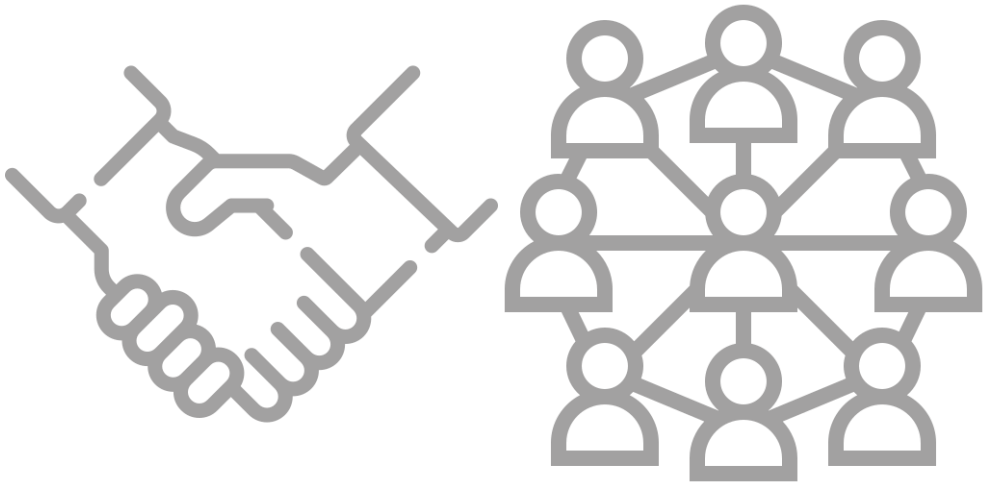
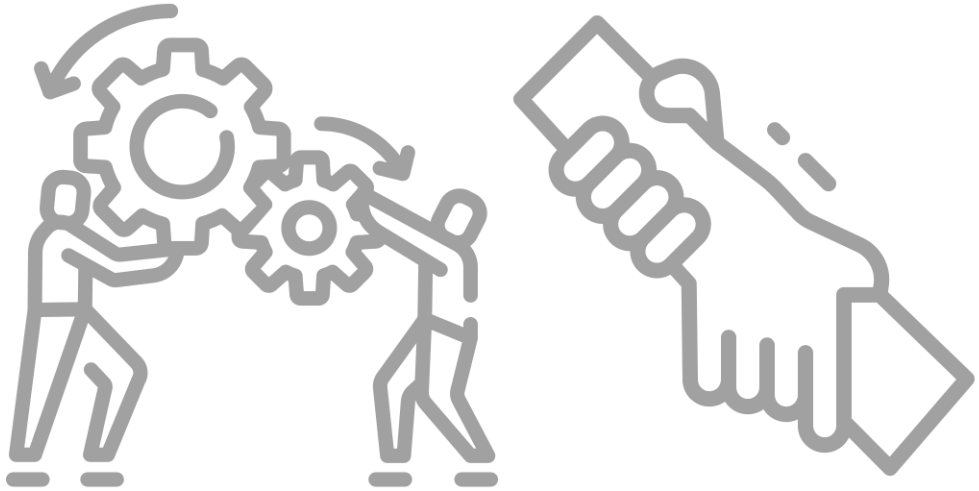


Figure 7: Synergies between building a core self-perpetuating KET-maritime innovation ecosystem, and goals across the other 4 roadmap foci.

Developing Trust

Developing trans-sectoral trust, and market-developer partnerships are essential to the Atlantic Area realising ambitious KET-maritime growth, and a thriving innovation ecosystem. This trust is a human dimension, critical to building capacity and innovation; it is hard won, and often easily destroyed. It requires targeted effort being dedicated to helping innovators and companies bridge sectoral, societal, and often spatial barriers and obstacles. The measures outlined in the following sections address key parts of building trust between companies and across borders. At its heart, this section recognises that awareness and trust in KETs is not yet readily seen in the maritime sector. Working in such a high-risk environment means you trust what has worked – that which you know you can depend upon. New technologies not only threaten profits, but can be a risk to life when considering the maritime domain. As such, building trust in KETS is critical to maximise uptake of these technologies.





Demonstrating KET-maritime successes

Demonstrating successes and being open and honest about challenges are key elements to building trust in new technologies, and the people behind their advancements. Maritime stakeholders must see KET applications responding to real needs in the maritime sector, transparently keeping them informed on the challenges being faced, and working with them to overcome these challenges.

Table 26: Actions to build trust with maritime stakeholders using targeted stakeholder-led demonstrations of KET applications.

Action Code	Action	Timeframe
KETM057	Support targeted demonstration initiatives by companies, which create real maritime products & services, demonstrate the business case, and achievable business opportunities possible by collaboration between maritime and KET communities.	Short
KETM058	Fund demonstrator KET-maritime activities in the following priority subsectors: Fisheries and Aquaculture (noting some may need to be prioritised); Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Medium
KETM046	Ensure innovative KET-maritime applications development is within areas of maritime needs, framed iteratively by maritime stakeholders (e.g. Maritime company associations, sectoral stakeholders) by gathering information on specific maritime issues and maritime industry problems.	Short-medium

Table 27: Complementarities between maritime stakeholder-led demonstration actions, and other action areas.

Action Area		KETM057	KETM058	KETM046
Developing trust	Demonstrating KET-maritime successes	✓	✓	✓
	Ensuring info on KETs is readily available			
	Developing and supporting networks of trust			
	Rewarding innovators and supporters fairly			
Ensuring value for money: Strategic Monitored Demonstrations				✓
Ensuring strategic innovation: Targeting short-term priority demonstrators			✓	
Ensuring strategic innovation: Responsible research and innovation				✓
Raising KET and maritime innovation awareness: Strategic outreach and animation		✓		
Demonstrating KET-maritime potential: Demonstrating KETs meeting maritime needs		✓	✓	

Ensuring info on KETs is readily available

A key aspect of every stakeholder engagement throughout this roadmapping process, was introducing KETs to maritime stakeholders. Awareness of what KETs are, and what they could unlock is sparse. KETs are difficult to interpret and conceptualise, unless you are working in Key Enabling Technology sectors. The action outlined here recognises that clear, understandable and relevant information about KETs, and companies developing KETs, is made available to the maritime sector. Furthermore, it must be framed with the maritime sector in mind, recognising that stakeholders and the KET-maritime market, has little familiarity with the terminology and language used to describe KETs.

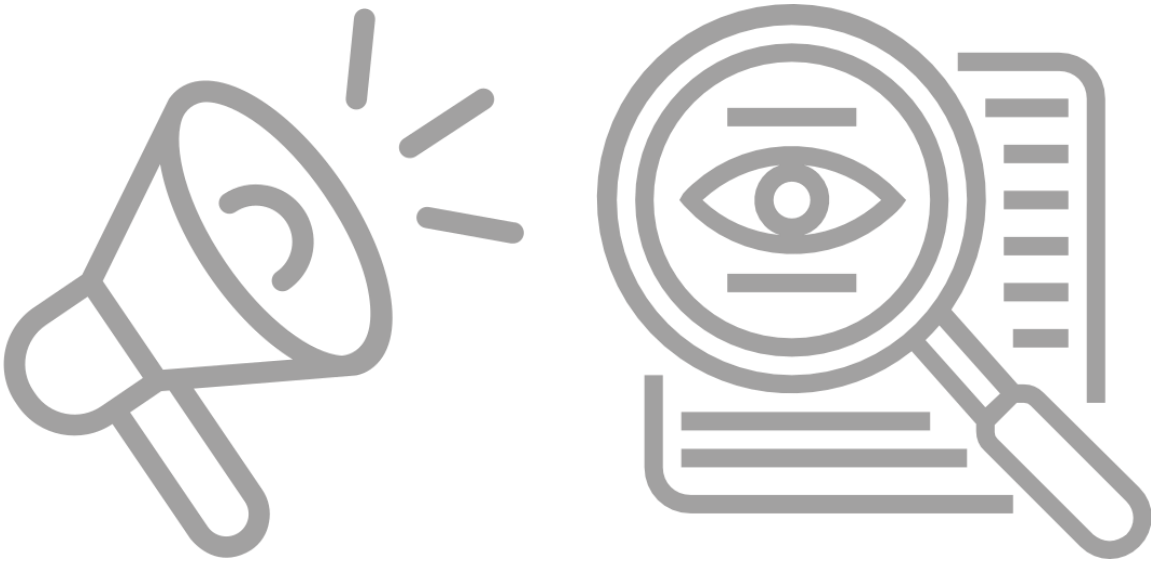


Table 28 Actions ensure KETs engagement with the maritime sector is supported by information provision about KETs, and what KET developers can offer.

Action Code	Action	Timeframe
KETM041	Ensure information on the services and capabilities of KET developers and companies are made accessible.	Medium

Table 29: Complementarities between developing information supports, and other action areas.

Action Area		KETM041
Developing trust	Demonstrating KET-maritime successes	
	Ensuring info on KETs is readily available	✓
	Developing and supporting networks of trust	✓
	Rewarding innovators and supporters fairly	

Developing and supporting networks of trust

Building trust across sectors and borders requires attention[7], to facilitate engagement between companies and people from the different sectors, and create the space for trust to develop[8]. The actions suggested here encourage the creation of networking opportunities, ensure funded initiatives specifically allocate effort to building trust between the sectors, and aid capacity building across the KET-maritime opportunity space. This will allow maritime stakeholders to familiarise themselves with the KET opportunities, and vice versa. seeking to develop those critical relationships that realise commercial innovations. These actions bridge multiple action areas, supporting the development of a KET-maritime innovation ecosystem, raising awareness itself, and building capacity in the KET and maritime sectors.

Table 30: Actions to build trust through facilitating the development of trans-sectoral and trans-boundary relationships.

Action Code	Action	Timeframe
KETM042	Implement a series of diverse trans-disciplinary networking opportunities to foster and embed innovation connections between the KET and maritime communities. These events must feature a team of intermediaries (translators) who can facilitate bridging the gaps between the two communities.	Short
KETM051	Support funding programme developers and actors to engage with the maritime and KET companies.	Short-medium
KETM041	Ensure information on the services and capabilities of KET developers and companies are made accessible.	Medium
KETM047	Identify companies active in KET technologies in EU Atlantic regions, and promote their existence.	Short
KETM059	Create technological support frameworks for non-KET innovators.	Medium





[7] For further insights into trust, and the central role it plays in the development of trans-disciplinary, and commercial innovation, see Ellingsen, M-B., Normann, A.K., Scarrott, R., Ferreira, F., O' Mahony, C., Alves, A.S. (2016) *Innovation mechanisms for the space and maritime sectors*. Deliverable report under the European Space Agency CINMarS project (contract no. 4000113554).

[8] The need to build trust was also emphasized by stakeholders examining the space to maritime sector innovation crossover, as reported in: Scarrott, R.G., O' Mahony, C., Ellingsen, M.B.E., Ferreira, F.,Shanahan, P, Silva, E., Cronin, A., Skogholt P.A., Morais, T., Alves, A.S., Almeida, C. (2017) Roadmap for the implementation of Space-Maritime Cross-sectoral Innovation Networks, with considerations for geographical and sectoral expansion. Technical note delivered to the European Space Agency under contract No. 4000113554. DOI: 10.13140/RG.2.2.27298.73927

Table 31 Synergies between trust-development activities, and other action areas.

Action Area		KETM042	KETM051	KETM041	KETM047	KETM059
Developing trust	Demonstrating KET-maritime successes					
	Ensuring info on KETs is readily available			✓		
	Developing and supporting networks of trust	✓	✓	✓	✓	✓
	Rewarding innovators and supporters fairly					
Building an innovation ecosystem: Building a community of Practice		✓			✓	
Building an innovation ecosystem: Facilitating ideas and testing			✓			✓
Enhancing capacity for knowledge synergies: Knowledge supports for innovation						✓
Raising KET and maritime innovation awareness: Strategic outreach and animation					✓	



Rewarding innovators and supporters fairly

Poor IP practices can irreparably damage collaborative initiatives, and trust in an innovation ecosystem. States across the Atlantic Area recognise the potential of their SMEs. However, these SMEs and larger scale partners they collaborate with, must feel that IPR processes are fit for purpose in developing an innovation ecosystem . To this end, the lack of clarity and awareness regarding IPR, how to secure IP, and how to ensure fair protection and benefits, is a concern. Funding programmes can help here, ensuring a minimal level of attention is paid to identifying foreground IP, who created it, and how it could be brought forward. The intention here is to slowly build innovators and companies awareness of IP, and best practice. The goal is that in the medium-term, IP is regularly addressed sooner rather than later, with collaborators developing the path forward for their partnerships, and building trust in the innovation ecosystem.

Table 32 Actions to build awareness and capacity in IP identification and management for healthy collaborations.

Action Code	Action	Timeframe
KETM010	Ensure there are clear approaches to IPR management available (with clear determination of inventing, licencing, and rights usage), and implemented as part of any collaborative initiative.	Medium
KETM044	Ensuring Intellectual property creation, assessment, transparency and security are embedded at the core of the KET-maritime innovation environment, with adequate supports in place for innovators and collaborators.	Short
KETM038	Ensure funding calls adequately resource the addressing of IPR concerns as part of the KET-maritime innovation process.	Short
KETM050	Ensure funding calls specifically promote collaborative opportunities, building long term innovation communities founded on trusted IPR practices.	Short
KETM043	Address the lack of clarity concerning IPR, providing guidance and surety to novice innovators, in particular those from non-commercial backgrounds.	Short

Table 33 Synergies between increasing IP awareness and best practice, and other action areas.

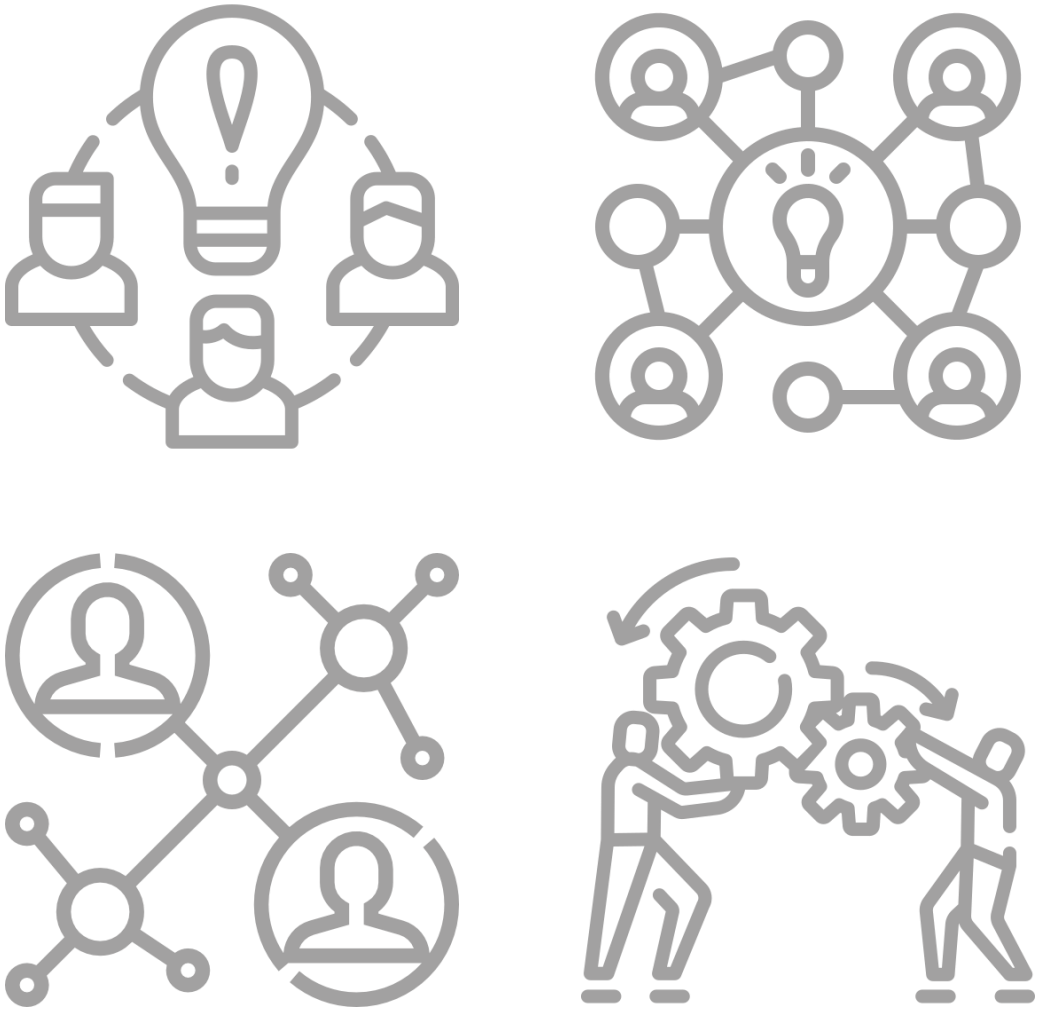
Action Area		KETM010	KETM044	KETM038	KETM050	KETM043
Developing trust	Demonstrating KET-maritime successes					
	Ensuring info on KETs is readily available					
	Developing and supporting networks of trust					
	Rewarding innovators and supporters fairly	✓	✓	✓	✓	✓
Fuelling innovation: Shaping funding initiatives to animate the KET-maritime ecosystem				✓	✓	
Building an innovation ecosystem: Building a community of Practice			✓			
Enhancing capacity for knowledge synergies: Staff training for innovation						✓

Building an Innovation Ecosystem

"*An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors*."

Granstrant & Holgersson, 2020[9]

Central to the vision of this roadmap, is the creation of an innovation ecosystem focused on the maritime and KET sectors. It involves people, companies, institutes, relationships, ideas, practices, synergies and competition. For the Atlantic Area to excel, a community of practice for KET-maritime must be fostered. Opportunities must be there for ideas to develop, and be brought forward to testing phases. The capability for ideas to fail is an essential element of innovation, particularly if disruptive innovations are sought. This requires long term strategy, and fostering an environment where risk and research is possible. Finally, this innovation ecosystem must allow and encourage knowledge to flow, partnerships and collaborations to form, and trust to develop in the maritime community for sustainable and safe KET-maritime innovations.



[9] Granstrand, O., Holgersson, M. (2020) Innovation ecosystems: A conceptual review and a new definition. Technovation, 90-91,102098. DOI: 10.1016/j.technovation.2019.102098.

Building a community of practice

A trans-sectoral community of informed, and trusted innovators and developers forms the bedrock of the envisioned innovation ecosystem. This involves people and companies from the KET and maritime sectors, who form collaborative and competive relations, and cement the bridges between the two sectors. The community must feature those assets of the Atlantic Area, government agencies, education and research institutes, as well as the SMEs and larger commercial entities. Key oppportuities are recognised in this roadmap, which could be used to foster exploratory or deeper partnerships, and build this community of practice.

Table 34: Actions towards developing an animated community of practice, in maritime applications of KET technologies.

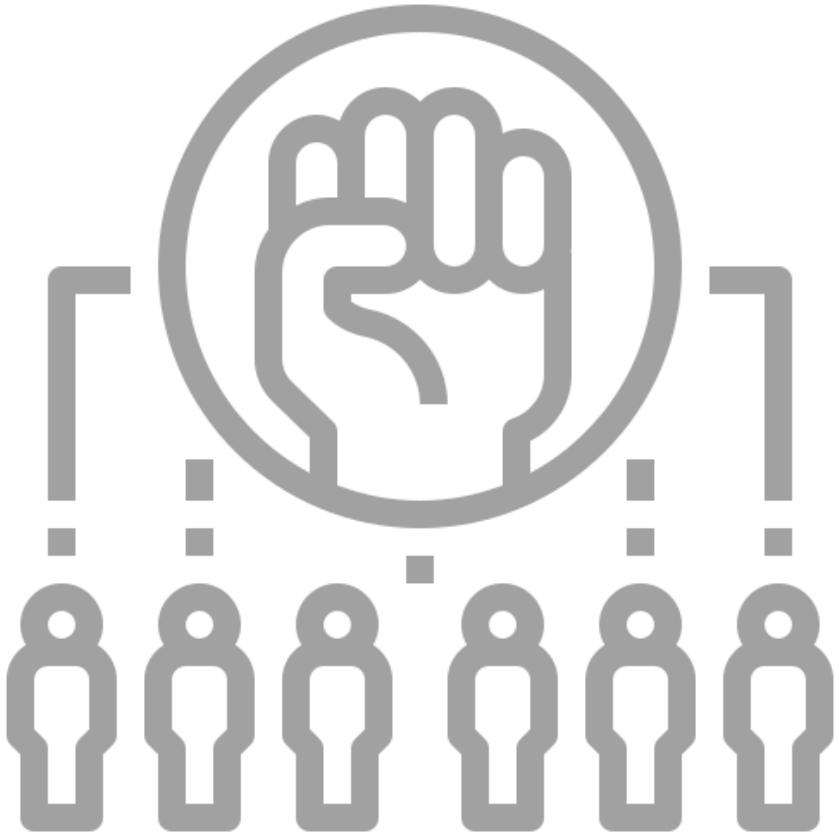
Action Code	Action	Timeframe
KETM011	Foster a community of practice, focused on supporting the maritime sector to take advantage of KET developments.	Short-medium
KETM012	Engage with policy makers, regulators and legislators to shape the KET-maritime innovation environment, and ensure development is in line with the principles of environmental sustainability.	Short - long
KETM044	Ensuring Intellectual property creation, assessment, transparency and security are embedded at the core of the KET-maritime innovation environment, with adequate supports in place for innovators and collaborators.	Short
KETM042	Implement a series of diverse trans-disciplinary networking opportunities to foster and embed innovation connections between the KET and maritime communities. These events must feature a team of intermediaries (translators) who can facilitate bridging the gaps between the two communities.	Short
KETM036	Enable, equip, and resource key public bodies: • to support companies in their efforts to develop KET-maritime innovations; • to guide and target new societal need opportunities; • to recognise and respond to both direct and indirect impacts of public-body support.	Short - long
KETM045	Ensure ports, and offshore renewable energy developers and engineers, are in the conversation regarding KET-maritime strategic initiatives.	Medium
KETM047	Identify companies active in KET technologies in EU Atlantic regions, and promote their existence.	Short





Table 35: Complementarities between fostering a KET-maritime community of practice, and other action areas.

Action Area		KETM011	KETM012	KETM044	KETM042	KETM036	KETM045	KETM047
Building an innovation ecosystem	Building a community of Practice	✓	✓	✓	✓	✓	✓	✓
	Facilitating ideas and testing							
	Matching SMEs with partners and collaborators							
	Promoting knowledge transfer							
Adapting policy frameworks: Equipping and resourcing public-sector supports						✓		
Developing trust: Developing and supporting networks of trust					✓			✓
Developing trust: Rewarding innovators and supporters fairly				✓				
Ensuring strategic innovation: Responsible research and innovation							✓	
Raising KET and maritime innovation awareness: Strategic outreach and animation								✓



Facilitating ideas and testing

A vibrant community, sharing knowledge and becoming increasingly aware of opportunities and capabilities, is a spawning ground for new ideas. To realise a functioning KET-maritime sector, these innovations must be captured, and tested. This must be flexible enough to allow for true Researh and Development, whilst also encouraging SMEs to explore innovations through *Doing, Using and Interacting* with new technologies and sectors. Whilst many ideas will not be commercially realisable, the innovation ecosystem must be capable of supporting the testing of ideas. It must allow for for the possibility of failure to occur, without catastrophic consequences for the innovators and developers themselves. This will enable them to take learnings from the process, and continue innovating in their respective areas.



Table 36: Measures to enable innovations to be captured, and brought forward into research and commercialisation.

Action Code	Action	Timeframe
KETM013	Provide frameworks for maritime companies to work with KET developers, seek technology supports, and access the knowledge to use them.	Medium
KETM014	Facilitate risk-reducing access to facilities for testing and analysis.	Short
KETM051	Support funding programme developers and actors to engage with the maritime and KET companies.	Short-medium
KETM059	Create technological support frameworks for non-KET innovators.	Medium
KETM060	Ensure that education sector involvement is: • orientated towards the market, • focuses on the development of innovative and disruptive initiatives considered too risky for smaller private sector companies, • equipped to support both start-ups and traditional companies.	Short-medium

Table 37: Complementarities between measures to facilitate capturing innovations, and other action areas.

Action Area		KETM013	KETM014	KETM051	KETM059	KETM060
Building an innovation ecosystem	Building a community of Practice					
	Facilitating ideas and testing	✓	✓	✓	✓	✓
	Matching SMEs with partners and collaborators					
	Promoting knowledge transfer					
Adapting policy frameworks: Equipping and resourcing public-sector supports						✓
Ensuring value for money: Synergising with Education						✓
Developing trust: Developing and supporting networks of trust				✓	✓	
Enhancing capacity for knowledge synergies: Knowledge supports for innovation					✓	
Enhancing capacity for knowledge synergies: Leveraging Europe's education systems and resources						✓



Matching SMEs with partners and collaborators

SMEs are seen as being the engine of European innovation. However, their knowledge of the KET or maritime scene may be limited. Furthermore, opportunities to connect with companies across borders may be limited as time spent by an SME networking, is time not spent developing or selling their product or service. This roadmap recognises this challenge, and it's potential to restrain collaboration development. It recognises the importance of not only new small companies, but also established traditional companies in the sectors, or indeed larger companies, who could synergise with a fast developing yet inexperienced innovator. Furthermore it recognises the role of education and research instututes in innovation partnerships and collaborations, and the role of policy in opening doors to key sectoral capacities such as ICT.

Table 38: Actions to promote contact between SMEs and potentially collaborative partners.

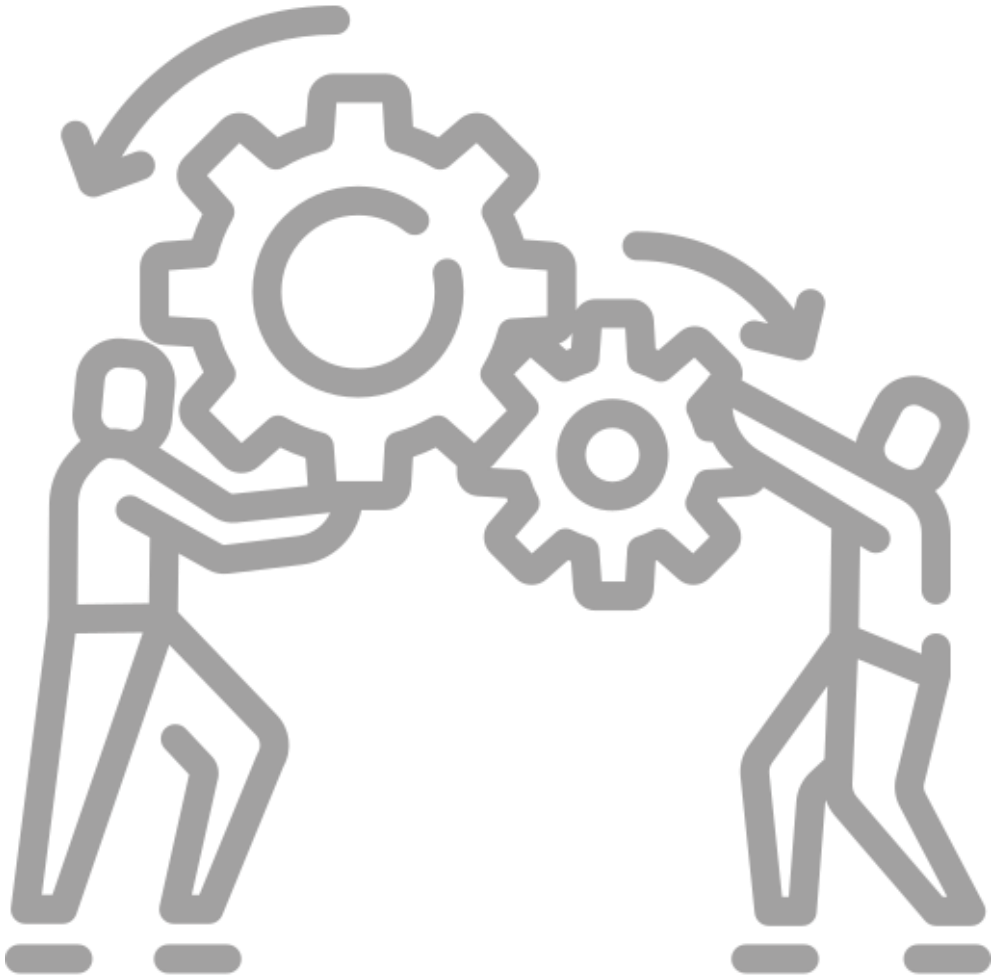
Action Code	Action	Timeframe
KETM015	Recognise innovation clusters (of companies and agencies) as potential agents to facilitate technology transfer, and foster collaboration activities, guide long-term KETmaritime development, host the forums for maritime stakeholder needs, and inform state agencies of the sectors successes and needs.	Short-long
KETM016	Ensure any developed networks are open enough to facilitate companies/individuals (including larger companies) which are currently closed to collaboration.	Medium
KETM017	Support traditional companies with resources and advice to transform their business model adapting it to the transforming maritime sector.	Short-medium
KETM034	Recognise the importance of the ICT sector to KET uptake by the maritime sector in marine policy documents and revisions, emphasizing the Value Chain Approach.	Short
KETM052	Ensure the education (in particular both second and third level) sector is involved in the KET-maritime network, to maximise potential for best practice transfer, support of risk-reduced innovation, and fostering next generation innovators.	Short





Table 39: Complementarities between fostering SME partnerships with other entities, and other action areas.

Action Area		KETM015	KETM016	KETM017	KETM034	KETM052
Building an innovation ecosystem	Building a community of Practice					
	Facilitating ideas and testing					
	Matching SMEs with partners and collaborators	✓	✓	✓	✓	✓
	Promoting knowledge transfer					
Adapting policy frameworks: Mapping existing supports and contributory sectors					✓	
Enhancing capacity for knowledge synergies: Leveraging Europe's education systems and resources						✓



Promoting knowledge transfer

A core feature of the envisioned KET-maritime innovation ecosystem, is information and knowledge flow. Information and experience in the maritime sector must be available to inform and frame the KET solution space. Feedback and stakeholder/market involvement in directing innovators to identify needs is critical, particularly if socio-economic benefits are the focus of European and national level investment. A stakeholder in the maritime sector must be able to explore their options in KETs, and either be put in contact with, or access companies with potential solutions. This is not only an awareness challenge, but a facilitation challenge. At a time when awareness of KETs is limited in the maritime sector, how can state and European agencies foster increased knowledge flow between the two? The actions suggested here help realise that objective, smoothing the trans-sectoral flow of information, and increasing the potential for networks, conversations, and collaborations to form.

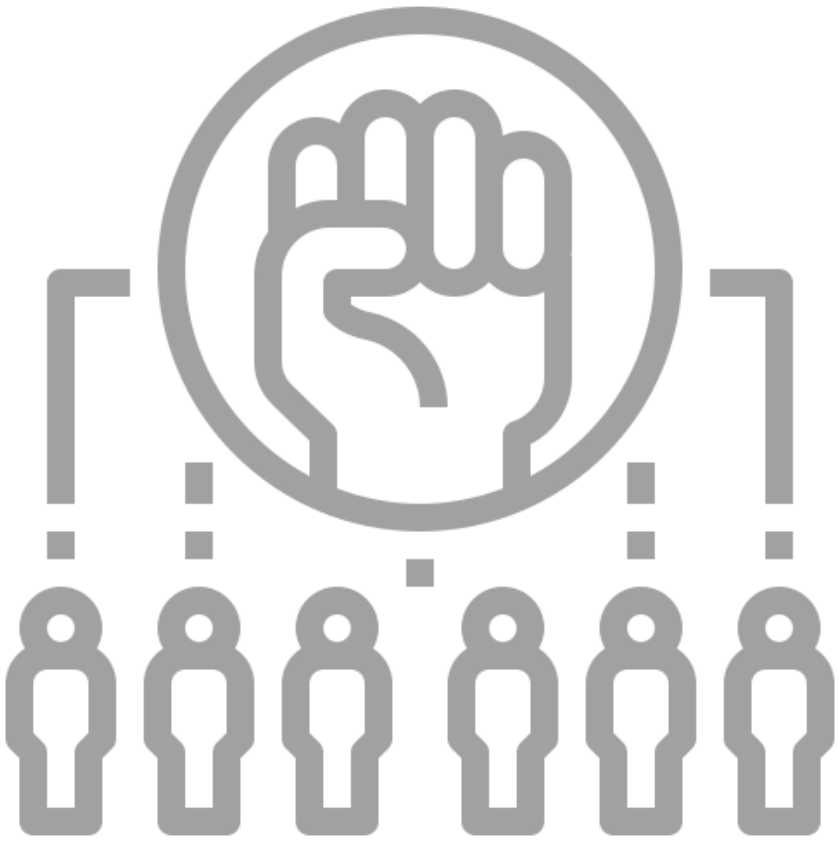


Table 40: Targeted actions to facilitate information and knowledge flow between the KET and maritime sectors.

Action Code	Action	Timeframe
KETM018	Develop online information resources for KET awareness building in the maritime sector.	Short
KETM035	Map, build upon, amend and supplement existing frameworks and structures which foster trans-disciplinary innovation development, with amendments to specifically target KET-maritime innovation development.	Short
KETM032	Promote linking companies to the R&D supports available to public bodies.	Short
KETM053	Capitalise on existing education assets by creating placement programmes where students/early-stage scientists/engineers from the maritime or KET sectors can be placed in the opposing sector.	Short
KETM054	Provide continuous training for companies/individuals to upskill in KET knowledge and technology uses.	Short-medium

Table 41: Complementarities between actions to promote and facilitate knowledge flow, and other action areas.

Action Area		KETM018	KETM035	KETM032	KETM053	KETM054
Building an innovation ecosystem	Building a community of Practice					
	Facilitating ideas and testing					
	Matching SMEs with partners and collaborators					
	Promoting knowledge transfer	✓	✓	✓	✓	✓
Adapting policy frameworks: Grounding supports in policy				✓		
Adapting policy frameworks: Mapping existing supports and contributory sectors			✓			
Enhancing capacity for knowledge synergies: Leveraging Europe's education systems and resources					✓	
Enhancing capacity for knowledge synergies: Staff training for innovation						✓



Ensuring Strategic Innovation

This roadmap envisions a sustainable, animated maritime sector, actively harnessing KETs to realise growth and sustainability potential. There is evidence of grassroots innovation taking place[10]. These innovators and companies were key to developing this roadmap, which recognises they are already pushing the boundaries of what is possible, albeit at a pace which does not match Europe's potential. To grow and nurture these grassroots innovators, Europe must be strategic. It must put in place enabling conditions to open the door to solutions, which meet existing and future needs of citizen and market stakeholders. In doing so, Atlantic Area states can show the potential value of their investment in KETs, rapidly demonstrating KET-maritime innovations to companies, citizens, and markets. To this end, the following set of actions strongly target the above range of activities towards key subsectors of the maritime economy. These would ensure refined, and impactful goals are available to guide innovators and energise KET-maritime advancement.



[10] See the mapping of KET-maritime innovations being commercially exploited in Williams, J. *et al.* (2020) *Capitalisation: blue growth projects and how these map onto the KET ecosystem*. Deliverable Report (D3.1) under the INTERREG Atlantic Area KETmaritime project (E.U. Grant no. EAPA_595/2016).

Targeting short-term priority demonstrators

Demonstrations of technology application provide real-world, tangible examples of rewards. A strong element of stakeholder discussions emphasized the need for maritime stakeholders to see the investment value. KET developers would also benefit from targeted supports for demonstration development, and goals to frame and maximise the impact of their exploratory efforts. To this end, the suggested action provides guidance on where demonstrator supports should be targeted in the short to medium term. Ideally, in the medium term, the priorities will change, as maritime stakeholders examine advances and see opportunities for solutions in other areas.

Table 42: Actions to guide demonstrator development into the medium term.

Action Code	Action	Timeframe
KETM058	Fund demonstrator KET-maritime activities in the following priority subsectors: Fisheries and Aquaculture (noting some may need to be prioritised); Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Short-medium

Table 43: Complementarities between guiding demonstration development, and other action areas.

Action Area		KETM058
Ensuring strategic innovation	Targeting short-term priority demonstrators	✓
	Identifying niches	
	Responsible research and innovation	
Developing trust: Demonstrating KET-maritime successes		✓
Demonstrating KET-maritime potential: Demonstrating KETs meeting maritime needs		✓



Identifying niches

It is not the role of governments and state agencies to identify the niche opportunities for innovators to exploit. However, they can identify the general subsectors of relevance to their region, and highlight existing gaps and/or priorities at the sub-sector level. Furthermore, enterprise agencies can facilitate contacts between stakeholders in these subsectors and companies seeking to develop solutions. The actions defined here are specific to the current state of the maritime sector. It does not involve conceiving KET-maritime solutions, rather highlighting existing needs of coastal and marine communities and economies. These needs must be communicated in a clear and transparent manner, to enable solution developers to rapidly engage with the stakeholders involved. In doing so the companies themselves identify the niche solutions which can make a difference, and are at the forefront of the KET-maritime sector. Furthermore, their contacts could help maritime stakeholders identify new needs, shaping new priorities into the medium term. Note that while these actions are evidently independent, it does not diminish their importance.

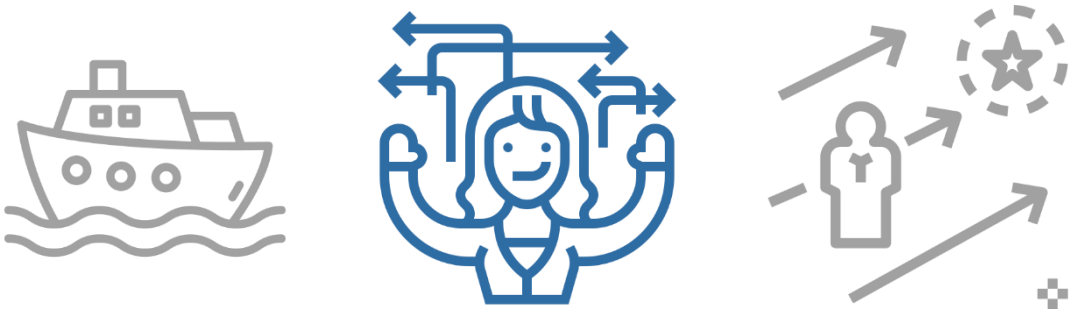


Table 44: Actions to facilitate companies and innovators rapidly engage with the maritime sector and identify niches.

Action Code	Action	Timeframe
KETM019	Help companies identify the customers and needs in the Maritime sector, for KET-maritime solutions.	Short
KETM020	Implement a user needs study of the maritime sector, laying out key target areas, to which KET technology developers can respond.	Short

Table 45: The independent nature of helping companies identify their own opportunity niches.

Action Area		KETM019	KETM020
Ensuring strategic innovation	Targeting short-term priority demonstrators		
	Identifying niches	✓	✓
	Responsible research and innovation		

Responsible research and innovation

Responsible research and innovation (RRI) is an approach that anticipates and assesses potential implications and societal expectations, with regard to research and innovation (in the context of public engagement, open access, gender, ethics and science education). The aim is to foster the design of inclusive and sustainable research and innovation. It implies that societal actors (researchers, citizens, policy makers, business, third sector organisations, etc.) work together during the whole research and innovation process, aligning both the process and its outcomes with the values, needs and expectations of society[11].

Adopting an RRI approach means that transparency, and visibly responding to societal and market needs, would be incorporated into a KET-maritime innovation ecosystem. To ensure this, it is vital that actors who align with the priority areas for demonstration, are strongly involved with shaping solutions. This has implications for a range of key action areas, such as ensuring value for money, fostering trust in the maritime sector, and establishing the foundations of the KET-maritime innovation ecosystem.

Table 46: Actions to ensure key stakeholders are at the forefront of guiding the direction of Europe's KET-maritime strategy.

Action Code	Action	Timeframe
KETM045	Ensure ports, and offshore renewable energy developers and engineers, are in the conversation regarding KET-maritime strategic initiatives.	Medium
KETM046	Ensure innovative KET-maritime applications development is within areas of maritime needs, framed iteratively by maritime stakeholders (e.g. Maritime company associations, sectoral stakeholders) by gathering information on specific maritime issues and maritime industry problems.	Short-medium

Table 47: Complementarities between ensuring Responsible Research and Innovation, and other action areas.

Action Area		KETM045	KETM046
Ensuring strategic innovation	Targeting short-term priority demonstrators		
	Identifying niches		
	Responsible research and innovation	✓	✓
Ensuring value for money: Strategic Monitored Demonstrations			✓
Developing trust: Demonstrating KET-maritime successes			✓
Building an innovation ecosystem: Building a community of Practice		✓	

[11] ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation

Equipping and capacity building for maritime innovation

Both the maritime and KET community are not ideally equipped to seize opportunities in a KET-maritime innovation ecosystem. There is a knowledge gap to be bridged, which prevents knowledge synergies from being realised. However, there are a range of simple, achievable actions which can unblock these restrictions. Targeted investment is needed in two primary areas. The first involves teaching and education, to raise awareness and community capability to recognise and seize opportunities in the unfamiliar sector. The second, involves equipping individuals, companies, institutes and agencies, with the tools and practices needed to carry innovations forward.

These two elements will enhance overall capacity for knowledge to flow, and synergies to form. It requires knowledge supports to be made available to build capacity in the existing workforce, and the next generation of innovators. It also involves harnessing and equipping Europe's extensive education assets, linking these to those innovators and companies that need to avail of them.

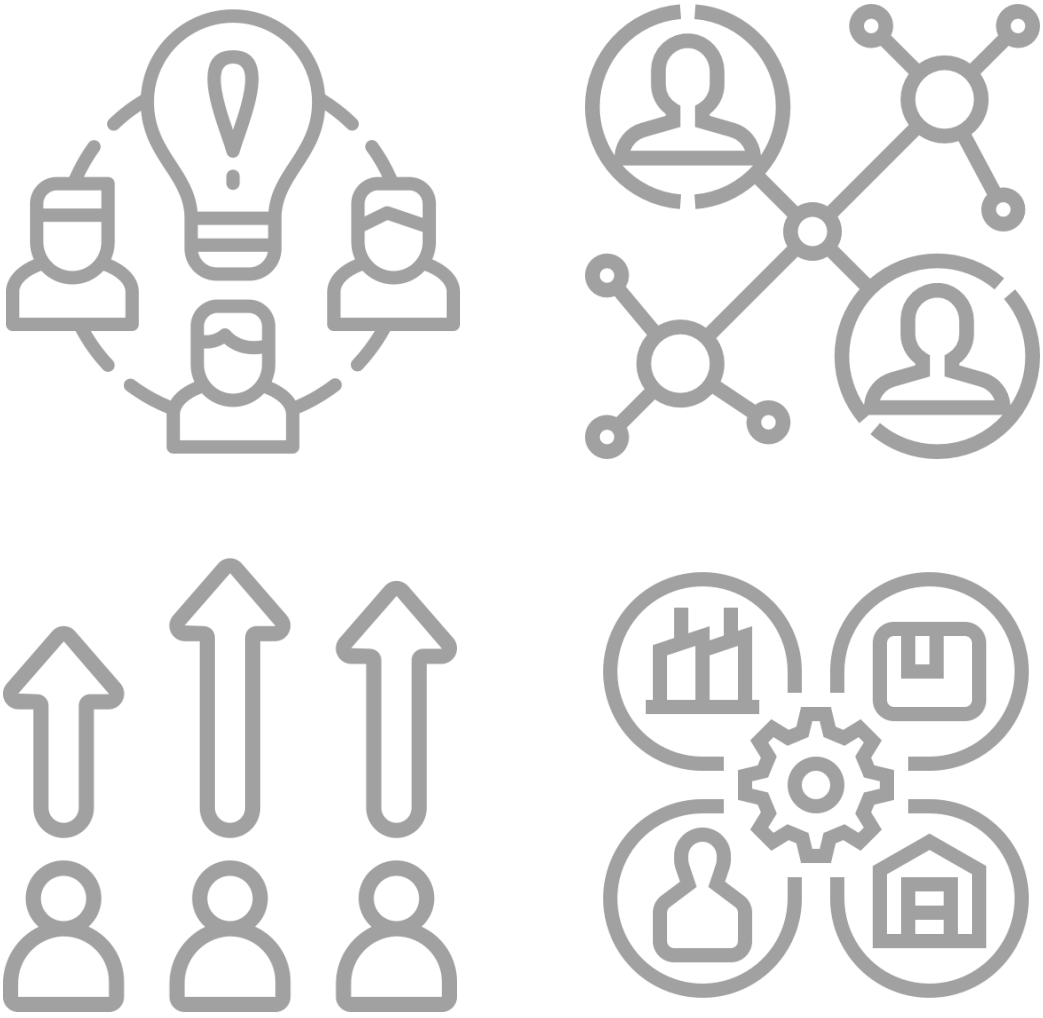


Figure 8: Synergies between capacity building activities, and goals across the other 4 roadmap foci.

Enhancing capacity for knowledge synergies

This roadmap aims to enable Atlantic Area societies and economies to harness the benefits that arise when one discipline meets another. The heart of this opportunity lies in people - those with knowledge of KETs meeting and working with others having knowledge of the marine world. There are many challenges to securing these interactions. For example there may be barriers in understanding each other, even if using a common language (e.g. different terms and phraseology in different sectors in the same native language). SMEs may lack the capacity to conduct Research & Development activities, preferring instead to innovate by Doing Using and Interacting with KETs. Underlying these challenges is an educational challenge – the need to equip innovators and communities to recognise potential, and collaborate towards realising beneficial synergies.

The key here is to ensure the environment is in place for disciplines and expertise to meet, knowledge to flow and synergise, and ideas to be captured and carried forward. The actions outlined in this section specifically address the knowledge aspect. Actions address the needs of companies to learn about available financial supports and information about other technology areas; they also recognise Europe's significant educational assets – a multitude of diverse, highly regarded third level institutions established in innovating, researching and educating. Furthermore, the need to foster knowledge synergies cannot omit the existing workforce. This involves providing knowledge supports, to equip and enable both marine and KET communities exploring synergy opportunities.



Knowledge supports for innovation

Upon conceiving a potential opportunity and solution, financing will be needed to test it and develop a proof of concept. Throughout the development process, different flavours of financing will be needed (for example demonstrator funding, accelerator financing, etc.). Furthermore, on the more practical side, there are logistical and technological uncertainties which need to be clarified such as where can the product be tested, and how can the innovator see what assets are available?

The actions suggested here address both the financial and non financial aspects of knowledge support. Addressing these areas would help innovators and business make connections, between idea-development, and financing. It would also enable technology access supports to be implemented, or harnessed, to ease the path into testing and examining the idea itself.

Table 48: Actions to help innovators identify the financial supports and technological assets they could use to develop an innovation.

Action Code	Action	Timeframe
KETM049	Support maritime and KET companies to engage with financial supports.	Short-medium
KETM059	Create technological support frameworks for non-KET innovators.	Medium

Table 49: Complementarities between knowledge supports for technology and financing, and other action areas.

Action Area		KETM049	KETM059
Enhancing capacity for knowledge synergies	Knowledge supports for innovation	✓	✓
	Leveraging Europe's education systems and resources		
	Staff training for innovation		
Fuelling innovation: Funding supports to facilitate innovators		✓	
Developing trust: Developing and supporting networks of trust			✓
Building an innovation ecosystem: Facilitating ideas and testing			✓

Leveraging Europe's education systems and resources

Education, vocational training and lifelong learning play a vital role in the economic and social strategies of the European Union (EU) and the United Kingdom. The EU's strategic framework for European cooperation in education and training for example, pursues four common objectives[12]: make lifelong learning and mobility a reality; improve the quality and efficiency of education and training; promote equity, social cohesion and active citizenship; and, enhance creativity and innovation, including entrepreneurship.

Alongside health, education is often considered as one of the most important investments a country can make in its people. Education has the potential to drive forward socio-economic development[13]. Its importance to realising the stakeholder's ambitions cannot be understated. The actions outlined here highlight the role that Europe's education assets could play as part of the KET-maritime innovation ecosystem. They recognise that truly disruptive and risky innovation can occur in the research settings of third level institutes, serving to de-risk the innovation process for commercial entities. Furthermore, all levels of the education system have a part to play, in equipping citizens to recognise opportunities linked to technological advances. Note that the actions suggested here should, where appropriate, harmonise with Continuous Professional Development (CPD) and/or accreditation for individuals in companies. It should also consider enabling those returning to education (later life learning), to maximise synergies of experience and new insights in the next generation of innovators.

Table 50: Actions to ensure the Atlantic Area's education assets are well placed to support and benefit from a KET-maritime innovation ecosystem.

Action Code	Action	Timeframe
KETM040	Explore the potential to integrate education on KET innovation into secondary level education.	Short
KETM052	Ensure the education (in particular both second and third level) sector is involved in the KET-maritime network, to maximise potential for best practice transfer, support of risk-reduced innovation, and fostering next generation innovators.	Short
KETM060	Ensure that education sector involvement is: - orientated towards the market, - focuses on the development of innovative and disruptive initiatives considered too risky for smaller private sector companies, - equipped to support both start-ups and traditional companies.	Short-medium





[12] https://ec.europa.eu/education/policies/european-policy-cooperation/et2020-framework_en [last accessed 14th November, 2020]

[13] https://ec.europa.eu/eurostat/statistics-explained/index.php [last accessed 14th November, 2020]

Table 51: Complementarities between enabling our education assets to synergise with the KET-maritime economy, and other action areas.

Action Area		KETM040	KETM052	KETM060
Enhancing capacity for knowledge synergies	Knowledge supports for innovation			
	Leveraging Europe's education systems and resources	✓	✓	✓
	Staff training for innovation			
Adapting policy frameworks: Equipping and resourcing public-sector supports				✓
Ensuring value for money: Synergising with Education		✓		✓
Building an innovation ecosystem: Facilitating ideas and testing				✓
Building an innovation ecosystem: Matching SMEs with partners and collaborators			✓	



Staff training for innovation

Countries throughout the Atlantic Area feature well-trained, well educated, and adaptable workforces. There is a culture of workplace training and capacity building across Europe's industrial sectors, liinked strongly with Continuous Proessional Development and accreditation for the workforce. This culture must be harnessed if we are to realise the KET-maritime vision. Key staff in the maritime sector must be equipped to recognise the value and potential of KETs. KET developers must be enabled to understand the perspectives of their maritime stakeholders and markets. Furthermore, the recognition of ideas and fair ownership of their conception and development is a learning challenge which must be addressed, particularly given that trust[14] is a key element underpinning a growing KET-maritime innovation ecosystem.

Table 52: Actions to ensure capacity is built in the Atlantic Areas existing industrial workforce to recognise and critically evaluate KET-maritime innovations.

Action Code	Action	Timeframe
KETM021	Implement targeted, tailor-made, employee training/workshops in KETs.	Short-medium
KETM043	Address the lack of clarity concerning IPR, providing guidance and surety to novice innovators, in particular those from non-commercial backgrounds.	Short







Table 53: Complementarities between capacity building efforts for the Atlantic Areas current workforce, and other areas.

Action Area		KETM021	KETM043
Enhancing capacity for knowledge synergies	Knowledge supports for innovation		
	Leveraging Europe's education systems and resources		
	Staff training for innovation	✓	✓
Developing trust: Rewarding innovators and supporters fairly			✓

[14] For further insights into trust, and the central role it plays in the development of trans-disciplinary, and commercial innovation, see Ellingsen, M-B., Normann, A.K., Scarrott, R., Ferreira, F., O' Mahony, C., Alves, A.S. (2016) *Innovation mechanisms for the space and maritime sectors*. Deliverable report under the European Space Agency CINMarS project (contract no. 4000113554).

Demonstrating KETs and Enhancing maritime awareness

An overwhelming aspect of the stakeholder perspectives concerned the lack of awareness about KETs in the maritime community. The lack of awareness not only limits the volume of maritime stakeholders seeking KET solutions, it also restrains the development of trust in the maritime community in new technologies.

A dual-avenue approach is proposed here. The first concerns awareness raising activities themselves. It highlights the need to be strategic to maximise activity impact, and focus on harnessing the growing evidence of KET-maritime innovations in subsequent outreach activities. The second avenue concerns producing the evidence, demonstrating the application of KET technologies to meet maritime means. It also provides guidance on how to approach and target these demonstration activities, recognising the need for short and long term perspectives, and the need to examine and ease the innovation to commercialisation process.

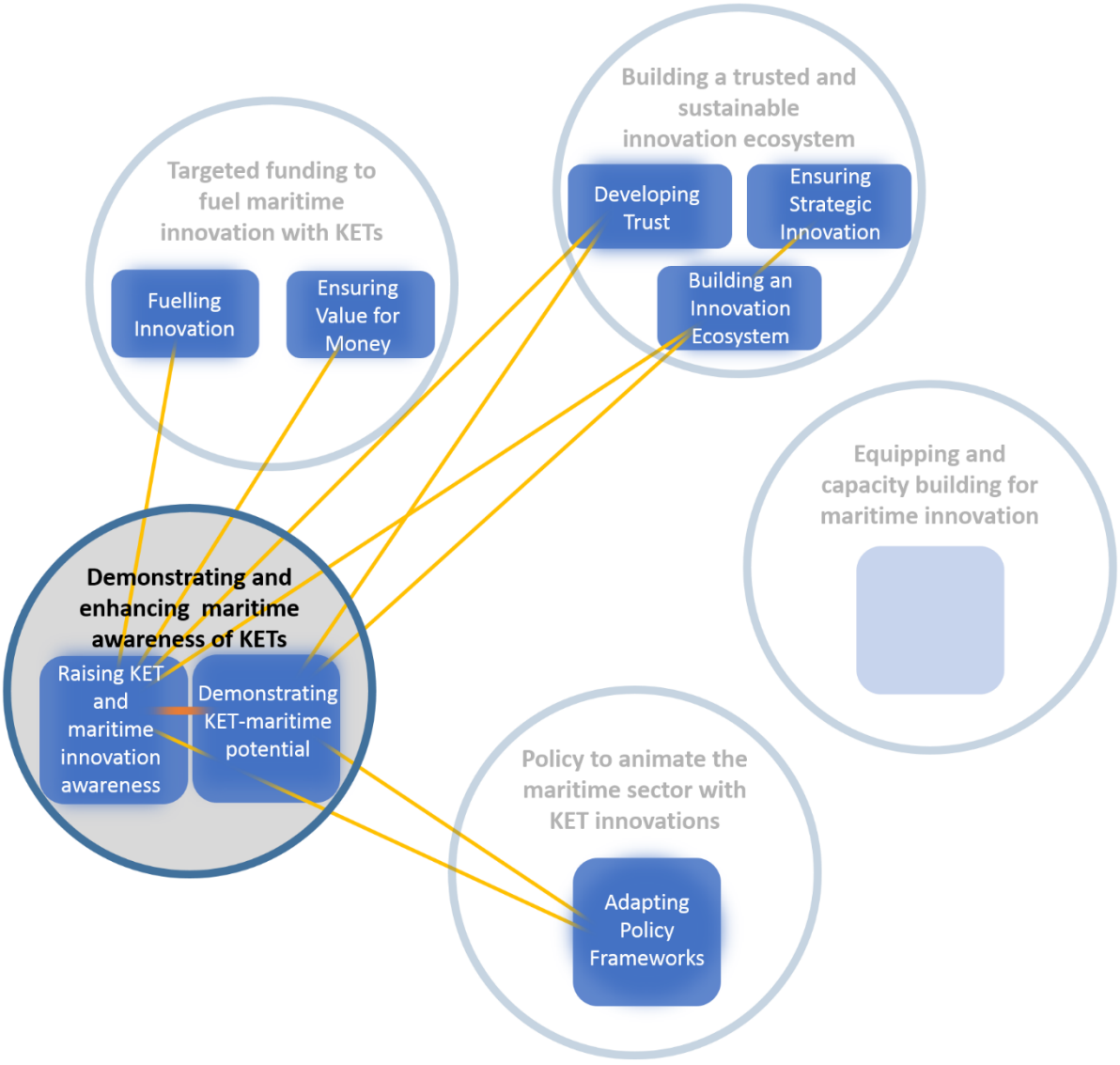
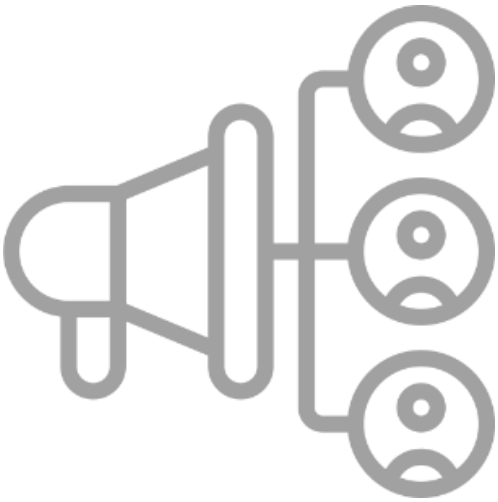


Figure 9: Synergies between demonstrating KET applications to the maritime sector, and enhancing awareness, and goals across the other 4 roadmap foci.

Raising KET and maritime innovation awareness

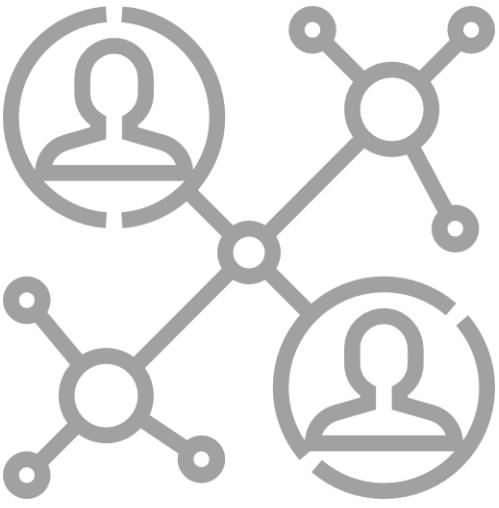
A lack of awareness presents a challenge for any innovator or company attempting to reach maritime markets with new and innovative technologies or products. It also serves to reduce the impact of any investments into building a vibrant, and rapidly growing, KET-maritime innovation ecosystem. To address this, strategic investment in awareness raising, and outreach is needed. It involves two primary audiences – the maritime community, and the KET community. As such, outreach efforts must seek to highlight the potential of KETs in maritime forums, and opportunities in the maritime sector in KET forums.

It is important that this outreach does not oversell the potential of KETs, but presents real, pragmatic opportunities founded on evidence. This is critical given the need to build trust in the maritime sector for new technologies. It is also important that this outreach opens the doorway to further engagement, offering windows for the KET community to examine maritime realities, and work with the maritime sector to identify further opportunities and synergies.









Strategic outreach and animation

Outreach and awareness raising requires resources. It is essential these resources are deployed in a strategic targeted manner, addressing those people who can best animate others within their networks and / or other communities. The following actions shape the manner, and priorities of any coordinated outreach seeking to animate potential KET-seeking stakeholders in the maritime sector.

Table 54: Actions to ensure the impact of resourcing outreach about KETs is maximised and targeted.

Action Code	Action	Timeframe
KETM022	Ensure KET outreach in the maritime sector is prioritised and targeted (initially, and not exclusively) towards key sub-sectors: Fisheries and Aquaculture; Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Short
KETM023	Conduct targeted informative outreach activities, to maximise awareness of KETs, at: • global maritime events; maritime trade shows; • trade conferences in marine monitoring, offshore energy, and wind energy; • maritime trade shows.	Short
KETM024	Conduct awareness activities which include: • Holding outreach booths at conferences and trade shows; • Implementing targeted 1-day workshops at conferences, and within companies, which feature intermediaries (translators) to translate maritime needs to the KET community, and KET opportunities to the maritime community.	Short
KETM025	Support outreach activities with: • Visual outreach materials summarising KET-enabled products; • Information, and stories about successfully and practical KET maritime application products (demonstrations); • Information regarding cost savings and financial opportunities, and alignment with environmental sustainability.	Short
KETM026	Invest in targeted awareness building with educational material on KETs, to inform maritime innovators about KETs.	Short
KETM047	Identify companies active in KET technologies in EU Atlantic regions, and promote their existence.	Short
KETM057	Support targeted demonstration initiatives by companies, which create real maritime products & services, demonstrate the business case, and achievable business opportunities possible by collaboration between maritime and KET communities.	Short



Table 55: Complementarities between targeted outreach activities, and other action areas (Table 1 of 2).

Action Area		KETM022	KETM023	KETM024	KETM025
Raising KET and maritime innovation awareness	Strategic outreach and animation	✓	✓	✓	✓
	Awareness raising with evidence				

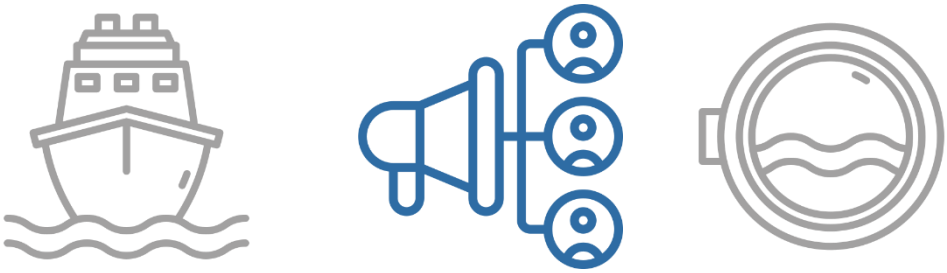


Table 56: Complementarities between targeted outreach activities, and other action areas (Table 2 of 2).

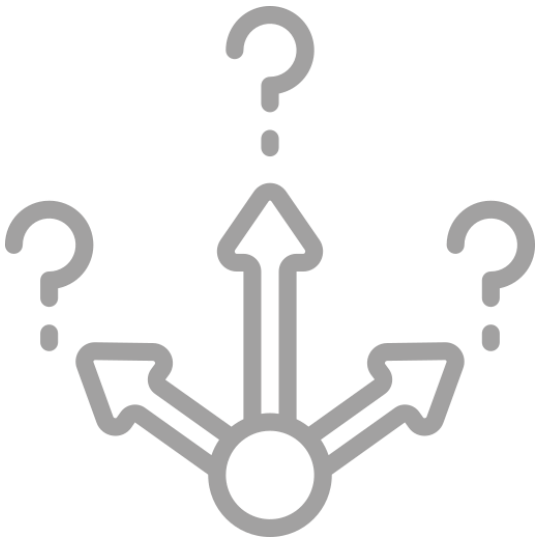
Action Area		KETM026	KETM047	KETM057
Raising KET and maritime innovation awareness	Strategic outreach and animation	✓	✓	✓
	Awareness raising with evidence			
Developing trust: Demonstrating KET-maritime successes				✓
Developing trust: Developing and supporting networks of trust			✓	
Building an innovation ecosystem: Building a community of Practice			✓	
Demonstrating KET-maritime potential: Demonstrating KETs meeting maritime needs				✓

Awareness raising with evidence

In the age of widespread dis- and mis-information, building trust is a challenge any innovator or company faces. This roadmap recognises the challenge faced in building this trust, and recommends that insofar as is practical attention is paid to ensuring perspectives disseminated are factual, traceable, and transparent. The evidence of benefits, successes and challenges arising from the growing KET-maritime innovation ecosystem must be acknowledged, and used to guide the community forward. This requires not only the principles of being open and honest, but also being aware of what is occurring in the KET and maritime sectors, and the KET-maritime innovation ecosystem. This is particularly important when considering the investment of taxpayer funds in key animating and support activities.

Table 57: Actions towards establishing evidence-based awareness raising, to support and animate an innovation ecosystem.

Action Code	Action	Timeframe
KETM039	As the KET-maritime activity increases, gather information to clearly describe the professional and economic advantages which are evident in KET applications to the maritime sector.	Short-medium
KETM055	Create a long-term adaptable framework for monitoring successes and challenges innovators are facing, with measurable (monitorable) indicators of impact, and aiding the promotion of success stories.	Short
KETM056	Ensure initiatives examine how KETs perform in boosting maritime economies and commercial activity (e.g. reducing operating costs, or improving productivity), actively raise awareness of it, and factor this into their project strategy.	Medium



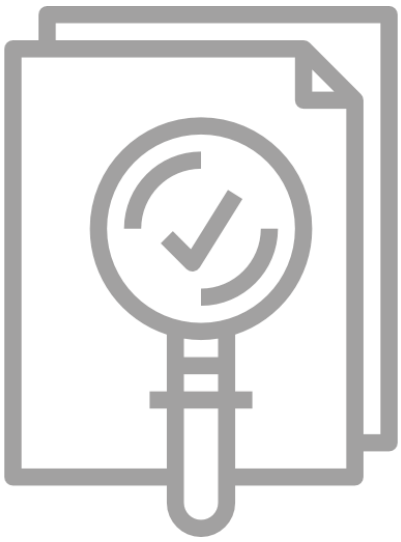
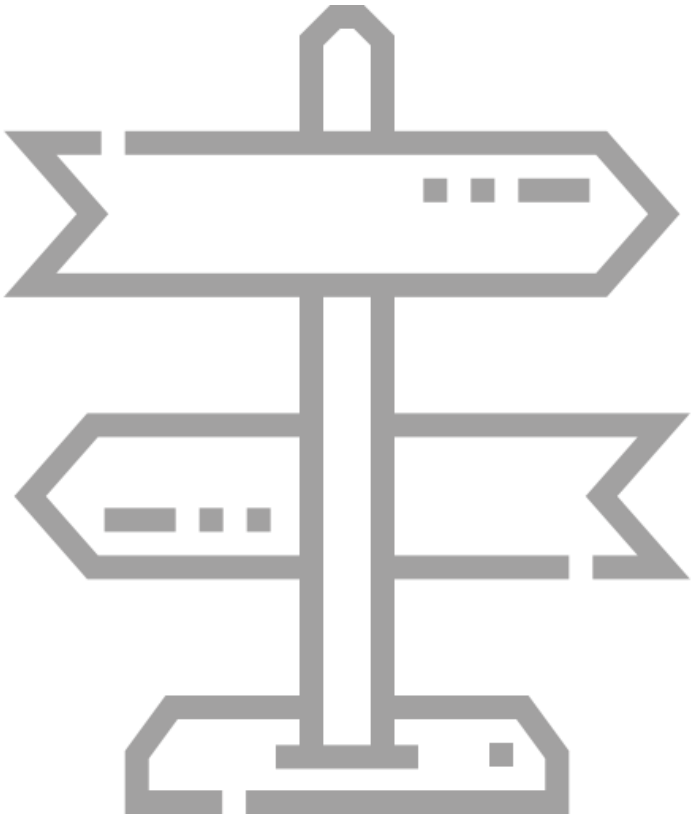


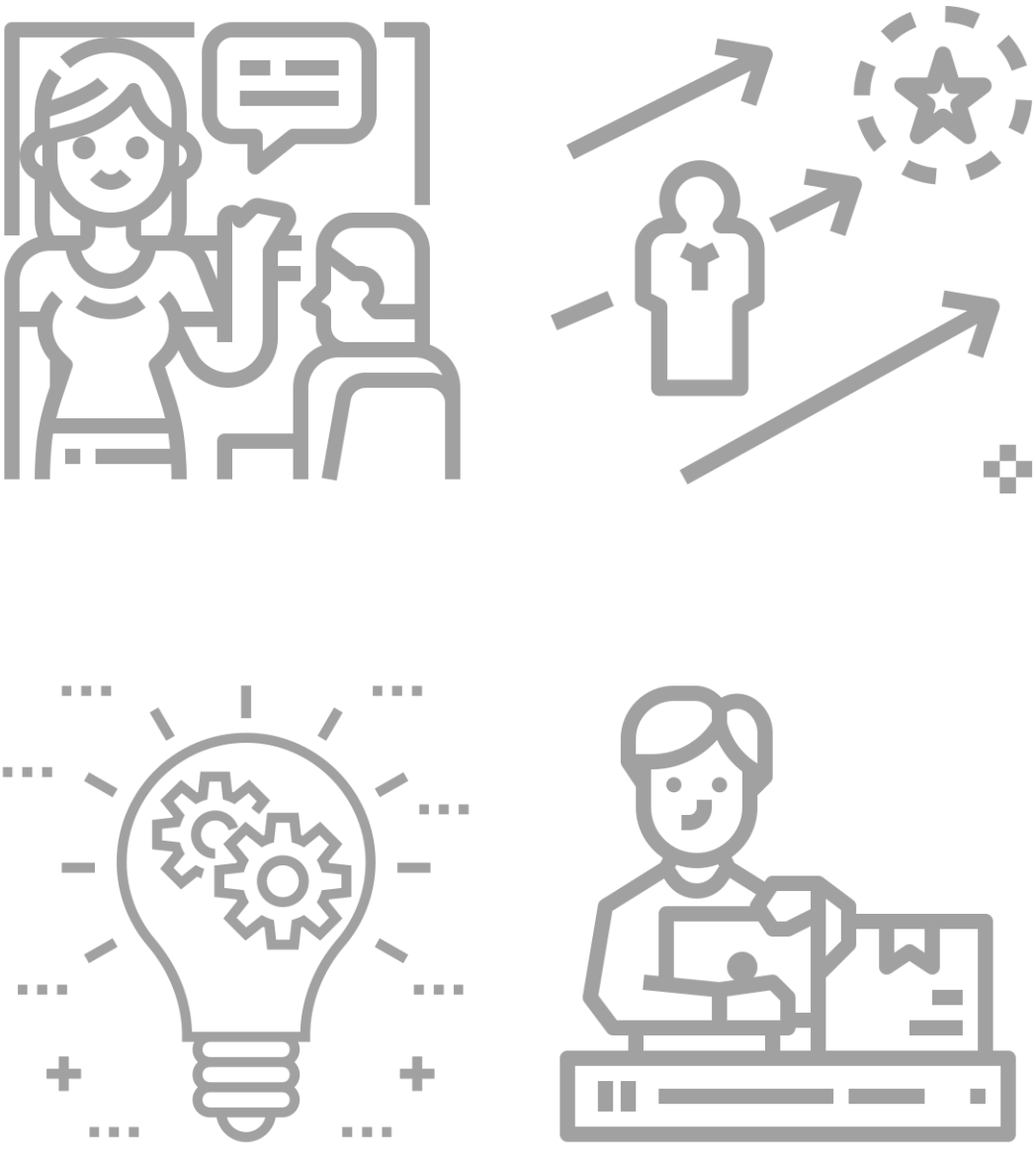
Table 58: Complementarities between actions to ensure awareness raising maximises the use of evidence, and other action areas.

Action Area		KETM039	KETM055	KETM056
Raising KET and maritime innovation awareness	Strategic outreach and animation			
	Awareness raising with evidence	✓	✓	✓
Adapting policy frameworks: Ensuring responsive policy			✓	
Fuelling innovation: Shaping funding initiatives to animate the KET-maritime ecosystem				✓
Ensuring value for money: Monitoring an advancing maritime landscape		✓		
Ensuring value for money: Ensuring supports to adapt to advances			✓	
Ensuring value for money: Strategic Monitored Demonstrations				✓



Demonstrating KET-maritime potential

A key perspective from the maritime stakeholders involved in the roadmapping process, was the need to see examples of KET-maritime innovation. To this end, a critical short-term priority must be demonstrating KET-maritime innovations in a transparent and open manner. This section describes actions to frame demonstrating, actions to facilitate faster testing of novel ideas, and actions to ensure the longer-term perspective is not lost in the short term drive to demonstrate. It also suggests priority areas within which demonstration activities should take place in the short term.



Rapid testing for accelerated innovation

Healthy competition is an important facet of the envisioned innovation ecosystem. For innovators, the time taken to get an innovative idea into testing, can severely affect the timely release and success of any derived products and services. A healthy innovation ecosystem will produce a number of products and services, a selection of which will translate into commercial success.

This action highlights the need to critically examine the supports available to get ideas into testing. It highlights the need to examine whether the process of accessing them is rapid and effective enough to meet the needs of a rapidly growing community of innovators and range of ideas.

Table 59: Actions to ensure the route from conceptualisation to testing is as effective and efficient as possible for innovators and companies.

Action Code	Action	Timeframe
KETM033	Ensure efficient and effective supports are available for Innovators, scientists and technology developers to trial KET technology transfers.	Short



Table 60: Complementarities between streamlining conceptualisation to testing, and other action areas.

Action Area		KETM033
Demonstrating KET-maritime potential	Rapid testing for accelerated innovation	✓
	Promoting long-term innovation	
	Framing Demonstrations	
	Demonstrating KETs meeting maritime needs	
Adapting policy frameworks: Grounding supports in policy		✓

Promoting long-term innovation

There is a risk that the drive to demonstrate would lead policy makers and innovators to lose sight of the long term goal, and restrict activities in fundamental scientific progress towards disruptive innovations. This also recognises that, while there are priority areas available for KETs to provide potential solutions, the KET sector is relatively young, and the scientific fields underpinning it are rapidly advancing. Some of these discoveries are important from the fundamental science perspective, but it will take time for them to make it to the applications level.

This emphasizes the need for this roadmap to adopt a long-term perspective. Demonstrator supports and funding are not only a short term priority, but must remain to support new discoveries, as they make it to the applications field. For those doing fundamental science with a goal of commercial applications, demonstrator funding must be long term, to enable the science to progress without the risk of a cash-flow disruption. Whilst this will be applicable in only a subset of the innovation developments, its importance cannot be understated, as long term progress coupled and synergising with shorter term progress is a stabilising facet of a sustainable innovation ecosystem. Note that the action itself is short-medium term, ensuring the long term perspective is integrated into the very start of the innovation ecosystem to shape future developments. Whilst the action itself is independent in nature, this does not diminish its importance and relevance to sustainable growth and progress.

Table 61: Actions to secure both longer term, and shorter-term perspectives in demonstrating KET benefits for the maritime sector.

Action Code	Action	Timeframe
KETM027	Ensure the demonstrator funding: - de-risks development (providing more cash-flow security for private investor stakeholders in truly innovative ventures); - adopts a longer-term perspective, to ensure funded demonstrators align with a longer term KET-maritime technology development strategy.	Short-medium

Table 62: Complementarities between promoting a longer term perspective in a subset of demonstrators, and other action areas. Note that the independence of an action does not diminish its importance for the innovation ecosystem envisioned.

Action Area		KETM027
Demonstrating KET-maritime potential	Rapid testing for accelerated innovation	
	Promoting long-term innovation	✓
	Framing Demonstrations	
	Demonstrating KETs meeting maritime needs	

Demonstrating KETs meeting maritime needs

To build a sustainable KET-maritime innovation ecosystem, KET innovators and developers must demonstrably be developing solutions that address real issues in the maritime sector. This builds trust with their stakeholders and markets, and trust in the technologies themselves. To this end, this roadmap emphasizes the need for KET demonstration activities to have the development flexibility to respond to unforeseen aspects of maritime realities. Having stakeholders engaged iteratively is crucial to realising this goal. Furthermore, the precautionary principle must apply. KET applications must not damage the sector which is seeking their help, and must remain in line with the environmental and socio-economic strategies of European states.

Table 63: Actions to ensure the KET demonstrations meet needs, and avoid creating issues.

Action Code	Action	Timeframe
KETM028	Ensure consideration of an innovation's environmental impact forms part of pilot demonstration activities which are funded.	Short
KETM029	Ensure the funded demonstrators have the flexibility to: • align with existing infrastructure and practices; • respond and adjust concepts/development quickly to the real stakeholder needs early on in development.	Short



Table 64: Complementarities between demonstrating to meet maritime needs, and other action areas.

Action Area		KETM028	KETM029
Demonstrating KET-maritime potential	Rapid testing for accelerated innovation		
	Promoting long-term innovation		
	Framing Demonstrations	✓	✓
	Demonstrating KETs meeting maritime needs		

Targeting Key Demonstrations

Prioritisation of short term demonstrations is needed to provide tangible evidence to the maritime sector, of the potential value of KETs. The roadmapping process has identified a number of priority areas for KETs to investigate, and for supporting agencies to facilitate engagement. Medium term priorities were also identified by the stakeholders involved in the roadmapping process, which are also presented in these actions.

Table 65: Actions to guide the framing of short- and medium- term demonstration activities

Action Code	Action	Timeframe
KETM030	Fund demonstrator projects to advance: • Deploying advanced biotechnology to improve fish health, and health monitoring, within aquaculture facilities; • Improving offshore facilities monitoring by deploying KET-enabled sensors and sensor systems on these facilities; • Enhancing offshore facilities durability using corrosion-resistant materials; • Improving offshore resource monitoring capabilities through sensors; • Reducing bio-fouling impacts on structures and sensors by application of novel biotechnology or nanotechnology solutions; • Improving environmental monitoring to detect threats and improve forecasting.	Short
KETM057	Support targeted demonstration initiatives by companies, which create real maritime products & services, demonstrate the business case, and achievable business opportunities possible by collaboration between maritime and KET communities.	Short
KETM058	Fund demonstrator KET-maritime activities in the following priority subsectors: Fisheries and Aquaculture (noting some may need to be prioritised); Blue biotechnology; Marine Renewable Energy; Maritime surveillance; Ship and boat building; Ports and Transport Logistics.	Medium

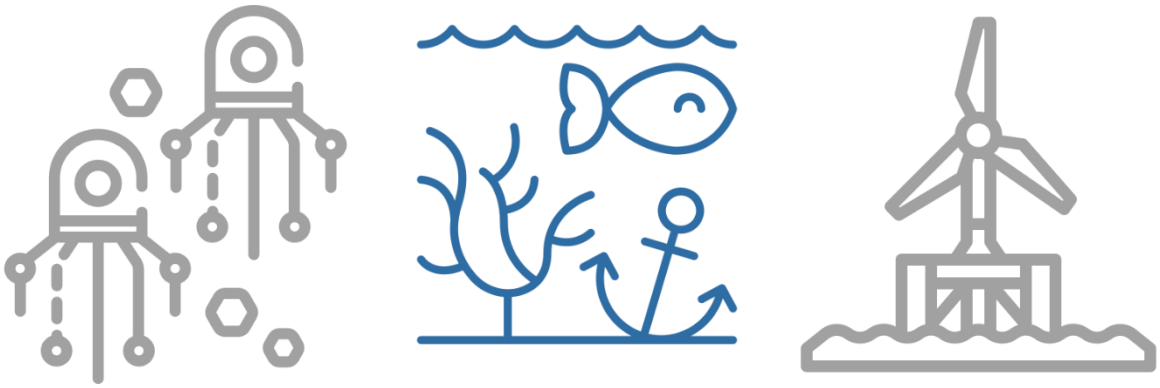
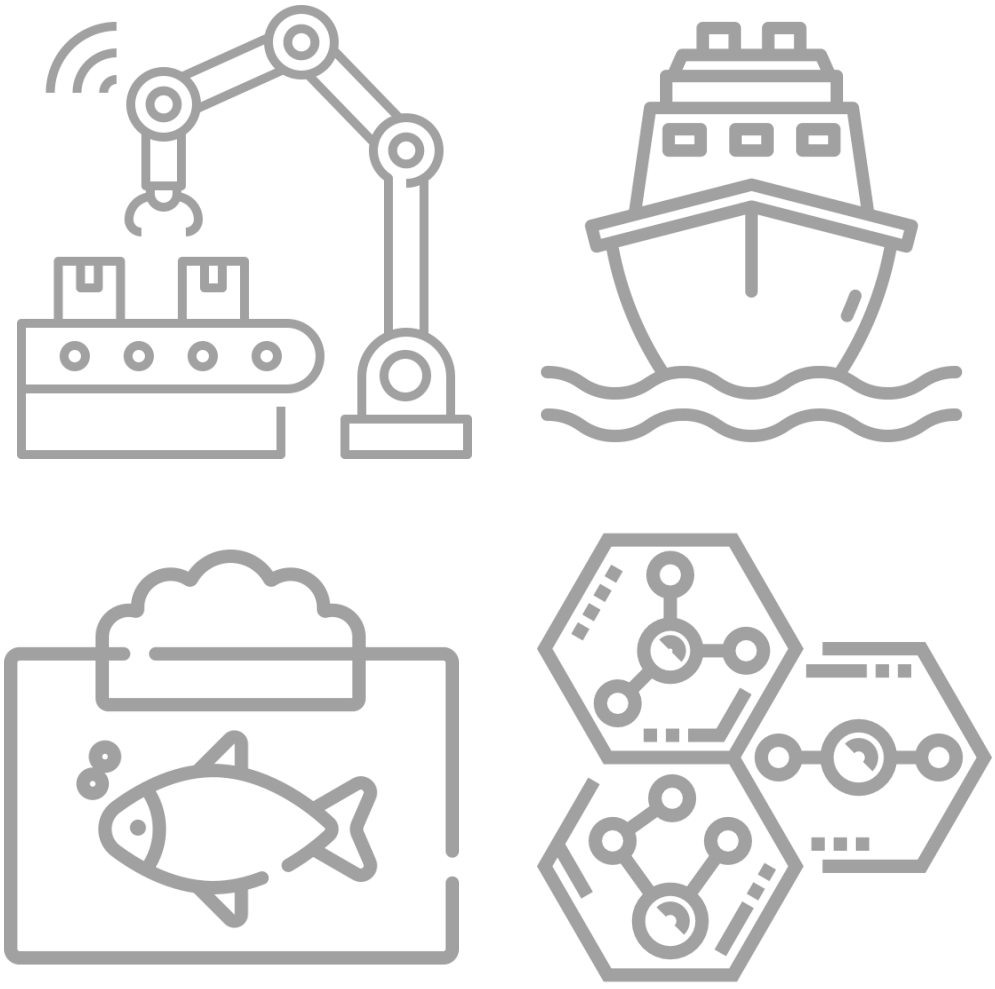


Table 66: Complementarities between the priority demonstration areas highlighted, and other action areas.

Action Area		KETM030	KETM057	KETM058
Demonstrating KET-maritime potential	Rapid testing for accelerated innovation			
	Promoting long-term innovation			
	Framing Demonstrations			
	Demonstrating KETs meeting maritime needs	✓	✓	✓
Developing trust: Demonstrating KET-maritime successes			✓	✓
Ensuring strategic innovation: Targeting short-term priority demonstrators				✓
Raising KET and maritime innovation awareness: Strategic outreach and animation			✓	



Priority areas for Research and Technology Development

The potential for KET applications across the Blue Economy is extensive, and all sectors offer at least some opportunities for KETs. Within this landscape, the following sectors are identified as having strong growth potential where KET's can help to drive that growth[15]:

Fisheries & Aquaculture

- Industrial Biotechnology: there is a significant potential for biotechnology methods to enhance fish husbandry in aquaculture facilities (e.g. reducing susceptibility to disease) and also in developing sustainable alternatives to fish meal. Given the expected growth in aquaculture, this application is likely to be large.

Blue Biotechnology

- Industrial biotechnology: there is growing interest in applying biotechnology methods to harvesting of bioresources from the sea, such as materials for clinical and pharmaceutical products, and well as prospecting for genetic material for medical research. Although this resource forms part of the 'blue biotechnology' sector, the majority of value-add will be generated in non-marine sectors.

Maritime Surveillance

- Micro- and nano-electronics: this is a very high growth sector with a high dependency on innovation in miniaturised, low power sensing and imaging devices. The level of historic RTD investment appears to be inadequate, but this needs to be checked since the rapid growth in this market has been relatively recent.

- ICT: advanced data analytics will play a critical role in extracting useful information from the big data resources new coming available from satellites, drones and ground-based devices (radars, sensors etc.). Behavioural analysis of fishing vessels can detect illegal fishing, and this kind of application will grow as fisheries management improves.

Marine renewable energy

- Advanced materials: Improvement in reliability and reduction in operations and maintenance (O&M) costs will be essential if cost competitiveness of marine renewable energy is to be achieved. The hostile environment (both underwater and in saline above-water conditions) in which these systems must operate is a key factor in determining O&M costs. Advanced materials can help overcome these challenges.

Ship & boat building

- Advanced manufacturing techniques: as modular fabrication approaches for vessel construction continue to expand, the role of advanced manufacturing techniques will grow. More off-site fabrication will take place in factories, freeing up capacity at ship yards. Introduction of mass-produced autonomous vessels will also create opportunities for advanced manufacturing facilities.

[15] See Williams, J. *et al.* (2020) *Plan to extend KET maritime outputs exploitation beyond the project.* Deliverable Report (D3.2) under the INTERREG Atlantic Area KETmaritime project (E.U. Grant no. EAPA_595/2016).

Priorities for research and technology development

Four areas have been identified where the growth potential of KET application is not adequately reflected in recent investment in KET development[16]. These are:

- **Advanced materials application in marine renewable energy**. This sector is growing very strongly yet requires enhanced technology to minimise degradation in the hostile offshore environment. The advanced materials KET has an important role to play, yet only 0.4% of a research database developed in this project[16] is directed at this field of application.

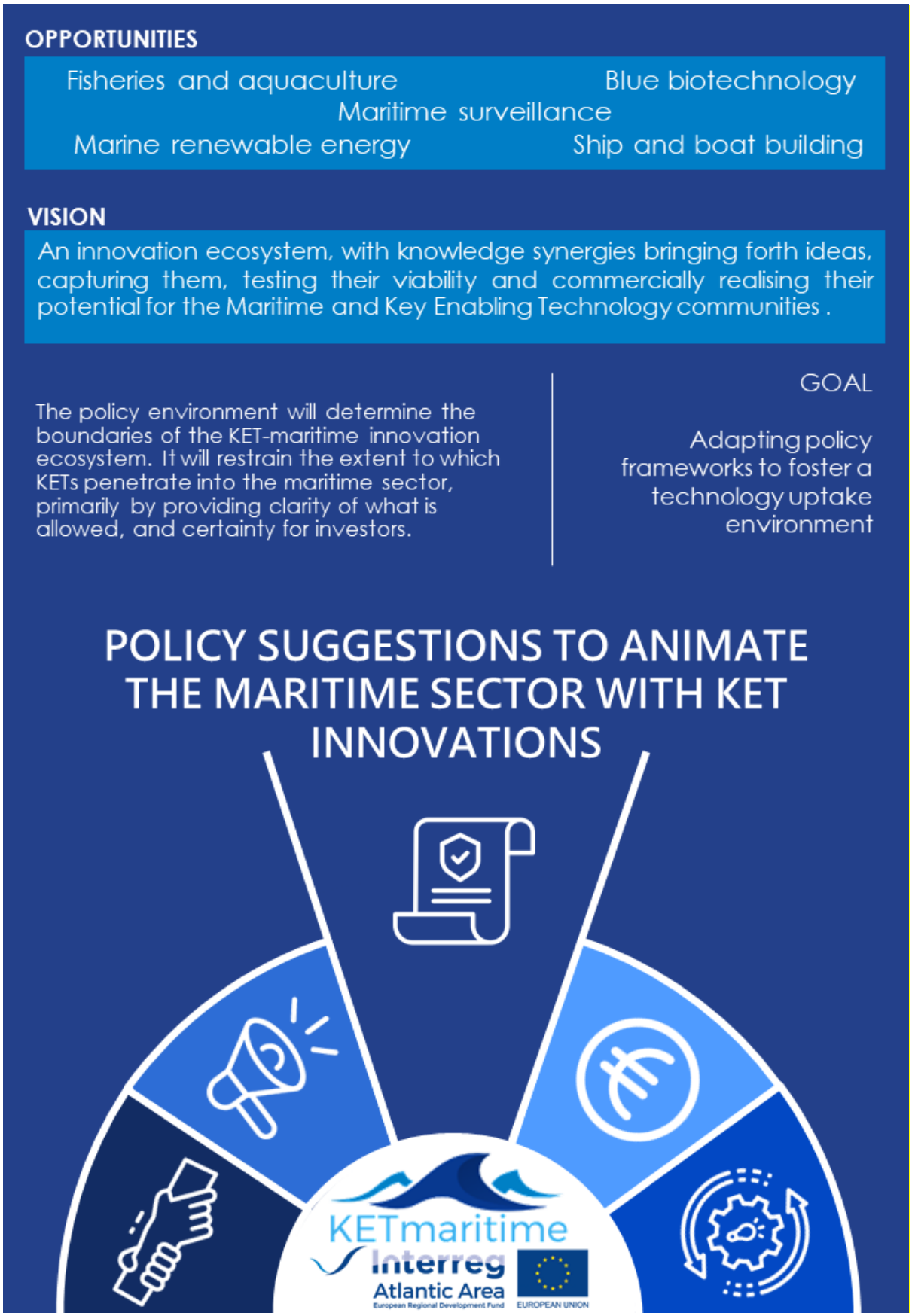
- **Photonics application in maritime surveillance**. This sector is also growing very strongly as effective governance of marine resources and maritime homeland security become more important. Photonics has a variety of roles, both in terms of imaging techniques and sensing devices, yet again only 0.4% of a research database developed in this project[16] is directed at this field of application.

- **Micro- and nano-electronics in maritime surveillance**. In addition to photonics, micro- and nano-electronics has a critical role in development of smart devices for detection and tracking of vessels. Such devices also have a crucial role in enabling fishery monitoring both to conserve stocks and to prove food provenance. 2.1% of a research database[16] is directed at this field of application which is considered too low in relation to its importance.

- **Advanced manufacturing techniques in ship and boat building**. Although ship and boatbuilding is a traditional, mature sector of the blue economy, it is also critical to the operations within other high-growth sectors. Builders are innovating rapidly in response to these opportunities, and advanced manufacturing techniques have a vital role to play in that innovation. An RTD level of 3% of a research database[16] is considered too low in relation to the strategic importance of this sector.

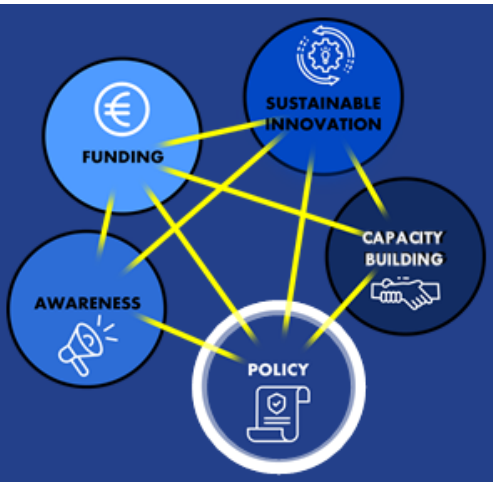
[16] The research database is contained in Williams *et al.* (2020) *Plan to extend KET maritime outputs exploitation beyond the project*. Deliverable Report no. 3.2 under the INTERREG-AA-funded KETmaritime project (Grant no. EAPA_595/2016).

Annex A – policy briefs



Adapting policy frameworks to foster a technology uptake environment

- Ground supports in policy
- Map existing supports and contributory sectors
- Equip and resource public-sector supports
- Ensure policy is responsive to an expanding and rapidly innovating sector



For detailed guidance on specific actions to achieve progress in action areas, see the KETmaritime Roadmap, available at www.ketmaritime.eu

Case study 1 of Marine opportunities with KETs

ADVANCED MANUFACTURING APPLICATIONS FOR SHIPBUILDING

Advanced manufacturing is not exclusive to any nation, nor limited to a specific technology. It incorporates of a range of innovative technologies within the manufacturing process, making an entire operation more agile, flexible and efficient.

Several forms of technology will greatly influence the future of shipbuilding:

- **Digital manufacturing technologies**, involving tools for design, simulation, engineering, manufacturing, 3D scanning and 3D printing.
- **Complementary technologies** including **ICT** infrastructures, technologies and services such as wireless networks, mobile devices, cloud computing, low cost development hardware, cross-platform programming languages and wearables. embraces current innovative technologies.
- Approaches such as **automation**, a key driver towards 'intelligent' robotics, artificial vision and autonomous vehicles.
- **Simulation and immersion technologies**, that are set to have a major impact involving virtual and augmented reality.

Advanced Manufacturing is now of greater relevance and importance than ever before for ship building. It is becoming highly compatible, lending itself to scalable implementation, and is also approaching a point of maturity and affordability which make the technologies and approaches commercially viable.

For further information, see the KETmaritime case study on **Advanced Manufacturing for shipbuilding**, available at www.ketmaritime.eu

This project has received funding from the European Union's INTERREG Atlantic Area Programme E.U. Grant no. EAPA_595/2016. The views and opinions expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the European Union.

OPPORTUNITIES

Fisheries and aquaculture — Blue biotechnology

Maritime surveillance

Marine renewable energy — Ship and boat building

VISION

An innovation ecosystem, with knowledge synergies bringing forth ideas, capturing them, testing their viability and commercially realising their potential for the Maritime and Key Enabling Technology communities .

A key tool to realise European Atlantic ambitions is the use of strategic targeted investment. With this they can promote activity in desirable sectors of the economy, and reinforce its perceived importance in the private investment community.

GOALS

Fuelling Innovation

Ensuring Value for Money

TARGETED FUNDING TO FEUL MARITIME INNOVATION WITH KETS

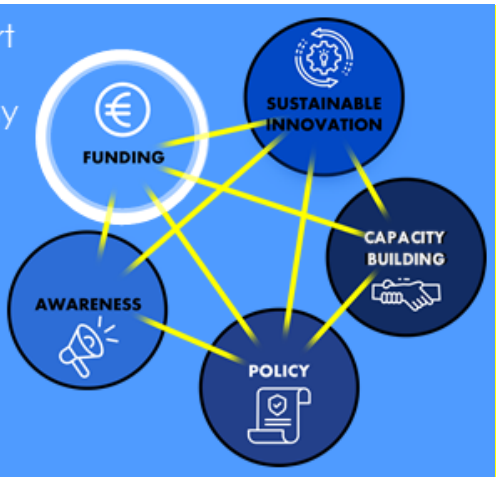


Fuelling Innovation

- Clarify what is available to support development
- Synergise with the digital economy
- Fund supports to facilitate innovators
- Shape funding initiatives to animate the KET-maritime ecosystem

Ensuring Value for Money

- Monitor an advancing maritime landscape
- Synergise with education
- Ensure supports to adapt to advances
- Monitor strategic demonstrations



For detailed guidance on specific actions to achieve progress in action areas, see the **KETmaritime Roadmap,** available at **www.ketmaritime.eu**

Case study 2 of Marine opportunities with KETs

NANOTECHNOLOGY MARINE APPLICATIONS

There is a growing interest in the pioneering form of technology known as Nanotechnology, which approaches products and processes from the smallest achievable physical scale. It's a broad concept that covers the design, characterization, production and application of structures, devices and systems by controlling shape and size at the molecular or atomic scale.

There are a multitude of ways in which nanotechnology can be applied to the marine sector and maritime environments. Key areas of interest include:

- **Nanocoatings** that protect against **corrosion and biofouling** on ships - two of the largest challenges affecting material exposed to harsh marine conditions
- The implementation of **nanotubes within shipbuilding materials** which significantly increases the strength of raw materials without increasing weight.
- **Nanostructured materials** can be used in the Oil & Gas industry – when used within filtering operations prior to the return of water to the environment, they drive performance by reducing the cost of conditioning operations by having a greater ability to retain contaminants compared to traditional filtering materials.
- The technology is also being used to advance the development of **fuel additives**, **alternative powering systems**, **aquaculture and fisheries**

For further information, see the KETmaritime case study on **Nanotechnology Marine Applications**, available at **www.ketmaritime.eu**

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OPPORTUNITIES

Fisheries and aquaculture
Blue biotechnology
Maritime surveillance
Marine renewable energy
Ship and boat building

VISION

An innovation ecosystem, with knowledge synergies bringing forth ideas, capturing them, testing their viability and commercially realising their potential for the Maritime and Key Enabling Technology communities .

Developing trans-sectoral trust, and market-developer partnerships are essential to the Atlantic Area realising ambitious KET-maritime growth, and a thriving innovation ecosystem. It requires targeted effort being dedicated to helping innovators and companies bridge sectoral, societal, and often spatial barriers and obstacles.

GOALS

Fostering Trust

Building an Innovation Ecosystem

Ensuring Strategic Innovation

BUILDING A TRUSTED AND SUSTAINABLE INNOVATION ECOSYSTEM



Fostering Trust

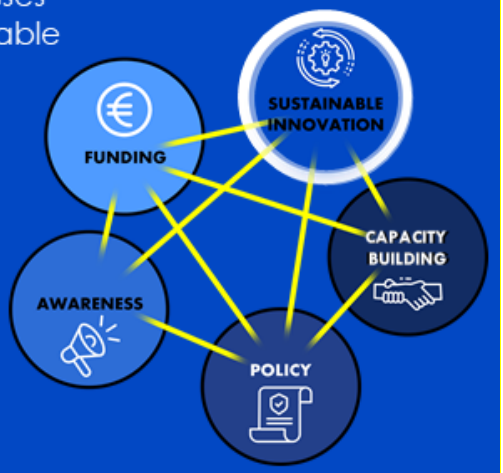
- Demonstrate KET-maritime successes
- Ensure info on KETs is readily available
- Develop and support networks of trust
- Ensure innovators and supporters are rewarded fairly

Innovation Ecosystem

- Build a community of practice
- Facilitate ideas and testing
- Match SMEs with partners and collaborators
- Promote knowledge transfer

Strategic Innovation

- Target short-term priority demonstrators
- Identify niches
- Embrace Responsible Research and Innovation



For detailed guidance on specific actions to achieve progress in action areas, see the **KETmaritime Roadmap**, available at **www.ketmaritime.eu**

Case study 3 of Marine opportunities with KETs

MARINE INDUSTRIAL BIOTECHNOLOGY

Industrial biotechnology is the application of biotechnology for industrial processing and production of chemicals, materials and fuels. Blue Industrial Biotechnology is used within the marine sector to explore and exploit marine resources to develop industrial products and processes. The KETmaritime project identified a number of key applications involving a high level of joint development:

- **Novel Enzymes and Micro-Organisms** - The development of novel bioprocesses demands new enzymes and micro-organisms with **high performance** qualities, which are able to withstand challenging environments such as high temperature and pressure. The marine environment offers an excellent source for these kinds of enzymes and micro-organisms, which have adapted to live in extreme conditions.
- **Marine Biomaterials and Biopolymers** – The marine environment is the source of a variety of components such as proteins and peptides (collagen, gelatine), polysaccharides (alginate, carrageenan, agar, chitin, chitosan), fatty acids (omega-3, DHA, EPA), vitamins and minerals.
- **Bioenergy** - **Biofuels** derived from the marine environment are being used as a potential source of **sustainable energy** contributing to future **global demands**

For further information, see the KETmaritime case study on **Marine Industrial Biotechnology**, available at **www.ketmaritime.eu**

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OPPORTUNITIES

Fisheries and aquaculture

Blue biotechnology

Maritime surveillance

Marine renewable energy

Ship and boat building

VISION

An innovation ecosystem, with knowledge synergies bringing forth ideas, capturing them, testing their viability and commercially realising their potential for the Maritime and Key Enabling Technology communities .

The heart of this opportunity lies in people - those with knowledge of KETs meeting and working with others having knowledge of the marine world. The key here is to ensure the environment is in place for disciplines and expertise to meet, knowledge to flow and synergise, and ideas to be captured and carried forward.

GOAL

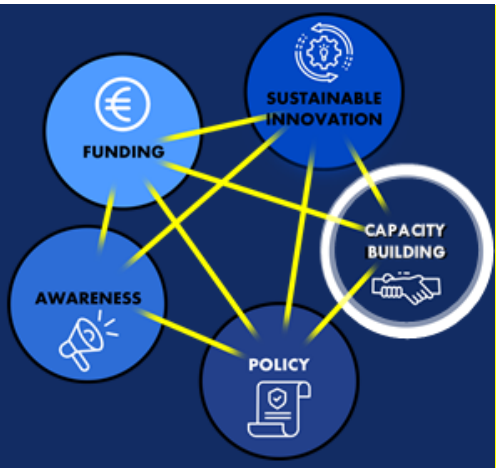
Enhancing capacity for knowledge synergies

EQUIPPING AND CAPACITY BUILDING FOR MARITIME INNOVATION



Enhancing capacity for knowledge synergies

- Provide knowledge supports for innovation
- Leverage Europe's education systems
- Provide staff training for innovation



For detailed guidance on specific actions to achieve progress in action areas, see the **KETmaritime Roadmap**, available at **www.ketmaritime.eu**

Case study 4 of Marine opportunities with KETs

PHOTONIC MARINE APPLICATIONS

The global photonics market is estimated to be worth €615billion by 2020. It is one of the most important technologies for the 21st century and can be used to tackle some of the global society's greatest challenges. Photonic science translates into a multitude of applications and can benefit a multitude of industries:

- **Aquaculture & Fisheries** - Photonics have been successful used for monitoring in aquaculture and fisheries where historic detection techniques (such as HPLC) were slow, required sampling and were not in real-time.
- **Seafood industry** - Applications enabling computer vision are found in automated systems for **sorting**, **grading and processing** fish and fish products. **Computer vision technologies** can objectively measure visual attributes related to seafood quality. This includes inspecting the appearance (size, shape, colour and texture), smell, category, bones and defects, presence of blemishes and textures on the surface of seafood products.
- **Oil & Gas industry** - Photonics can **enhance security** by monitoring plants and hazardous environments. Optical sensors have been used successfully for specific measurements where no replacement technology exists.
- **Marine renewable energy sector** - Photonics can inform new devices and systems for wider and more comprehensive **monitoring of marine environments**.
- **Shipbuilding sector** – Photonics can improve applications used in laser-welding, cutting, mapping and detection systems to improve navigability and to reduce risks.

For further information, see the KETmaritime case study on **Photonic Marine Applications**, available at **www.ketmaritime.eu**

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OPPORTUNITIES

Fisheries and aquaculture

Blue biotechnology

Maritime surveillance

Marine renewable energy

Ship and boat building

VISION

An innovation ecosystem, with knowledge synergies bringing forth ideas, capturing them, testing their viability and commercially realising their potential for the Maritime and Key Enabling Technology communities .

Strategic investment in awareness raising involving two primary audiences – the maritime community, and the KET community. Opens the doorway to further engagement, offering windows for the KET community to examine maritime realities, and work with the maritime sector to identify further opportunities and synergies.

GOALS

Raising KET and maritime innovation awareness

Demonstrating KET-maritime potential

DEMONSTRATING AND ENHANCING MARITIME AWARENESS OF KETS

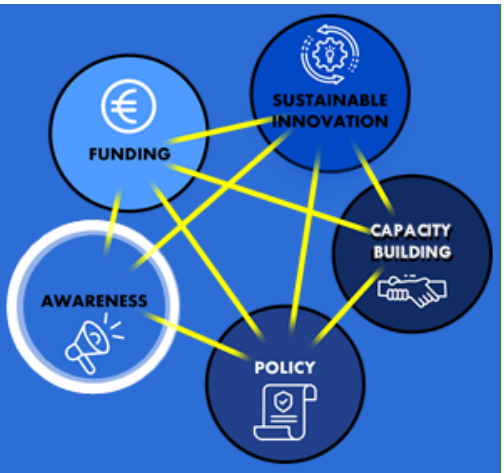


innovation awareness

- Conduct strategic outreach and animation
- Ensure factual evidence-based awareness raising

Demonstrating KET-maritime potential

- Facilitate rapid testing for accelerated innovation
- Promote long-term innovation
- Demonstrate KETs meeting maritime needs
- Target key demonstrations



For detailed guidance on specific actions to achieve progress in action areas, see the **KETmaritime Roadmap**, available at **www.ketmaritime.eu**

Case study 5 of Marine opportunities with KETs

MEMS (MICRO ELECTROMECHANICAL SYSTEMS) MARINE APPLICATIONS

The processing power of computers has evolved rapidly, and the speed and impact of this impressive advance has been felt across society. The demand for **reduced-scale electronic design and manufacturing**, and the evolution of **electronic architecture** based on silicon have exponentially increased the processing power of chips, reduced electrical consumption and in general given rise to a whole generation of 'microelectronics'. The possibility of **manufacturing mechanical elements at micrometric scales** has opened the doors to the development of multiple marine devices with different **sensory capabilities**:

- Within **navigation**, the development of **MEMS sensors** is key not only for the implementation of location and positioning technologies, but also for the development of complete **mobile platforms (potentially autonomous)** for the collection and distribution of **data** at **open water environments**.
- MEMS are further used for **monitoring water** properties and composition. This is highly valuable for **maximizing aquaculture** activity, identifying **potential pathogenic agents** and unwanted variations of acidity, etc. MEMS technology can also be used to **monitor marine structures**.
- The implementation of MEMS technology in **autonomous or semi-autonomous** operations can further aid **underwater prospecting**, the **discovery** of underwater resources, and marine deposit, and even the **early detection** of earthquakes.

For further information, see the KETmaritime case study on **MEMS Marine Applications**, available at **www.ketmaritime.eu**

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Annex B – Stakeholder and Literature Data analysis.

To discuss accessing the data analysis workbook, containing the full traceable details of the action-derivation process, please contact Mr. Rory Scarrott (lead author), University College Cork at r.scarrott*at*ucc.ie.

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