

Unleashing the Potential of Maritime Innovation Networks

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This report analyzes collaboration within the maritime industry for innovation, determines the key enablers, barriers, and mechanisms of maritime innovation networks, identifies the key characteristics of collaborative innovation processes applied in the maritime industry, and suggests necessary managerial actions for organized and successful innovation in networks. The authors' ambition is to establish common knowledge and understanding across the industry concerning network innovation dynamics and provide the context within which maritime organizations can assess the benefits and risks of their participation in different types of innovation networks.





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Published by DTU Business, Kgs. Lyngby 2015

The report is based on analyses from the research project "Innovation in Networks", supported by a grant from the Danish Maritime Foundation (project number 2012-121).



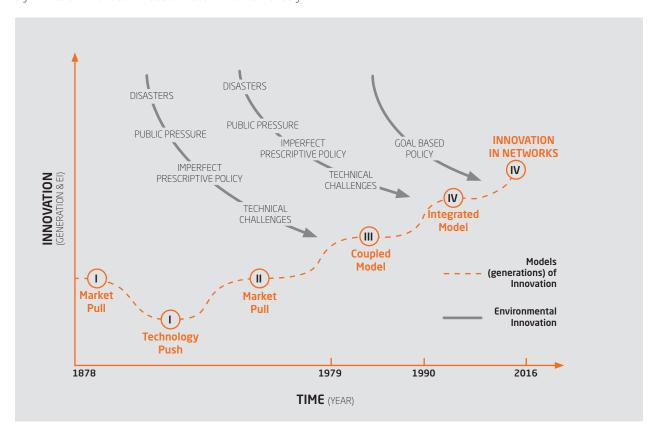
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Why innovate in networks?

Maritime organizations have innovated in the past by alternating between linear technology push and market pull models, well suited to the opportunities and challenges of former market environments. Today, technological, market, and regulatory challenges are creating a specific complex context for contemporary maritime organizations and their innovative efforts. Single organization rarely has all necessary competences and capabilities to deal with multiple challenges and uncertainties. Therefore, the industry is expected to form networks of organizations and collaborate for innovation.

Dynamics of innovation models in the maritime industry¹



Maritime stakeholders should be prepared to apply the basic principles of network innovation. Recognizing this trend and institutionalizing innovation processes could be essential to achieving and sustaining competitive advantage.

Method

The data have been collected over an 18 month period from multiple sources: interviews with more than 100 key informants from 40 maritime organizations, analysis of numerous internal company materials, industry reports, publicly available reports on over 30 innovation networks, newspaper and magazine article, and an extensive literature review of more than 50 academic journal articles.

¹ Adopted from Perunović Z., Vidić-Perunović J., (2012). "Environmental Regulation and Innovation Dynamics in the Oil Tanker Industry", *California Management Review*, 55, 1, pp. 130-148

The context for maritime innovation

Most practitioners agree that the major drivers for innovation in the contemporary maritime industry are environmental regulations. However, participants in the maritime industry still operate in volatile markets where competition is fierce, costs are high, and margins are decreasing. The context for maritime innovations is influenced by the interaction of three major groups of challenges:

THE MARKET

- 1. Discrepancy between the dynamics of global trade and the shipbuilding industry are reflected in new vessel ordering times, yard capacity, and the cost of new construction. During the recession, the result was surplus vessel capacity and a lack of incentive for industry innovation.
- 2. Trade specialization of ships. Dispersed global manufacturing and trade route movability could lead to surplus capacity or obsolete vessel types undermining ship owners'/operators' earning potential, decreasing the new vessel orders and, ultimately, reducing willingness to innovate.
- 3. Unpredictable fuel prices could influence intensity to which companies innovate to reduce CO₂ because the major incentives for operators are to reduce fuel cost and increase performance.
- 4. The competitive efficiency of existing fleets in terms of future performance requirements and compliance with future regulatory requirements focus innovation efforts on either retrofit solutions or new vessels.

REGULATIONS

- 1. Uncertain enforcement dates. High capital intensity causes a tendency in stakeholders to postpone innovation activities until the last moment before enforcement. However, uncertainties with actual enforcement dates and enforcement mechanisms create additional barriers to innovation.
- 2. Variations in regional and country regulations complicate decisions concerning the choice of solution, which hampers innovation drive, and both owners/operators and technology suppliers are affected.
- 3. Lack of compliance control and enforcement capability denies operators and owners the incentive to invest in compliance enabling technologies. If competitors do not comply with the requirements, there is no perceived risk from the consequences of non-compliance.

TECHNOLOGY

- 1. Customized solutions for retrofit projects because of fleet variety. These solutions are expensive.
- 2. Myriad of unproven technologies and suppliers. Technologies are available, but many are not yet proven because of the difficulty in validating performance reliably.
- **3.** Contradictory solutions. Some solutions benefit from a reduction in one environmental factor but increase another.
- 4. Incompatible and uncomplementary technologies. A lack of unanimous maritime standards is a characteristic of the maritime industry.
- 5. Scalability of technologies for large capacities, particularly with respect to ballast water management solutions.

Which networks are used for maritime innovations?

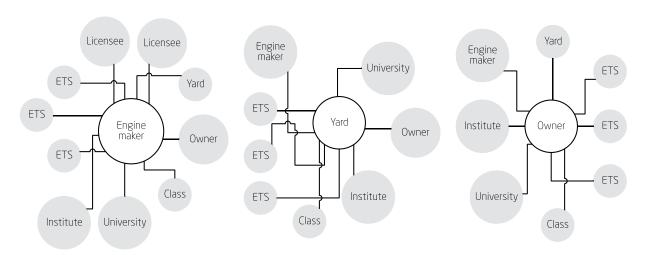
The maritime industry is perceived as less innovative than other industries with incremental innovations conceived through closed and slow-paced processes. However, despite the perception of closeness, the maritime industry is very active in innovating in networks. We identified six different types of networks within which maritime industry's stakeholders innovate:

- 1. Centralized a central organization with suppliers, customers, and partners.
- Triad a network of three different types of stakeholders with strong ties.
- Publicly funded when pursuing available public funding.
- Horizontal between the same type of stakeholders.
- 5. Experts' forums formal experts' networks.
- 6. Informal without formal agreements and developed from personal relationships.

Each of the types has its own characteristics i.e., the way they are formed, designed, managed, how they evolve, and what results they are achieving.

Centralized

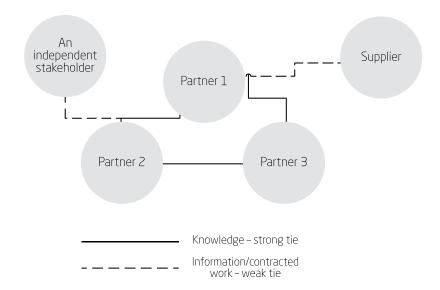
Centralized networks are networks among central, sufficiently large organizations with strong positional power in the industry and their suppliers, clients, and partners. Innovation activities are conducted bilaterally between central organizations and partners who have no little or no formal communication between themselves.



Formation	Management and organization	Evolution	Performance
Owner driven	User-driven	Engine maker and shipyard driven	Indirect measurement of success
Fast and affordable access to knowledge and technologies	Formal agreements for exploration in engine maker and shipyard-driven networks. Informal agreements	Long term Growing number of	Objectives met in most cases
Formed when needed	for scouting and testing and formal agreements for	partners	Suppliers may delay the process because of
Engine maker and shipyard driven	new builds in owner-driven networks	Owner driven Time limited	uncertain sales and a lack of resources
Access to new knowledge, technologies, and market segments	Strong ties between central organization and individual partner. Little or no formal relationships between the	Disbands into dyads	Untapped potential of structural holes Networking capabilities not
Suppliers	partners (structural holes) Ideas and needs shared with		regarded as KPI
Test technology, understand user's needs, obtain sales with a sizeable customer	partners who are expected to come up with solutions R&D unit/entity is the coordinator		
	Engine maker and shipyard protects IPR through patenting, Owner protects IPR by being first on the market		

Triad

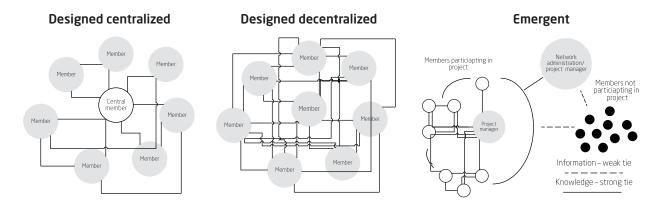
Triads represent the smallest networks, but they are often perceived as the most important form of innovation collaboration. Although the networks can have many members, three-member networks have equal distribution of power and influence. Triads are joint industry projects funded by members who choose to collaborate. Triads are formed on the basis of missing competences. Two partners initiate an innovation process and invite the third to join. Members of a triad typically have a high level of competence complementarity.



Formation	Management and organization	Evolution	Performance
Emerge with a recognized business opportunity	Exploration with fit for exploitation	Time limited Allow flexibility for	Successful in achieving objectives
Partners chosen based on complementarity of competences	Easy to manage Governance based on openness, flat-structure, and	partners to establish new triads Can initiate new	Acknowledges learning as success criteria
Occasional satellite members	good relationship manage- ment	networks to add more competences	
Clear commercial interest from all partners	Trust driven by network size, previous experiences, and personal relations		
	Equal distribution of knowledge and information		
	Formal, exploit structural holes		

Publicly funded

Publicly funded networks are formed when maritime organizations seek an opportunity to access available funding from public organizations. To improve overall competitiveness of the maritime industry, international and national public institutions allocate financial resources, which may not exclusively target the creation of effective technological solutions but seek to improve stakeholders' networking and innovation capabilities.



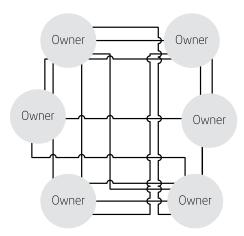
In the designed centralized network the central organization has control of knowledge flow and learning, whereas members benefit from knowledge creation and learning only through participation in work packages. The ties between partners strengthen only if partners are involved in multiple work packages. Designed decentralized network have fewer structural holes and better distribution of knowledge sharing. The design of work packages in this structure ensures equal participation of all members. These networks are usually formed around projects with no dominant partner.

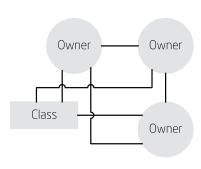
Emergent type is based on voluntary participation in public-private partnerships with a bottom-up approach to formation. This variant involves organizations participating in a project and organizations that are not participating in a project but are still members of the network. Emergent networks allow for more openness towards new members and ideas.

Formation	Management and organization	Evolution	Performance
Stakeholders Access to public funding Public funds Support the development of solutions and industry's innovation and networking capabilities Top-down and bottom-up generation of subjects. Relevance of subjects depends on individuals Rules for formation in topdown could negatively affect enthusiasm	Three variants: Designed centralized, designed decentralized, and emergent Designed types for exploration. Emergent types for development (more open) Work-package driven Complex and bureaucratic organization hinders innovation. Heavy management apparatus Natural stability is sensitive to the quality of governance and operational management	Designed networks are time limited Emergent network will continue if the experience with results and management is positive Partners from work packages may establish new exploitative networks	Successful commercialization of network results is not captured and disseminated Universities benefit from academic publications No established measures to capture and follow the improvement of members' innovation, networking competences, capabilities, and the commercialization of solutions
Negative effect of imposed collaboration			

Horizontal

Horizontal networks link the same types of stakeholders. These networks emerge when there is a common uncertainty that affects all members of the industry. Although they are common in industries such as offshore oil and gas and the automobile sector, horizontal innovation networks are in the early stages of development in the maritime industry.

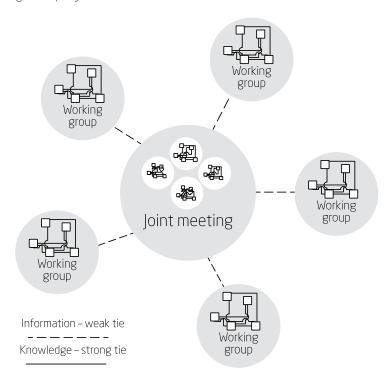




Formation	Management and organization	Evolution	Performance
Rare and found in the development phase of the innovation process	Decentralized with formal agreements Simple and flat management	Positive experience spurs new projects and the admis- sion of new members	Small improvements. Main achievement is that competitors learn to work
Reasons Pulling joint experience, effort, and resources to make a business case for all members to build network- ing capability, the inability to develop environmental solutions alone. Primarily focused on shared learning	structure because of small size Each member involved in project management, participation in projects, and decision making Top management and work	Small incremental steps increase trust and improve networking capabilities	with each other
Prevention of opportunistic behavior Classification society initiates formation and manages the network Members with different market specializations	groups jointly make decisions on the strategic development of the network Efficient knowledge flow because of short distances between the nodes and teams		
Fully committed top management			

Experts' forum

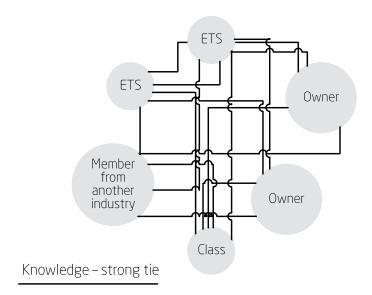
Experts' forums are official national or international expert networks. These networks serve as advisors to regulators and influence the creation of regulations. The networks also serve as catalysts for idea generation that can spur innovation projects either within a single company or within networks.



Formation	Management and organization	Evolution	Performance
Founder Seeks expert opinion and advice on regulation Expert Recognition of personal achievements Participating organization Access to knowledge and influence on regulators	Closed, designed, and decentralized Experts are organized within working groups Governing body sets topics Knowledge sharing intensive within groups. Information sharing in joint meetings. Little or no formal relationships between working groups (structural holes) Power of single member rooted in technical competency	Permanent network with temporary groups and members	Advice to regulators Ideas and initiatives for the formation of publicly funded networks Influence on the formation of innovation projects in industry is not captured

Informal

Informal innovation networks are networks among stakeholders that conduct innovation activities on an informal basis and without any formal agreement. These networks are formed as a result of initiatives that are developed from personal interactions between individual stakeholders. Social networks are the prevalent mode of exchange of information, knowledge, and ideas across the maritime industry.



Formation	Management and organization	Evolution	Performance
Based on initiatives developed from personal relationships Partners chosen based on technical competences, prestige, expected quality of contribution, and added value No contract involved. Trust is guarded and publicly funded behavior prohibited by personal relationships and accepted norms of behavior Mutual benefit for all members is expected	Decentralized Different stakeholders Informal because too much bureaucracy can hinder innovation Light management and strong governance	Successful informal collaboration in exploitation	Results in commercial projects Deep insight in short time frames

How is maritime industry using innovation networks?

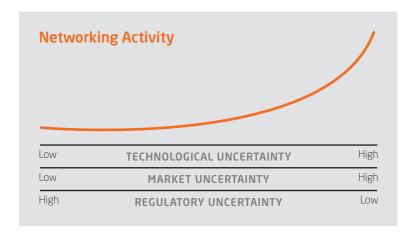
The maritime industry has clearly recognized the need to collaborate to better understand how market, regulatory, and technical challenges can be jointly solved. In that context, we are seeing an increase in numbers of innovation networks. The maritime industry is even reaching out more broadly to create new collaboration opportunities. The rapid development of collaborative innovation activities has impact on the way in which maritime industry utilizes potential of innovation networks.

Our analysis showed that the current overall characteristics of network utilization are:

- > The level of networking activities for innovation increases with the level of technological and market uncertainties, but decreases with the increase of regulatory uncertainty. Maritime industry is reactive to regulations, and tends to initiate networked innovation activities late, thus reducing opportunity for effective innovation.
- > Values and risks of innovation networks are poorly understood. As a consequence organizations could inadequately utilize certain innovation network. For instance:
 - > Networking activities are often initiated without consensus on risks, benefits and mutual value gain, delaying contractual process and impacting engagement.
 - > Status of technology maturity is not fully understood by all parties, leading to optimistic expectations of the networked innovation activity.
 - > Publically funded networks tend to have unrealistic expectations of what can be achieved within such boundaries, and partners tend to take an opportunistic approach just to release funding to in-house development.
- > The industry is pursuing routine (utilization of existing business models and technological competences) and incremental innovation.
- > Closed networks are predominantly used in the exploration, open networks in the development, and closed networks in the exploitation stages of an innovation process. There is limited joint ideation taking place; ideas are often identified in-house or within closed networks, and partners are thereafter selected to develop and commercialize the solution.
- > Key stakeholder groups are not present in maritime innovation networks currently, creating limitations for innovation. Very often, solutions are brought to commercialization before engaging end user.
- > Design of some networks and inner work packages feature an abundance of structural holes, which do not favor flow of new ideas, efficient innovation process, and holistic approach in new value creation. Even experts' forums are lost opportunities for idea identification due to lack of synergetic thinking.
- > New insight developed in innovation networks are kept within project groups and new knowledge is not effectively absorbed by the organization.
- > Innovation network performance is not properly monitored.

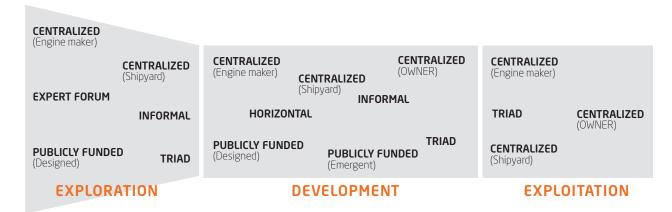
Response to uncertainties

The underlying hypothesis of this research project is that to reduce the uncertainties or difficulties in predicting the future, which originate from incomplete knowledge, the maritime industry must engage in collaborative innovation activities. The way the industry utilizes innovation networks mostly confirms this hypothesis. The analysis shows that the level of networking activities increases with the level of technological and market uncertainties. However, when regulatory uncertainty is high, the industry is reluctant to innovate and form innovation networks. This particularly refers to ratification and enforcement of environmental policies. If the ratification of a certain policy is unknown, the industry shows no or a minimal level of networking activity. When ratification becomes certain, the closer the enforcement date, the higher the level of networking activity.



Networks and innovation funnel

The generation of ideas and the conceptualization of innovative solutions predominantly rely on closed and controlled environments where networks are formed on the basis of past alliances and the existing ties between stakeholders and individuals. Firm and individual technological and technical reputations, position, and power in industry dictate their ability to form innovation networks. In this stage, the industry pursues centralized ego networks, designed publicly funded networks created as a push from public authorities to urge stakeholders to explore solutions for challenging problems and host experts' forums. Some organizations also pursue more decentralized forms such as informal and triad networks. The choice of partners is based on strict social capital mechanisms. If a technology or product successfully moves to the development phase, the industry's interest in that product or technology increases paving the way for the formation of more open and decentralized horizontal and emergent publicly funded networks. Large owners also enter the arena with their centralized networks. The industry's focus is on increasing the technology's readiness level. Regardless of the innovation networks' success in qualifying technologies, advanced collaborative networks disband at the end of the development phase, the industry closes again, and centralized and closed networks prevail in the exploitation phase. Although most networks cease to exist after the completion phase of a project, technology or product development is advanced in another network, that is, the output from one network becomes input for another network.



Choice of partners

The maritime industry is a mature industry and is often perceived as conservative and based on traditional social networks. Therefore, maritime organizations' embeddedness in social networks and past alliances will enable the industry's ability to create new partnerships but, predominantly, with known organizations. Social networks are built on existing ties that should preferably form dense space in which deviant and opportunistic behavior of members are easily sanctioned because of the embedded reputation-building mechanism. Members in such closed networks are committed to each other.

Although the choice of partners will depend on organizational culture, corporate strategy, and innovation capabilities, maritime stakeholders show a tendency to bond with new partners in centralized and publicly funded networks. Previous relationships, on an organizational or personal level, seem more important when forming experts' forums, horizontal networks, and informal networks. Triads are equally formed with new and "old" partners. If we follow the analogy with firm-specific and industry-specific uncertainties, we could argue that centralized and publicly funded networks are used in cases of firm-specific uncertainty, whereas stakeholders protect themselves from industry uncertainty by forming experts' forums, horizontal, and informal networks. As suggested, triads are always used, regardless of the nature of uncertainty.

New partners Firm-specific uncertainty	Previous partners Industry-specific uncertainty
CentralizedPublicly fundedTriad	Experts' forumsHorizontalInformalTriad

Structural holes

Structural holes are sparsely occupied regions between dense clusters or between firm partners with no links². Because of the non-redundant nature of information, novel ideas and the basis for effective innovation network is located in these unconnected regions.

Despite the uniqueness of each maritime organization, we find a tendency to organize work in certain types of innovation networks. Central organizations such as engine makers, large owners, and shipyards encourage only bilateral collaborative development with their partners in centralized networks. These central organizations seek competitive advantage by protecting information and preventing the connection of first and second tier suppliers. In addition, there are a limited number of collaborations between centralized networks, for example, between owners and shipyards. Publicly funded networks have high connectedness only within work packages while collaboration between different work packages is more sequential than simultaneous. Similarly, experts' forums predominantly consist of partners who work closely in committees and working groups but with limited joint inter-collaborations between committees and working groups. Horizontal maritime innovation networks are evolving as quietly in maritime clusters with a high level of multilateral collaboration. The same is valid for informal networks. By definition, triads have a high level of collaborative innovation activity.

Open structural holes	"Patched" structural holes
CentralizedPublicly fundedExperts' forums	> Triad> Horizontal> Informal

Stakeholders' presence in innovation networks

Not all stakeholders participate in maritime innovation networks. The dots in the table represent predominant activity, but we acknowledge that there could be some isolated, uncaptured cases of a stakeholder's participation in a certain type of network. Owners and universities, symbolically representing the beginning and the end of innovation funnel, are the only stakeholders participating in all types of maritime innovation networks. Classification societies and equipment and technology suppliers are also very active in collaboration although they avoid participating in horizontal innovation networks. Designers, as a creative arm of the industry, and shipyards, being both the creative and manufacturing arms, are surprisingly underrepresented in experts' forums. Ports are predominantly visible in publicly funded networks, whereas financing and insurance institutions are completely absent from any active collaboration concerning innovation.

The absence of stakeholders from some types of innovation networks as indicated in the stakeholder-innovation network activity map suggests two problems. First, a holistic perspective is lacking because the maritime industry's value chain is not mirrored in innovation networks. Second, structural holes potentially hinder the creation of technologically advanced, cheaper, and user-appreciated solutions.

	Centralized	Triad	Publicly funded	Horizontal	Experts' forum	Informal
Regulators			•		•	
Classification society	•	•	•		•	•
Owners, charterers, operators	•	•	•	•	•	•
Designers	•	•	•			•
Equipment and tech- nology suppliers	•	•	•		•	•
Shipyards	•	•	•			•
Financiers						
Insurers						
Ports			•			
Universities and institutes	•	•	•	•	•	•
Industry associations			•		•	

Unleashing the potential of maritime innovation networks

As we have seen, maritime organizations do collaborate for innovation in various forms of networks. Nevertheless, the concept and its mechanisms are relatively new to the industry. With increased awareness and capability building, the industry can unleash more potential from innovation networks. Based on our analyses we suggest following improvements:

- > Assess benefits and risks of different types of innovation networks.
- > Use networks (particularly horizontal) to reduce regulatory uncertainty.
- > Use open networks to enhance flow of new ideas and bridge knowledge gaps in exploration.
- > Seize breakthrough innovation through networking with new partners and patching of structural holes.
- > Involve stakeholders from the entire value chain to enhance holistic and life-cycle approaches, leading to faster and cost efficient innovation process.
- > Capture progress in both technological and organizational aspects of innovation.

Management governance is essential for realizing the innovation potential. In that context, to fully benefit from collaborative innovation, maritime organizations need to consider implementing adequate measures to satisfy the following criteria:

- > More effective innovation leadership and management practices are needed to improve networking and innovation capabilities.
- > Governance to secure a firm's central position in an innovation network and the efficient selection of partners for innovation.
- > Focus to foster respect, harmony and trust among partners.
- > Tight or loose contracting systems should depend on the level of uncertainty of the innovation topic.
- Management organization needs to provide network stability, knowledge flow and innovation coherence.
- > Traditional maritime conservative norms which preserve closed networks, and typically target task execution rather than exploratory work and knowledge-sharing, will need to open up to support more innovative thinking.
- > Absorptive capacity of the organization is a key enabler for engaging in open innovation activities.

By considering changes in these factors, maritime stakeholders can improve their innovativeness and the way that they gain and sustain innovation-based competitive advantage.

Which innovation network to use?

Maritime stakeholders are stimulated to actively engage in innovation networks if they perceive added value from participation. Understanding the characteristics and mechanisms of each innovation network, together with the specific benefits and the associated risk of network collaboration, should increase the awareness of the need for collaborative innovation in the industry. This awareness can facilitate improved planning of innovation activities and the selection of partners. A better understanding of the structural setting and each company's role and level of value creation in a certain type of network can provide innovation projects an improved likelihood of success.

	Benefit	Risk
Centralized	Central organization > First-mover advantage > Access to new knowledge and technologies > Shared cost and risk of development > Access to "custom-made" > Full control over development process > Contractual prevention of opportunistic behavior > Appropriation of intellectual property rights Supplier/Member	 Lack of idea, knowledge, and information sharing between suppliers Uncoordinated development Problems at one supplier could impact others without the latter having control over the situation
	 Insight into user needs Potential large contract and long-term relationship with central organization 	
Triad	 Decrease in the speed and cost of development High likelihood of commercial success Good control of partner opportunistic behavior 	> Choice of partners based on long-term relationships diminishes innovativeness
Publicly funded	 Financial support to industry and universities Increased visibility of members Access to versatile knowledge sources Influence strategic R&D agenda in the industry Potential to create smaller and more efficient networks Establish new relationships Improvement of networking capabilities Effective knowledge transfer on industry-academia-government axis Early insight into industry needs 	 Slow Bureaucratic Irrelevance of offered topics Members participate because of the need to be visible Abundance of work packages No idea, knowledge, and information sharing between work packages
Horizontal	 Sharing or joint experience and idea generation for resolving common challenges Creation of industry standards Shared development costs and risks 	Undisclosed vital knowledge that could have resolved joint challenge
Experts' forum	 Access to experts' knowledge Idea generation Advice to regulators Initiation of publicly funded networks Influence on regulators 	 Lack joint innovation activities between committees and working groups No diversity in topics and experts' subject matter expertise within committees and working groups have the same subject-matter expertise
Informal	 Fast check of technical and business feasibility Fast access to commercialization 	 Choice of partners based on long-term relationships diminishes innovativeness Lack of contractual protection

Using networks to create standards and influence regulations

Regulatory uncertainty is often blamed for a lack of innovation engagement. However, this could be changed if maritime organizations would engage in innovation networks at an early stage to resolve technical and market challenges and discuss future trends. This would improve participant's competitiveness and create standards from a user perspective, improve industry practices and considerations for implementation, and ultimately influence regulation. The timing of network formation is more important than any particular type, but horizontal networks have proven to be effective and efficient for the creation of standards and influencing regulations. Experts' forums and emergent publicly funded networks are also useful for those purposes.

Enhanced holistic and life-cycle approaches

Although the industry is embracing the life cycle approach to vessel design, the networking activities show that the industry's value chain is not entirely captured by network innovation. Additionally, groundbreaking innovations in the maritime industry may require a systemic approach whereby opportunities can be enabled by adjustment and optimization throughout the value chain. Therefore, when forming networks, stakeholders representing the entire value chain should be included in active work. Regulators, financial organizations, ports, and industry associations must be encouraged to participate in various types of innovation networks. Moreover, the final users of particularly centralized networks should be involved in the process in its early stages. For example, large Asian shipyards are increasingly expanding their R&D activities and are still employing the technology push strategy i.e., conducting the invention and early development work in-house. Their customers, owners, and operators are seldom involved in the exploration and early development stages of the innovation process, which eventually undermines shipyard selling capability.

A new measurement system for capturing value

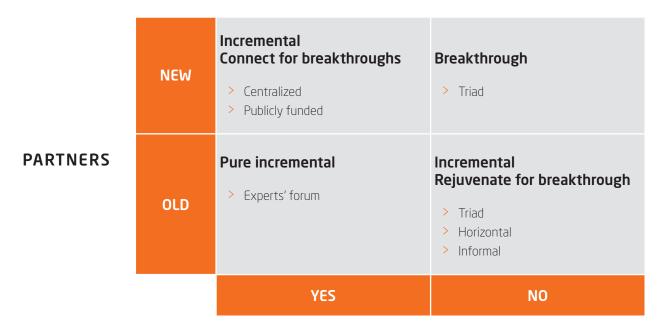
Linked with the industry's awareness of the benefits of participating in innovation networks is the fact that the networks, particularly publicly funded and informal networks, are not capturing and communicating to the industry and general public the commercial success of their collaboration. In addition, many companies are capturing predominantly technological dimensions and, in some cases, the associated commercial value of the technology. However, networking for innovation has a much broader set of benefits that should be captured. This will enable participants to see their potential and actual participation in a new light, encouraging the realization of extensive benefits. Some exemplary measures that could be considered both at the network and organizational levels are the following:

- > Technology readiness maturation index.
- > Number of patents.
- > Knowledge receiving/giving ratio.
- > New ideas gained/internalized ratio.
- > Commercialization probability.
- Actual commercialization (could be several years after disbanding of the network).
- > Number of successor and partnership networks.
- Number of new contacts established (customers, complementary stakeholders, competitors).

Improving novelty - from a routine to breakthrough or disruptive innovation

We rarely see breakthrough innovations in the maritime industry, and they are predominantly the result of in-house R&D, such as the double-hull tanker concept. Successful innovation networks provide an environment for improving participants' innovativeness and competitive advantage. Open and decentralized types of networks should be more evident early in the exploration phase if organizations are in pursuit of new ideas. They should also consider loosening up the dominant social capital approach based on old relationships. Therefore, organizations seeking novelty should rejuvenate relationships and form networks with new partners within and outside the maritime industry. This action could be useful particularly for triads, horizontal networks, and informal networks. Another way to improve innovativeness is to "patch" structural holes when designing the network, that is, enable an active connectivity between various stakeholders and work packages. Centralized and publicly funded networks particularly could benefit from this action.

The highest level of novelty, discontinuous, or breakthrough innovation can be expected when new partners form a network with a high level of mutual connections (the top right quadrant). When a network is formed with old acquaint-ances, with a small number of ties and knowledge sharing, the innovation will be incremental with minimal improvements (bottom left quadrant). If organizations are open to new partnerships but the actual collaboration is limited across nodes, the network's potential for breakthrough innovation is underutilized. If these networks wish to pursue a higher level of novelty, they must reorganize the way partners collaborate and create more ties between them (top left quadrant). Finally, when firms with established trust through current or previous relationships innovate in a decentralized network with a high level of connectedness, the extent of knowledge sharing and learning is great, the network is efficient, and members are comfortable with each other. However, in the long run, they may lose exclusivity and the edge for innovation (bottom right quadrant). To maintain a high level of innovativeness, these networks should open up to new members.



STRUCTURAL HOLES

The maritime industry's experts' forums are often composed of old partners and associates who work closely in committees and working groups but with limited joint inter-collaboration of those committees and working groups. Horizontal maritime innovation networks are quietly evolving into maritime clusters with strong social capital and, once formed, with a high level of multilateral collaboration. The same is valid for informal networks. By their definition, triads have a high level of collaborative innovation activity and are equally frequently formed by old and new partners.

Innovation network management system

Throughout our research, we conclude that most maritime organizations preserve closed and conservative organizational cultures built on traditional maritime norms. Such culture is not supportive of innovation in networks and companies are not likely to bear the fruit of inbound and outbound knowledge sharing and internalization in internal creative thinking or innovation process. We also find that substantial networked innovation activities are formed based on the need to execute necessary tasks only, and engagement in an exploratory, knowledge-sharing phase is limited. Top management, therefore, has a significant role in creating an open organizational culture that supports innovative thinking. In addition, top management should define innovation strategy and guidance concerning the purpose of a company's participation in different networks.

Success of an innovation network will depend on management quality of network's managing organization and on the quality of governance and operational management of each participating organization



Governance is practiced at a strategic level and consists of initiating, planning, organizing, staffing, contracting/agreeing, and controlling innovation network partners and activities³. In addition, governance should secure a firm's central position in an innovation network and the efficient selection of partners for innovation⁴, preferably avoiding redundant partnerships that share little additional information. Contracting systems in principle have three different modes⁵. The tight and formal system is used by experienced innovative organizations in mainstream innovation projects. Tight and formal agreements will have clear structure, goals, strategic intentions, and clear definition of responsibilities in the technical domain often involving a separate project management organization, joint advisory committees, working groups consisting of members from all participating companies, and implying contractual rules for conflict resolution. A loose system is typical for managing exploratory research. Between those polarities lies an intermediate management system. The intermediate system is used for innovation activities with high uncertainty. Large corporate R&D typically allocates 10% to 15% of

³ Ritter T., Gemunden H.G., (2004). "The impact of a company's business strategy on its technological competence, network competence and innovation success", *Journal of Business Research*, 57, pp. 548–556

⁴ Hagedoorn J., Roijakers N., van Kranenburg H., (2006). "Inter-Firm R&D Networks: the Importance of Strategic Network Capabilities for High-Tech Partnership Formation", *British Journal of Management*, 17, pp. 39-53

⁵ van Aken J.E., Weggeman M.P., (2000). "Managing learning in informal innovation: overcoming the Daphne-dilemma", *R&D Management*, 30, 2, pp. 139-149

their R&D budget to explore and test ideas in open and informal networks, which serve as a feeder for further in-house R&D activities.

Operational management is based on managing processes that drive performance and the management of network and organizational-level activities. At the network level, the managing organization's role is to provide network stability, knowledge flow, innovation coherence, and appropriability, which leads to solid innovation leverage of the innovation network as a whole and for each of the participating organizations⁶. At the organization level, operational management refers to the management of processes that enable efficient flow through the innovation funnel and technology readiness-level improvements. Managing an organization's ability to internalize results and the knowledge gained from an innovation network into mainstream innovation processes (absorptive capacity) is of particular importance.

