



Marine Technology Research Markets Analysis

Comparative study of marine technology research centres



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Research centres comparative analysis – context and introduction

The Norwegian Government is considering different funding options for building/development of a Centre for Marine Technology in Trondheim, Norway. The new Centre, Ocean Space Centre (OSC), will be operating within for marine and maritime research and education. Access to advanced laboratory infrastructure is a key element of meeting the opportunities offered by OSC.

The key focus point of the study is therefore to provide an overview on how the infrastructure of other, similar centres is organized and financed, and how this is influencing their market operations and pricing.

This study delivers a comparative analysis of ten marine technology research centres located worldwide, focusing on a description of infrastructure financing and ownership, the price formation for research services offered and a general overview of the market perspectives.

The information is needed to grasp the possible options regarding the directions, the functioning and the financing of the Centre, to identify the factors that will clearly influence the Centre's functioning, to analyze best practices from other similar centres that are well established globally, especially in the context of their ownership structures and financing and finally, to get a solid picture of these centres based on facts and comparable set of indicators.

I hope this report will be useful in the Ministry's considerations related to the development of the OSC.

OXFORD RESEARCH AS

A handwritten signature in blue ink that reads "Harald Furre".

Harald Furre

CEO.

Content

Executive summary	7
Chapter 1. The sector	9
1.1 A brief introduction to the marine industry sector as a whole.....	9
1.2 Global trends.....	9
1.3 Research & Development Activities in the marine sector	11
1.4 Main R&D challenges for the future	11
1.5 Centres selection	12
1.6 Study methodology	14
1.7 The research sector financing.....	15
1.8 Norwegian experience in the field.....	16
1.9 Ocean Space Centre concept.....	17
Chapter 2. A comparative view.....	18
2.1 Ownership.....	18
2.1.1 Management and ownership.....	18
2.1.2 Ownership of the research infrastructure	24
2.1.3 Commercial sales of research services offered to external customers.....	25
2.1.4 Administration and maintenance.....	25
2.1.5 Access to research infrastructure by scientists (non-commercial users)	26
2.2 Market size and budget.....	28
2.3 Historical and current sources of the infrastructure financing. Income and profit distribution	29
2.4 Pricing	31
2.5 Budgets.....	33
2.6 Infrastructure overview.....	36
2.7 Markets	40
2.7.1 Overview of current main activities	40
2.7.2 Customers of centres analysed.....	42
2.7.3 Key factors shaping the market.....	43
2.7.4 Trends shaping the demand	45
2.7.5 Main customers.....	46
2.7.6 Competitors perception	46
2.7.7 The main barriers to entry	47
Annex - List of interviewees.....	49
Research centres interviews	49
Industry interviews	50

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Executive summary

The key focus point of the study is to provide an overview on how the infrastructure of marine technology research centres is organized and financed, and how this is influencing their market operations and pricing.

The investigation covered 10 centres selected from the global population representing different organizational setups, specialisation, history and location. The analysed centres were:

- Brazil LabOceano
- Canada Oceanic
- China China Ship Research Scientific Centre
- Germany HSVA The Hamburg Ship Model Basin
- Italy Insean – The Italian Ship Model Basin
- Korea MOERI - Maritime & Ocean Engineering Research Institute (MOERI) (part of KIOST: Korea Institute of Ocean Science & Technology) in October 2013 named Korea Research Institute of Ships and Ocean Engineering (KRISO).
- Norway The Norwegian Marine Technology Research Institute (Marintek)
- Singapore Singapore Maritime Institute
- The Netherlands MARIN
- USA Offshore Technology Research Centre

The ownership structure of institutes is very polarized. They are either owned fully by the state (as public research institutions) or organized as private companies. Some extraordinary formations appear. One particular case here is Marintek in Norway, operating as a private company with some shares kept by the Norwegian government (Norwegian Maritime Directorate) and other not-for-profit bodies. Another is MARIN in the Netherlands – a not-for-profit company established by a foundation composed of various private actors, advised by a mix of industry and public bodies (therefore classified here as public). Finally HSVA – also a not-for-profit company but owned directly by a set of commercial industry companies.

The ownership of the infrastructure in the institutes which were analysed follows very much the general ownership pattern. For all public centres the ownership is also public and stays in most cases in the hands of the Institute or the University where the centre is located. Private companies own the infrastructure they operate, with some exceptions. This being Marintek in Norway (the infrastructure is owned by the Norwegian University of Science and Technology) and Oceanic in Canada. The latter is a private company, only marketing and selling services based on the infrastructure of two owners: National Research Council of Canada and Memorial University. In most cases the research centres have built their infrastructure over the years using full or large direct governmental financing.

There are examples where centers actually contributed to infrastructure investment from their own resources. This will be the German HSVA, Marin and Norwegian Marintek, contributing to some recent infrastructure developments alongside a large public grant. Historically also the infrastructure development of the Italian Insean has been financed by the industry, but this situation was only possible due to the monopolistic nature of its initial activities (certification). From the 70s till now all the following Italian investments in infrastructure were undertaken with government grants.

In most cases the public institutes are also commercially responsive, selling research services externally or, in other words, implementing research projects financed with private funds. Obviously the more private the set-up, the more market focus is recorded in turnover.

Only in two cases the institution responsible for commercial sales is not simultaneously the owner of the infrastructure. These are i) Oceanic in Canada, where the ownership is public (being Research Council and Memorial University), but where sales and marketing are delegated to an external company (Oceanic), ii) Marintek in Norway, where the ownership is by University but all operations are on the private company side (Marintek) and finally.

In most of the analyzed cases daily administration of the facilities is in the exclusive competence of the single owner and research / commercial operator, being, in most cases, the same institution.

A different organizational setup is again recorded in Canada and Norway. In the case of Canadian Oceanic, the daily administration and maintenance of the NRC and MUN research infrastructure is the responsibility of NRC and MUN, respectively. Oceanic is a “customer” of NRC and MUN and NRC and MUN earn revenue for use of their respective testing facilities by Oceanic and its consulting clients. In the case of Norwegian Marintek, the company is fully responsible for daily operations and maintenance of the infrastructure, covering these expenses from its commercial activity. A discussion is ongoing in Singapore (being a centre under construction) on how this is to be set up, but the options considered indicate that the operations will be managed by either University of Singapore or the State Agency (A-Star).

In terms of cooperation with external scientific institutions, different cooperation patterns result from different general setups. The university-related centres cooperate more closely with the local university human resources on a project to project basis, or regularly. This is the case with LabOceano and OTRC. Norwegian Marintek operates with a varied structure depending on the type of laboratory to be used and type of research project. Asian centres seem to operate with a clear setup of formalized cooperation procedures within the government projects they implement. In general, the more commercial centres like HSVA, MARIN or Marintek, have open access to infrastructure, based on commercial rules and grant project financing.

The biggest market share of the centres in scope shall be attributed to the European actors and Oceanic in Canada. It shall be differentiated from the budget size, where the Asiatic centres in Korea and China will definitely be leading with large scale national funded projects. In terms of market operations, clearly the leading centres are Marin, Marintek and HSVA, followed by Oceanic.

Most of the analysed centres income depends on commercial or publicly funded projects/grants. Only four of the analysed public institutes receive block funding on a regular basis, with Italian Insean being here the most privileged (with 70% block financing). In terms of sources of income, there is a balanced division between institutes being fully or largely commercially oriented (including those with clear commercial focus being Oceanic, Marintek, Marin, HSVA and university-type of centres like OTRC and LabOceano) and those operating with most public financed research projects with especially MOERI and Insean. No precise data was received for CSSRC. It might be assumed that due to its public financing and public structure, the focus is dedicated to public funded projects with large block financing.

The customers of the analysed marine research centres might be divided into two main categories. These are public institutions and commercial companies. Most of the centres service a mixture of these two. The research centres which are directly linked to high education institutions or being public research centres, administrated and subsidized by the state budget, are simultaneously largely focused (or “dependent”) on public financing. Those institutes operating in more in the free market of research services and competing for clients, present generally a lower share of publicly financed projects in their annual turnover.

As regards the market focus, the development of oil and gas technologies is clearly on the top of market exploration. Another historically important part of the market and still with growth prognosis in terms of turnover volume is ship building technology and design. These two are generally shaped by large clients in the market, who are able to invest proportionally large budgets into research, development and testing.

The main barriers to entry for any new research centres of this kind are the following:

- Expensive infrastructure that is considered as non-reimbursable investment
- Customer relationship takes a long time to establish and yields the incumbents a large advantage.
- Experience and competence must be available to operate any lab infrastructure, not only budget for investment in the infrastructure.
- Marketing, knowledge of the market and the human factor behind it: the word-of-mouth and track record are extremely important.

Chapter 1. The sector

1.1 A brief introduction to the marine industry sector as a whole

The world marine industry can be divided into four main areas, each of them comprising some specific subsectors¹:

- The area of Services, comprising Shipping Industry, Marine Tourism, Ports, Cruise Industry, Marine Commerce, Submarine Telecoms and Ocean Survey. The total value of this area was €2,454bn over the period 2005–2009, and it is dominated by the shipping industry and tourism.
 - The area of Resources, comprising Marine Fisheries (Fishing, Aquaculture, Seaweed and Seafood Processing), Energy (Offshore Oil & Gas and Marine Renewable Energy) and Minerals & Aggregates. The total value of this area was €1,306bn over the period 2005–2009, and it is dominated by Fisheries and Energy.
 - The Manufacturing area, comprising Shipbuilding, Marine Equipment, Marine IT and Marine Biotechnology, with a total value of €541bn over the period 2005–2009
 - **The Education and Research area, comprising Education & Training and Research & Development activities, with a total value of €62bn over the period 2005–2009.**
- Technology and design for offshore oil and gas activities
 - Technology and design for ocean/offshore renewable energy
 - Technology and design for aquaculture and fisheries
 - Arctic areas

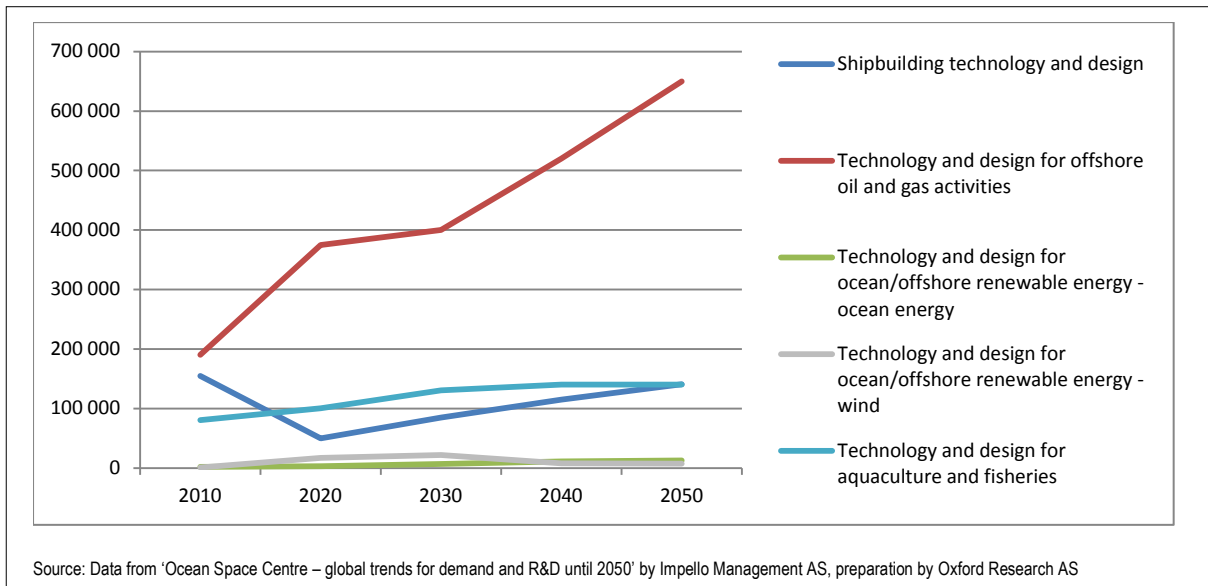
1.2 Global trends

The report 'Ocean Space Centre – global trends for demand and R&D until 2050' by Impello Management AS provides market analyses for the future global demand, total market and R&D-market until 2050 using the following sector split:

- Shipbuilding technology and design

¹ Information from Douglas-Westwood Limited, World Marine Markets, March 2005 (see http://www.schleswig-holstein.de/MJKE/DE/EuropaOstseepolitik/Meerespolitik/Download/studieWorldMarine_blob=publicationFile.pdf).

Figure 1: Investment prognosis for the marine industries in million USD for the period 2010 - 2050



The above chart shows indicative development of listed sub-sectors, depicting their relative importance in the future.

It is clearly seen that technologies related to oil and gas will shape the future market for a very long time and this trend will not be influenced largely with technologies related to renewable resources at the sea (almost not visible in the figure presented below), depicting the situation forecasted for the marine technology R&D sector.

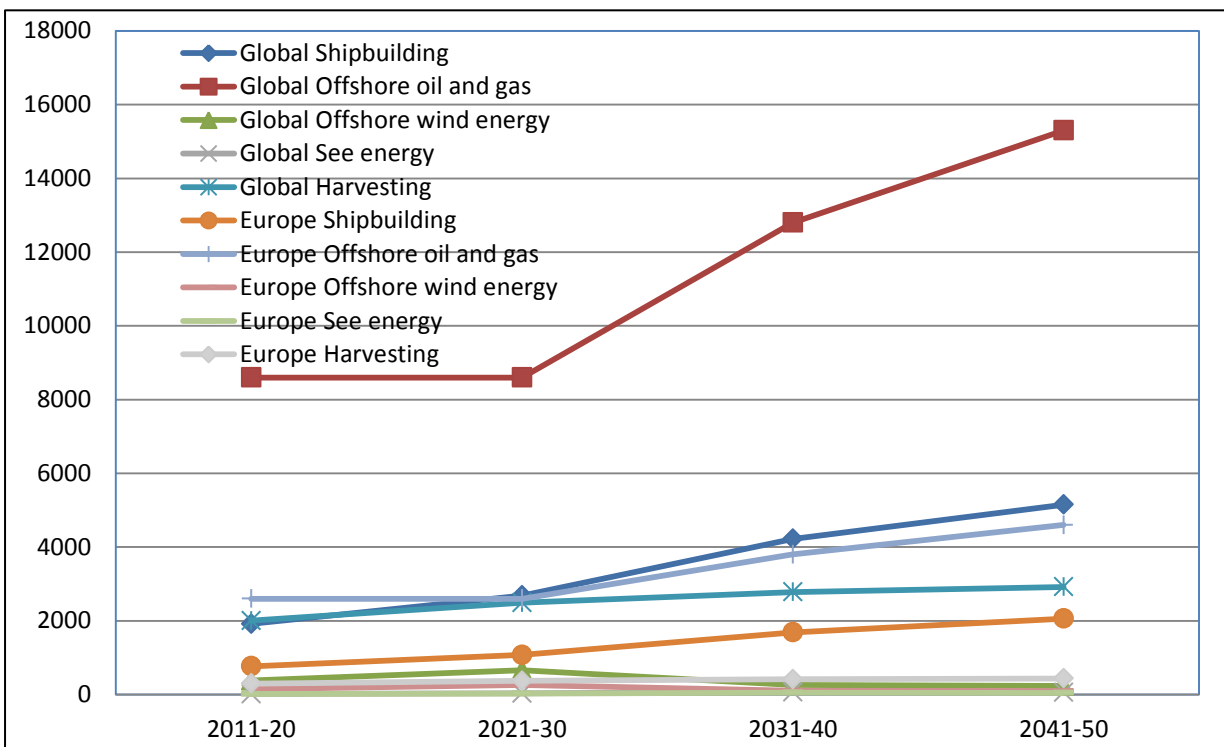


Figure 2: Global and European market for R&D services in marine sector – foresight scenario (mill USD)

Source: Data from 'Ocean Space Centre – global trends for demand and R&D until 2050' by Impello Management AS, preparation by Oxford Research AS

1.3 Research & Development Activities in the marine sector

The world marine R&D sector can be valued at €54bn for the time period 2005-2009, where the European share amounts to a 30 % of the total world figures². A number of sectors make up this global value, including the Government sector (with a value of 52 % of the total R&D value), the shipbuilding R&D (a 16 % of the total value), the oil & gas industry (with a total estimation of 23 % of the total value) and, finally, other marine industries (9 % of the total).

As it can be seen, **government is a major spender**, via for instance 'research' vessels operating worldwide. The US leads this government market, where the response to global warming is likely to increase this. Meanwhile, shipbuilding R&D is mainly a function of future growth of revenues, where centres of shipbuilding R&D exist through Europe and Asia. Finally, estimations for the oil & gas industry suggest an increase in line with the technical challenges that will be faced in the future, with major R&D centres located in Western Europe and the US.

The competitiveness and innovativeness of the marine sector is strongly dependent on the efforts in the R&D domain. For example, the European shipbuilding industry reports spending 10 % of revenues. Also, the capacity for adding value in the shipbuilding sector is moving towards the domain of the equipment suppliers, who are increasingly delivering entire turnkey systems and are helping clients to find specialized and innovative solutions for special problems.

1.4 Main R&D challenges for the future

Some of the major R&D challenges for the future marine industry can be summarized as follows:

- Oil & Gas – Increasing exploitation of gas reserves in light of reducing oil supplies, increasing oil & gas recovery from brown fields and greater water depths, and economically developing small fields. In this regard, the main technical challenges for this concrete subsector are now focused on two main areas, i.e. deep-water (ex-

ploiting the many remaining small shallow water fields) and maximizing recovery from depleting fields ('brown fields'). Other interesting research fields include new, greener technologies so as to protect the environment or the focus on renewable energies. Increase in the use of floating production systems and subsea production.

- Renewable Energy – Reducing capital costs and improving reliability. Operating wind farms in deeper waters and at greater distances from the shore. Development of wave and tidal current power. Increasing efforts to commercially exploit methane hydrates. Reduce costs by use of large turbines involving increased distances from the shore and water depths.
- Shipbuilding and marine equipment – How to employ technology to counter high European labor costs and the threat of China and South Korea's penetration of the 'special complex vessels' sector that accounts for much of Europe's business (super yachts, fishing, dredging, demanding services for the off-shore oil and gas industry, coast guards, naval vessels, or vessels for specific transport tasks including short-sea shipping and inland navigation, project cargo with heavy lifting requirements, transport under ice-conditions or other particularly challenging cargos, cruises). Overall long-term increase in ICT content in the marine sector. Long-term potential in the marine biotechnology sector (for instance in the search of pharmaceutical products).
- Marine fisheries sector – How to add more value to the raw product, opportunities offered by 'new' (previously unexploited) species, better use of scarce fishing resources. Opportunities opened up by the farming of seaweed.

² Information taken from Douglas-Westwood Limited, World Marine Markets, March 2005 (see http://www.schleswig-holstein.de/MJKE/DE/EuropaOstseepolitik/Meerespolitik/Download/studieWorldMarine_blob=publicationFile.pdf).

1.5 Centres selection

This study was designed as a comparative analysis of 10 selected centres located worldwide.

The research centres and their organizations vary from each other in terms of financing resources, their relationships with other external agents (i.e. universities, private agents, enterprises, etc.) or their specialization on different research segments (i.e. shipbuilding, offshore oil and gas activities, ocean/offshore renewable energy, aquaculture and fisheries, naval etc.).

The selection procedure was based on a list of selection criteria deemed important for study stakeholders. These criteria might be summarized in the following:

- Ownership (private /public /membership /other)

- Geographical location (European /non-European including representation in the Americas and Asia),
- Market orientation (education & research type / market-oriented type)
- Size of operations

The ultimate goal was to get a representative sample of institutes / research centres characterized by diversified ownership structures, operating advanced but comparable infrastructure with various size of activity on the commercial market. The final list of institutes to be covered with the study was shaped in a consultation process between the Norwegian Ministry of Trade and Fisheries, Marintek and Oxford Research team.

The final list of centres selected include:

Table 1: Selected centres

No	Country	Name of the institution	Web address	Location	Description
1	Brazil	LabOceano	http://www.laboceano.coppe.ufrj.br	LabOceano - COPPE / UFRJ - Parque Tecnológico do Rio - Cidade Universitária - Ilha do Fundão – Rio de Janeiro, Brazil	The Laboratory of Ocean Technology - LabOceano - part of the Program Naval and Oceanic Engineering COPPE / UFRJ. Is able to provide services in experimental hydrodynamics, computational hydrodynamics and numerical modeling of ocean and marine systems, and the development of research projects and personnel training. In operation since 2003, LabOceano already held more than 70 projects involving tests with hydrodynamic models in reduced scale, including tests with semi-submersibles, turret and spread moored FPSOs, jack-ups, mono-columns, barges and other floating structures, and also tests for assessing the installation and operation of subsea equipment. Those projects were done both for national and international clients.
2	Canada	Oceanic	http://www.oceaniccorp.com	St. John's, Newfoundland and Labrador, Canada	Ocean and coastal engineering, including: marine vehicles design and operation; ice forecasting and measurement; methods to predict structural loading in ice; coastal defences (e.g. against erosion and storm damage); marine safety and risk management systems; flood forecasting and modeling; aquaculture equipment design and operation
3	China	China Ship Research Scientific Centre	www.cssrc.com	Binhu District, Wuxi city, Jiangsu Province, China	With a history of more than 60 years and as a member of ITTC and ISSC, China Ship Scientific Research Center, affiliated to China Shipbuilding Industry Corporation, is China's largest ship and ocean engineering research institute and possesses more than 500 research engineers and 23 large-scaled test facilities, mainly engaged in the research and consultation of ship hydrodynamic performance, propulsion, high performance ships, underwater engineering, vibration and noise reduction, underwa-

					ter structure, marine and offshore structures as well as information technology.
4	Germany	HSVA The Hamburg Ship Model Basin	http://www.hsva.de	Hamburg, Germany	Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), The main task is to advise the maritime industry (world-wide) in the fields of hydrodynamics and ice technology (ships, structures). HSVA is especially experienced in computer fluid dynamics computations (CFD), waterborne transport systems and in model test experiments in open water and in ice.
5	Italy	Insean – The Italian Ship Model Basin	http://www.insean.cnr.it/en	Rome, Italy	Insean carries out research in the fields of naval architecture and marine engineering, developing models, technologies and innovative design methodologies, with applications: <ul style="list-style-type: none"> • in the transport and other maritime activities; • in the study, observation and monitoring of the marine environment; • in the eco-sustainable use of sea resources
6	Korea	MOERI - Maritime & Ocean Engineering Research Institute (MOERI) (part of KIOST: Korea Institute of Ocean Science & Technology) In October 2013 named Korea Research Institute of Ships and Ocean Engineering (KRISO) , still part of KOIST	http://www.moeri.re.kr/	Daedeok Science Town, South Korea	Conducting research projects within <ol style="list-style-type: none"> 1) Future ship technology <ul style="list-style-type: none"> • Energy Saving technology • Environment friendly ship technology • Ship safety technology 2) Offshore plant engineering technology <ul style="list-style-type: none"> • Offshore plant FEED technology • Offshore structure safety technology • Ocean energy utilization technology 3) Ocean accident & ocean traffic system technology <ul style="list-style-type: none"> • E-Navigation technology • Technology on ocean accident response & minimise pollution • Safe ocean traffic technology 4) Underwater robot & offshore equipment technology <ul style="list-style-type: none"> • Underwater robot technology • Underwater acoustic technology • Deep-sea equipment technology
7	Norway	The Norwegian Marine Technology Research Institute (Marintek)	http://www.sintef.no/home/Marintek	Trondheim, Norway (main office). Subsidiaries in Rio de Janeiro and Houston.	Performs research and development for companies in the field of marine technology. Marintek develops and verifies technological solutions, business and operating concepts for the shipping, marine equipment, ocean energy and petroleum industries.
8	Singapore	Singapore Maritime Institute	http://www.maritimeinstitute.sg/	On the campus of National University of Singapore (NUS) Singapore	Activities in Ocean Engineering Basin. Main activities will be related to offshore petroleum activity, marine equipment and ship construction.
9	The Netherlands	Marin	http://www.marin.nl/web/show	Wageningen, The Netherlands	Service provider for the maritime sector: hydrodynamic research applied for the benefit of Concept Development, Design Support, Operations Support and Tool Development
10	USA	Offshore Technology	http://otrc.tamu.edu	Main facilities and most per-	Research primarily focuses on use of the wave basin in the facility to conduct testing on offshore/deep-

		Research Centre		sonnel located at Texas A&M University's Research Park in College Station, Texas. Additional satellite office located in Austin, TX at the University of Texas. USA	water platforms, installation operations and seafloor engineering. While the wave basin can also be used for limited towing simulation, this is not the primary area of research. Some research is also conducted on surface vessels' behaviour.
Source: Oxford Research AS					

The list of centres and organisations taken into consideration in the initial stage included also:

1. Centre for Marine Science and Technology (CMST), Australia
2. AIMS Australian Institute of Marine Science: Australia's tropical marine research agency (<http://www.aims.gov.au/>), Australia
3. Oceanic Consulting Corporation, Canada (see <http://www.oceaniccorp.com/>)
4. Halifax Marine Research Institute (HMRI) (<http://hmri.ca/>) (membership organisation) Canada
5. Centre for Cold Ocean Resources Engineering (Canada) (<http://www.c-core.ca/>)
6. Jia Tong University, school of Naval Architecture, Ocean & Civil Engineering NAOCE, China (see <http://en.sjtu.edu.cn/> and <http://naoce.sjtu.edu.cn:8080/Naoce/faces/cmsview.xhtml>)
7. FORCE Technology, Denmark (see <http://www.forcetechnology.com/>)
8. Machine Technology Centre Turku Ltd, Finland (see <http://www.koneteknologiakeskus.fi/content/en/1/5/Home.html>)
9. SIREHNA, France (see <http://www.sirehna.com/>)
10. Technological Educational Institute of Athens (Department of Ship Building Technology), Greece (see http://www.na.teiath.gr/info_en.html)
11. The Irish Marine Institute, Ireland (see <http://www.marine.ie/home/research/MIRresearch/>)
12. CETENA, Italy (see <http://www.cetena.it/>)

13. Japan Agency for Marine-Earth Science and Technology (JAMSTEC) (public)
14. Krylov Institute, Russia (see <http://krylov-centre.ru/old/eng/>)
15. Korea Advanced Institute of Science & Technology, South Korea (see <http://www.kaist.edu/edu.html>)
16. Tecnia Corporación Tecnológica, Spain (see <http://www.tecnia.com/>)
17. SSPA Sweden AB, Sweden (see <http://www.sspa.se/sspa>)
18. The Institute of Marine Engineering, Science and Technology (IMarEST), United Kingdom (see <http://www.imarest.org/>)
19. David Taylor Model Basin, United States of America (see <http://www.navsea.navy.mil/nswc/carderock/src/what/facilities.html>)

1.6 Study methodology

The study is based on ten "case studies", one for each selected organisation, providing mostly qualitative data and allowing for a comparative analysis in the final report. The central purpose of the case studies was to collect information about each Centre, using in-depth research, primary with publicly available data supplemented by direct interviews with relevant actors.

Case studies were conducted by a network of researchers, with a single responsible researcher in each country. A separate training session using a teleconference platform was organised for the research team, introducing the structure of the investigation, the approach to field work and providing the opportunity to discuss and understand the study itself and the data gathering template.

The template for data gathering was prepared by the core team of Oxford Research and presented and discussed with the Ministry and Marintek.

In many of the cases listed above, the infrastructure ownership is separated from the unit responsible for commercial use of facilities or allocated to separated organisations, therefore in the first step the team addressed the issue of the organisation being in the centre of the case study. For the sake of this study it was important to identify the unit, being the one legal entity operating the research facilities for commercial purposes. From this perspective, the study explores how the capital investment in infrastructure is influencing costs calculation and pricing. Finally how the public support for infrastructure investment influences the entire institutional setup.

Information sources used:

- Publicly available information from web search, covering the main Centre website and any other web sources identified that might be relevant for the case.
- Other sources (e.g. local press or printed publications).
- Direct interviews with the Centre's staff. Taking into consideration the nature of this study and the sensitive content of the information in scope, we have been able to cover 8 Centres with direct interviews. Selected Centres located in Korea and China refused participation in this part of the investigation.

In terms of market operations the study operates with the following split of the research services:

- shipbuilding technology and design
- technology and design for offshore oil and gas activities
- technology and design for ocean/offshore renewable energy
- technology and design for aquaculture and fisheries
- technology and design for arctic operations

1.7 The research sector financing

This section includes an overview of the types of research funding available. The main split can be

broadly seen between commercial and non-commercial (including internal funding):

- Commercial
 - Industry and private companies (national and multinational)
- Non-commercial
 - Charities
 - National research councils
 - Government ministries and departments
 - International institutions e.g. European Commission via Framework programme 7 and Horizon 2020 in the near future
 - Other national internal schemes

In regards to public funding, we distinguish between:

- block grant based regimes, where the majority of research funds are allocated directly to institutions according to particular formulae, performance indicators or budget negotiations among actors;
- and project-based regimes, where scientists obtain project funds from external sources competitively.

Funding is one of the major instruments used to steer the science and innovation system. Many countries have introduced reforms in their research funding systems in order to foster excellence, knowledge transfer and socio-economic innovation, reducing the proportion of institutional funding without "strings attached".

The current (global) trend towards more selective and competitive funding was established some years ago. In addition, countries that increased their government budgets have often fed the investment towards specific programs such as centres of excellence or towards the advancement of priority-specific research sectors. Some countries also implemented performance-based research evaluation systems with significant consequences for research funding at the institutional level.

There is debate about whether the increasing reliance on competitive project or program funding at the expense of block grant and long-term institutional funding has pressured public sector research resulting in an emphasis on short-term, low-risk projects and away from longer term fundamental research. There are also concerns about whether

this negatively affects an institution's capacity to invest in infrastructure. It is difficult to balance performance-based funding approaches with autonomy and flexibility to public research institutions. Programme-oriented funding also raises some concern in non priority areas. In either case, the diversification of the funding portfolio of public sector research organisations in relation to interactions with more social and economic actors may positively affect innovation performance. However, the conditions that generate markets and research users are not the same for all scientific and technological areas. Likewise, institutional arrangements in different research organisations may either hinder or favor specific funding strategies. The degree of external research funding diversity (i.e. number of different agencies and foundations) has also affected institutional arrangements by increasing the pluralism of funding sources.

Governments are traditionally the major funders of public sector research. Governments fund research either directly or indirectly. Direct funding occurs through particular departments with competencies in the STI domain and they often have their own mission-oriented public research organisations and large national research centres within their charts. Conversely, indirect funding occurs through intermediary research funding organisations such as research councils or research agencies. Governments show increased interest in improving their scientific output internationally but are providing less funding without "strings attached", thereby strongly emphasizing scientific excellence and performance.

Institutional block funding provides research organisations with a stable basis for research activities. This can help them to acquire funding from other sources, provides them with a certain degree of autonomy in the selection of their research, and allows them to build up expertise in new fields. Conversely, a surplus of block funding may disincentivise organisations and researchers to look for funding from other sources. When referring to institutional block funding, it is useful to make a distinction between "pure block funding", where recipients have a relatively large discretionary power on how to use these funds, and "ear-marked funds", which can only be used to cover specific expenses such as the salary costs of permanent staff. Many countries have undergone a shift away from block funding in favour of more project funding. However, most European research systems are still characterized by a higher share of block funding when compared to the US system (Lepori et al. 2007). Several countries have

introduced new performance based approaches to the distribution of institutional funding (OECD 2010). For example, the United Kingdom, Australia and New Zealand have implemented national evaluation frameworks based on a different combination of quantitative and/or qualitative indicators (Coryn et al. 2007, OECD 2010). Funding agencies use these evaluation outcomes as part of a funding formula used to distribute part of the block funding among institutes.³

The research conducted in this study also confirms that most of the institutes being subject to investigation are largely subsidised from public sources. Using different possible streams, including both project and block financing as well as investments in infrastructure.

1.8 Norwegian experience in the field

For generations, Norway has been a leading maritime nation, due to: dependence on the ocean, long-term thinking, brave decisions, and marine technical knowledge and expertise. In 2009 around 100 000 people were employed in marine and maritime activities. These activities contributed to around 130 bn. in gross value added. This is equivalent to 8 percent of the value, excluding oil and gas operations and public sector⁴.

Marine Technology Centre consists of Marintek and the Department of Marine Technology (IMT) at Norwegian University of Science and Technology (NTNU). Marintek operates within industry-oriented strategic research, applied research and commercial mission activities in marine engineering. NTNU's main focus is higher education in marine engineering at MSc and PhD level. The strategic research is a common venue for both, and joint strategies for business-oriented strategic research have been established. The marine technology laboratories are owned by NTNU, and operated by Marintek in cooperation with NTNU. Together, Marintek and IMT account for one of the best education and research institutes in marine hydrodynamics and marine structures worldwide. The laboratories are used by researchers in Marintek and NTNU for research and educational purposes. Furthermore, the laboratories

³ Chapter based on OECD Innovation Policy Platform www.oecd.org/innovation/policyplatform ISSUE BRIEF: PUBLIC SECTOR RESEARCH FUNDING

⁴ http://www.regjeringen.no/upload/NHD/Temasider/Maritime_Naringer/KVU-dell_Ocean_Space_Centre.pdf

are used for paid research projects of Norwegian and international industry, Norwegian authorities and other actors contributing to the largest use of the facilities. Researchers from other Norwegian institutions have access to the facilities on the same terms as other external users. Through international research cooperation the laboratories are also available to researchers from other countries to some extent, for example through EU-funded projects.

1.9 Ocean Space Centre concept

Ocean space technology and marine technology, and expertise are critical factors in offshore oil and gas, fisheries and aquaculture. New industries such as renewable ocean energy, requires considerable knowledge and innovation. Marine technical centre consist of Marintek and NTNU, together with parts of SINTEF, and are international leaders in important parts of ocean space technological research and

development. However, parts of the research laboratories at Tyholt in Trondheim, do not satisfy the requirements of a future world's leading knowledge centre for ocean space technology. Foreign operators surpass Norway in regard to ocean space knowledge, laboratories etc.

The Norwegian Government is considering different funding options for the building/development of a Centre for Marine Technology in Trondheim, Norway. The new Centre, Ocean Space Centre (OSC), will be designed for marine and maritime research and education. Access to advanced laboratory infrastructure is a key element of meeting the opportunities offered by OSC.

In this context it was important to obtain an overview of current management, ownership and market situation of similar Centres.

Chapter 2. A comparative view

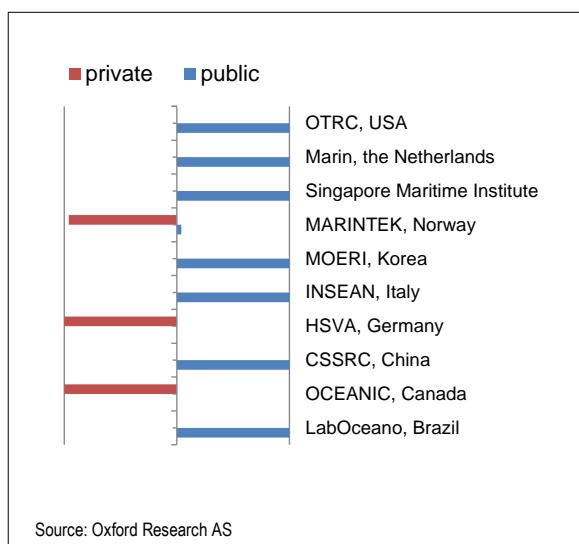
2.1 Ownership

This first initial chapter brings an overview of ownership and management situation of all centres in scope of the study.

2.1.1 Management and ownership

The ownership structure of institutes is very polarized. They are either owned fully by the state (as a public research institutions) or organized as private companies. Some extraordinary formations appear. One particular case here is Marintek in Norway, operating as a private company with some shares kept by the Norwegian government (Norwegian Maritime Directorate) and other non for profit bodies. Another is MARIN in the Netherlands – a not-for-profit company established by a foundation composed of various private actors (therefore classified as public and not private). Finally HSVA – also a not-for-profit company but owned directly by a set of commercial industry companies.

Figure 3: Ownership



Detailed information about the structures of the institutes in scope is presented below.

Brazil - LabOceano:

LabOceano is part of the Oceanic Engineering Program of COPPE, the Graduate and Research Centre for Engineering of the Federal University of

Rio de Janeiro. COPPE is an international reference in research and development.

LabOceano management: The research centre has administrative autonomy, a dedicated CEO, research, technical and operational staff and a commercial department. However, LabOceano and COPPE (its parent entity) are not legal entities/companies themselves, depending on a private, non-profit university owned Foundation called COPPETEC to hire, celebrate contracts and provide services to the public and private sectors. The profits of contract research projects are invested in new research, scientific equipment and competence development.

LabOceano ownership: 100% owned by COPPE/Federal University of Rio de Janeiro (Public). Its ownership structure allows the centre to provide highly specialised research and development services at competitive prices, since it has no obligation to pay back the public investments made to its research facilities and assets.

Canada - Oceanic

Oceanic Consulting Corporation (“**Oceanic**”) is an indirect subsidiary of J.D. Irving Limited, one of Atlantic Canada’s largest private companies. J.D. Irving Limited owns Fleetway Inc., which acquired Oceanic in 2011. Prior to this acquisition, the Oceanic brand was tied to a Canadian not-for-profit entity.

These testing facilities are owned by National Research Council Canada (“NRC”) and operated units of Memorial University of Newfoundland and Labrador (“MUN”).

Oceanic’s contract with National Research Council Canada (NRC) establishes it as the exclusive channel for all non-governmental and non-Canadian university use of the NRC testing facilities.

China – China Ship Scientific Research Centre (CSSRC)

China Ship Scientific Research Centre (CSSRC) is affiliated with China Shipbuilding Industry Corp.(CSIC). It is not registered as a business entity but as an Institutional Organization with legal

person status. Institutional Organization can be understood as a non-profit making unit established by the Chinese government (fully public). In Chinese language, Institutional Organization is pronounced as “*shiyè danwèi*” and is always attached or managed by a governmental body or state-owned enterprises to conduct specialized tasks.

Institutions named by governmental authority being parts of CSSRC:

- Two National Key Laboratories on Hydrodynamics, on Ship Vibration and Noise
- National R & D Center on Offshore Engineering
- National Ship Overall Performance Test & Inspection Center
- National Metal Structure Test & Inspection Center

- Jiangsu Provincial Key Laboratory on GreenShip Tech.

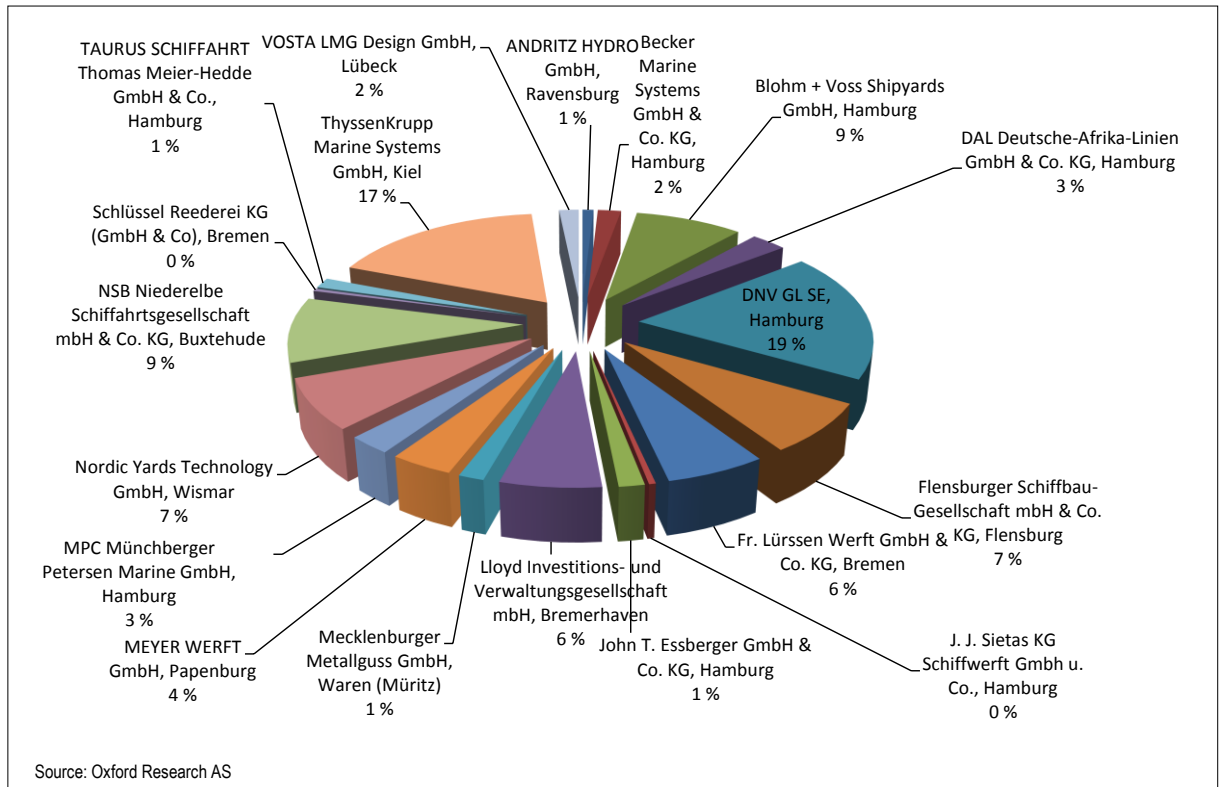
One of the first-batch institutions in China awarding masters and doctors degrees, presently having 24 PhD tutors and MSc tutors. It has a post-doctoral work station on the science of ship and offshore engineering.

Germany - The Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA)

HSVA is a private self-supporting, non-profit research organisation.

The shares are owned by a large and diversified group of industrial companies with DNV GL SE (of Norwegian origin) holding 19 % of all shares. The second important stakeholder is German heavy industry concern ThyssenKrupp.

Figure 4: HSVA ownership structure



Italy - The National Institute for Studies and Experiments in Naval Architecture (Insean)

Insean is an Institute of the National Research Council of Italy (CNR) and in particular it belongs to

the CNR’s Department of Engineering, ICT and technologies for energy and transport. It is a non-commercial organization.

Insean has a very long history which goes back to 1927. It was established under the name “National Basin for Experiences in Naval Architecture” and played a key role in the development of the national shipbuilding industry and in the research in the maritime field. It became a public research establishment in 1975 operating as an independent entity. Since 2011 Insean is part of the CNR which owns 100% of the Institute.

Korea – MOERI Maritime & Ocean Engineering Research Institute, now Korea Research Institute of Ships and Ocean Engineering (KRISO), a part of Korea Institute of Ocean Science and Technology (KIOST)

Founded in October 1973 as a Ship Research Institute belonging to Korea Institute of Science and Technology (KIST). Officially Maritime & Ocean Engineering Research Institute (MOERI) was established at the Daedeok Science Town on May 1st, 1997. It was recently reorganized in October 2013 and is now operating as Korea Research Institute of Ships and Ocean Engineering (KRISO), a part of Korea Institute of Ocean Science and Technology (KIOST).

KIOST is fully state owned institute operating with a large state block contribution (around 35 % of total yearly expenses) as well as large national and sponsored project financing (where private funds amount to only 5 % of the total income).

KIOST is composed of a number of institutes including:

- Ocean Science Research Department
- Applied Ocean Technology Research Department
- Operational Ocean Science & Technology Department
- Ocean Observation Technology & Information Department
- South Sea Research Institute
- East Sea Research Institute
- **Maritime & Ocean Engineering Research Institute**
- plus additional structures dedicated to management and education.

MOERI is the biggest institute of KIOST in terms of building area: 41,173m² and ground area: 153,985m²

MOERI is organized around the following Divisions:

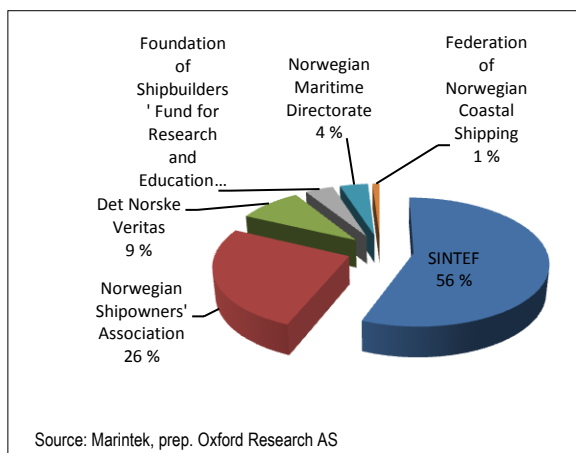
- Marine Transportation Research Division
- Ocean Plant Research Division
- Maritime Safety Research Division
- Ocean System Engineering Research Division
- Industry Policy & Cooperation Section
- General Management Division
- Off-shore Plant Industry Support Centre



Norway – Marintek

Marintek is a company in SINTEF, the largest independent research organization in Scandinavia. SINTEF is a non-commercial organization. The profits of contract research projects are invested in new research, scientific equipment and competence development. In the course of the past five years, SINTEF has invested approx. 65 million € (NOK 500 million) of its funds in laboratories and scientific equipment.

Figure 5: Marintek ownership structure



Marintek is legally classified as a private company. Marintek ownership structure is vital for the owners, since it was created for the purpose of managing the infrastructure and offering research services, a function the owners could not do themselves.

Marintek is co-located with NTNU Department of Marine Technology at the Marine Technology Centre in Trondheim. The close cooperation between NTNU and Marintek was established from the beginning, with the aim to maintain international excellence together.

The Ship Model Tank was opened in 1939 and was operated by the University (the former NTH which was reorganised in 1996 and took the name NTNU) until 1972. In 1951 the RCN (Research Council of Norway, actually the former NTNF) established the Ship Research Institute (SFI). In 1972 the Norwegian Ship Research Institute (NSFI) was established, and the operations of the existing infrastructure were up-taken by this institute. Still the infrastructure was fully owned by the university.

In the early 80s the discussion started regarding the link between various research institutes to the Research Council as they were too closely linked to RCN.

As a result the SINTEF Group was established in 1985 and NSFI was linked to SINTEF, together with two other similar research institutes in Trondheim within energy (EFI) and petroleum (IKU). NSFI, EFI and IKU all changed their names and were established as share holding companies. Marintek (Norwegian Marine Technology Research Institute) was established as a successor of NSFI.

The relation with the former NTH, now NTNU, developed along the years. E.g. the professors

work as scientific advisers to Marintek and also Marintek researchers supervise some of the students and teach courses. These agreements are based on institutional agreements.

There is no mix in formal daily operations. Marintek and NTNU are separate legal bodies co-located in the same buildings. The professors at NTNU don't participate in the daily operations of Marintek, they are only advisers. The operation of the infrastructure is regulated in separate agreements. Marintek has a dedicated responsibility to operate and maintain the main laboratories.

The Ship Model Tank and the Marine Technology Centre were partly financed by the state and partly by private money. The Ocean Basin was fully financed by the state. Marintek has financed some offices, storages and workshops for building models. The Ocean Basin was owned by the Research Council NCR until 2004 and then transferred to NTNU. The operations costs are on Marintek's side in all terms.

The Centre for Ships and Ocean Structures (CeSOS, in Norwegian "Senter for skip- og havkonstruksjoner") hosted by NTNU was established as a Centre of Excellence (CoE) by the Research Council in 2002. This is organized as a project being a separate department of the NTNU, not institutionally influencing the ownership relations described above. Marintek acts as a research partner in this CoE.

Singapore - Singapore Maritime Institute

The Centre in Singapore is still in an early planning stage, and will not be ready before 2017-18. No figures for operating costs, infrastructure costs or current clients are therefor available. Financing has been discussed in general terms. Agencies that are currently involved are Singapore Maritime institute, National University of Singapore, Agency for Science, Technology and Research (A*STAR) and National Research Foundation (NRF)

The Singapore Maritime Institute (SMI) is a joint effort by Maritime Port Authority (MPA), the Agency for Science, Technology and Research (A*STAR) and the Economic Development Board (EDB) in partnership with local Institutes of Higher Learning (IHLs) and reflects Singapore's continued commitment to the maritime industry. SMI aims to develop strategies and programmes related to the academic, policy and R&D aspects of the maritime industry. Key focus areas of the SMI include sec-

tors such as shipping, port and maritime services, as well as offshore and marine engineering.

The SMI coordinates and aligns the strategic activities of the various maritime institutes established at local IHLs. The SMI will also encourage more industry R&D projects to be undertaken in Singapore.

As a whole-of-government approach, the agencies have so far committed 350 million SGD (around 200 million EUR) to fund initiatives through the SMI.

SMI initiated plans for a marine and offshore testing facilities in 2012. The plan was for the testing facilities to support research and development in offshore & deep-water technologies, equipment and specialised vessel design and others. A feasibility study has been conducted to analyse the industry's infrastructure needs, potential utilisation, business model and specifications of the facilities.

In 2013 the responsibility for the project was transferred from SMI to The National University of Singapore (NUS) and a working committee was set up with members from A-STAR, NUS and National Research Foundation. The chair of the committee is Professor Chan Eng Soon, Dean of the Faculty Of Engineering at NUS. The planned centre with an Ocean engineering Basin as the initial infrastructure is expected to be ready in 2017-2018.

As of today the ownership structure has yet to be decided, but it is intended to be a national laboratory, which indicates 100% public ownership of the centre. Most likely the management and ownership will be by NUS and/or A-STAR, at least initially. The parties involved are open for collaboration with foreign research centres, both public and private entities. This might change in the future management and ownership structure.

The Netherlands – MARIN

The Maritime Research Institute Netherlands (MARIN) was founded in 1929 by the Dutch government and industry. The institute has a dual mission: to provide industry with innovative design solutions and to carry out advanced search for the benefit of the maritime sector as a whole.

MARIN is supported by the so-called MARIN Stakeholders Association (MSA), which was founded in 2004. The MSA consist of 13 members: IHC Holland Merwede, Damen Shipyards, Maersk, Shell, Heerema, Bluewater SBM Offshore, Wartsila

Netherlands, City of Wageningen, Wagenborg, Imtech Marine & Offshore, Huisman Itrec and Boskalis. Originally, all members of the MSA were Dutch companies; nowadays, Maersk is the exception, because they took over Nedlloyd in 2004/2005.

MARIN therefore is in fact a not-for-profit company owned formally by a foundation and has so to speak no direct public or private owner. Private and public partners have both their influence via the Supervisory board and MSA.

MARIN is a so-called not-for-profit organization. The profits of the research projects are invested in MARIN itself, especially in the MARIN academy.

MARIN independence was underlined as an important factor, especially appreciated by the main customers on the market.

The Advisory Board has the task of advising on commercial activities (market strategy), but more importantly on R&D activities. The members advice on the strategic plan, the R&D annual plan and the market position. The advice is directed to MARIN's management. Next to company members (like Shell and Damen Shipyards), the advisory board consists of 8 universities and research organizations. MARIN has strong relations with the universities of technology in the Netherlands; TU Delft, TU Eindhoven and TU Twente. MARIN also finances two professorships.

The Supervisory Board consists of 3 members of the MSA, 2 members of the government (of which one represents the employee's interests) and has a total of 7 members. They supervise the management of MARIN. The local government is represented by the mayor of Wageningen. The reason why he is participating on the board is because of the (historical) connection with Wageningen as a big employer for the local population. The second member of the government is a representative of de Dutch Ministry of Economic Affairs.

USA- The Offshore Technology Research Centre (OTRC)

OTRC is a public research centre in the administration of TEES.

The Texas A&M Engineering Experiment Station (TEES) is an umbrella organization that manages numerous research institutions at Texas A&M University. As such, TEES is officially the contracting entity for all external customers, but executive authority for usage of facilities and research infra-

structure of OTRC resides in the director of OTRC. Director of OTRC is also the lead figure in seeking and finalisation of all research agreements.

OTRC Industry Consortium - The OTRC Research Consortium includes some of the United States' largest companies as well as small consulting firms. The Consortium was formed when the centre opened in 1988 as a means for industry to participate in OTRC's research initiatives.

OTRC research program is carried out by staff engineers and faculty of Texas A&M University and the University of Texas at Austin. OTRC sponsors include federal and state agencies, national trade associations, non-profit regulatory corporations, and oilfield companies.

OTRC current research sponsors include:

- ABS Consulting
- American Petroleum Institute
- Delmar Systems, Inc.
- Minerals Management Service
- Shell International Exploration and Production Inc.
- State of Texas

2.1.2 Ownership of the research infrastructure

The ownership of the infrastructure in the institutes follows very much the general ownership patterns.

For all public centres the ownership is also public and stays in most cases in the hands of the Institute or the University where the centre is located.

Private companies own the infrastructure they operate.

Exceptions are Marintek in Norway and Oceanic in Canada.

Table 2: Ownership of the research infrastructure

Country	Institute	Ownership of infrastructure %	Comment
Brazil	LabOceano	100 % public	Fully owned by COPPE/UFRJ. The operational costs of the laboratories are fully covered by LabOceano. LabOceano has no legal identity and therefore cannot celebrate contracts (and get paid directly). All its revenues from research projects are incorporated to COPPETEC budget and then return to pay for LabOceano operational costs. COPPETEC manage the budget of all research centres associated to COPPE.
Canada	Oceanic	100 % public	NRC and MUN own their respective facilities. NRC and MUN both provide services to academic, government, and commercial researchers on various terms. In the case of NRC facilities, Oceanic has an exclusive marketing right for all non-governmental and non-Canadian university use. The National Research Council of Canada (Canadian Federal Government) owns the large tow tank, maneuvering basin, ice tank, and wave tank facilities. Memorial University (owned by the Provincial government of Newfoundland and Labrador) owns a flume tank and smaller tow tank. Oceanic has separate marketing arrangements with both organizations to market their facilities commercially. The NRC's facilities are much larger and would represent 80-90% of the total investment value.
China	CSSRC	100 % public	There are 23 large scale test facilities under the management of 5 research divisions of CSSRC. These labs and workshops manage and operate the infrastructure and facilities of CSSRC. All these were invested with public money and kept in public ownership and administration.
Germany	HSVA	100 % private	Infrastructure is fully owned by HSVA. The City of Hamburg is the owner of the property (land, not buildings) on which the HSVA is built. Historically, the rent paid for the land has been low, but has now been adjusted to more market-like prices
Italy	Insean	100 % public	Insean is fully owned by the National Research Council and therefore all the facilities remain fully public and under public administration
Korea	MOERI /KIOST	100 % public	KIOST is fully public and financed by the state.
Norway	Marintek	100 % public	The infrastructure operated by Marinetk is almost fully owned by NTNU. The operations costs of the laboratories are fully covered by Marintek.
Singapore	Singapore Maritime Institute	100 % public	The ownership of the infrastructure has not yet been decided, but it will remain public. Infrastructure will be located on the National University of Singapore's premises, but the infrastructure ownership may be with other government agencies such as A-STAR. Other university units and A-STAR's Institute of High Performance Computing (IHPC) will be important relationships that might make it difficult to differentiate some costs. They are also looking into joint industry collaborations.
The Netherlands	MARIN	Non-profit foundation (in juridical terms private entity)	The ownership of the infrastructure is not described in the statutes of MARIN. Historically, you could say that the Dutch government financed most of the investment in the infrastructure, MARIN is responsible for the operation and maintenance costs of the facilities. In the case of the latest investment in 2011, MARIN also financed 20% of the total investment costs.
USA	OTRC	100 % public	The OTRC infrastructure is public owned and under the administration of The Texas A&M Engineering Experiment Station (TEES) being the umbrella structure for the University.

Source: Oxford Research AS

2.1.3 Commercial sales of research services offered to external customers

This study was focusing on the institutions being authorized to perform commercial activities using the existing infrastructure.

In most cases the public institutes are also commercially responsive, selling research services externally or, in other words implementing research projects financed with private funds.

Only in three cases the institution responsible for commercial sales is not simultaneously the owner of the infrastructure:

1. Oceanic in Canada, where the ownership is public (being Research council and University), but where sales and marketing are delegated to an external company.

Oceanic has been the traditional marketer of research services associated with NRC's St. John's, NL facilities, and is the exclusive channel for all non-governmental and non-Canadian university use of the NRC testing facilities. This contractual arrangement dates back to a time when Oceanic was a Canadian not-for-profit corporation established to facilitate commercial sales of tank time.

NRC is responsible for sales of research services to Canadian government and Canadian university researchers.

It can be expected that the NRC facilities in St. John's will increasingly be made available to Canadian small and medium-sized enterprises through industrial assistance programs and other grant-based mechanisms, and that NRC will focus its in-house marketing efforts on the applied research needs of Canadian industry and Canadian government users. There is a great concern that the current world market prices for large test tank facilities are too low to be sustainable, because the pricing from many international facilities (particularly in Europe) does not reflect actual operating costs (including depreciation of capital assets). NRC has experienced difficulty competing, due to these low market prices and the Canadian government's requirement that commercial pricing reflect full operating costs.

2. CSSRC in China has a separate Department on industrialization. This Dept. invested in a dozen more companies on behalf of CSSRC with dominant shares. It is believed that through these

subsidiaries, external customers will gain access to the research facilities of CSSRC in the future. However, there is no evidence that these companies are "responsible" for this task.

3. Marintek in Norway, where the ownership is by University but all operations are on the commercial company side. Marintek is fully operating the commercial sales, based on an agreement with NTNU. NTNU Department of Marine Technology has around 2 % of economic activities, but this activity is only to a limited extent connected with the laboratories operated by Marintek.

Another interesting case here is MARIN in the Netherlands, where the infrastructure status is not clearly regulated. The great majority is financed by the state but operated by an independent company, although not-for-profit and considered public rather than private.

For Singapore it has not yet been decided, but initially the centre will work as not-for-profit organization, and will probably be administrated by NUS or A*STAR. In the future collaboration with other public or private entities might change this. A special public entity for commercial purposes might also be considered together with collaboration with foreign institutions. Some discussions to this regard have been reported with Marintek in the early stages of project planning.

Finally LabOceano has a slightly non direct structure. LabOceano is fully responsible for the commercial sales, but all the contracts are celebrated through the COPPETEC Foundation.

All other centres operate within the same legal entity for ownership, administration and commercial sales. An interesting example, different from all public research centres is German HSVA. As a private company, it is owned by a set of private entities, with a very clear commercial focus.

All remaining public centres function within larger structures of other research/university public establishments or as stand-alone public owned institutes.

2.1.4 Administration and maintenance

Daily administration of the facilities is in most of the analyzed cases in the exclusive competence of the single owner and research / commercial operator, being the same institution.

A different organizational setup is again recorded in Canada and Norway.

In the case of Canadian Oceanic, the daily administration and maintenance of the NRC and MUN research infrastructure is the responsibility of NRC and MUN, respectively. Oceanic is a “customer” of NRC and MUN and NRC and MUN earn revenue for the use of their respective testing facilities by Oceanic and its consulting clients.

In the case of Norwegian Marintek, the company is fully responsible for the daily operations and maintenance of the infrastructure.

A discussion is ongoing in Singapore on how this is to be set up but the options considered indicate that the operations will be managed by either the University of Singapore or the State Agency (A*Star).

2.1.5 Access to research infrastructure by scientists (non-commercial users)

Different cooperation patterns result from different operational setups. The university related centres cooperate more closely with the local human resources. This is the case of e.g. LabOceano and OTRC. Norwegian Marintek operates with a varied structure depending on the type of laboratory to be used and the type of research project. Asian centres seem to operate with a clear setup of formalized cooperation procedures within the government projects they implement. The more commercial centres like HSVA, MARIN or Marintek in general have open access to infrastructure based on commercial rules and project financing.

Brazil- LabOceano

Since the academic use of the laboratory produces no direct revenue stream, the LabOceano management team directly organises the access to the laboratory infrastructure for university researchers, in order to accommodate academic and external demands and not compromise the LabOceano budget. Currently the management team is studying forms of funding to compensate the academic use of the laboratory.

Canada –Oceanic

Canadian government users and Canadian university researchers are able to conduct research at the St. John’s NL facilities of NRC and MUN without the involvement of Oceanic. In the case of MUN, a memorandum of understanding with NRC provides access to NRC facilities for demonstrations, class experiments or for research work by graduate students.

When university researchers use NRC testing facilities, NRC is generally required to recover costs. Government of Canada funding, or funding from a government of a Canadian province, can sometimes be used for this purpose. [Note: A review of the rules regarding Canadian science & technology grants and industrial assistance program awards is beyond the current scope of this study]

China - CSSRC

CSSRC, being a large national research centre financed and administrated within the network of mostly public projects and block financing organises the access to research infrastructure depending on project specific conditions. The access to the infrastructure is organised in the same way as in case of every client. CSSRC is fully opened to the clients world-wide. Therefore all external clients are invoiced by CSSRC according to the agreements or contracts regarding the research project in scope.

Germany – HSVA

All users are subject to the same pricing structure, no exemptions for university researchers or students, which are frequent users of the facilities, especially the Small Towing Tank, which is seldom used commercially anymore.

Italy- Insean

Insean is part of the CNR (National Research Council) and as a public entity is freely accessible to anyone interested in its activities. The Institute hosts regularly visiting scholars (professors, PhD students, PostDocs) and interns from all over the world. There are currently two Marie Curie fellows, among others, working at the Institute. Italian Professors as well as other researchers have appointments within the Institute and, depending on the projects they work on, they have access to rooms and laboratories in which they need to conduct their research.

Korea – MOERI

As a public institute MOERI is actually a work place for scientists implementing national importance projects. All access to this infrastructure is therefore regulated within the network of national research institutes and depending on projects financed in great majority by national ministries.

Norway –Marintek

The access to the infrastructure is organized in the same way as in case of every client. Marintek is currently engaged in e.g. a network project financed by the EU Framework programme, with many Universities in EU involved and researchers from these

universities come to Trondheim to carry out tests in the laboratories, this being part of the project and its budget.

The laboratories at the Marine Technology Centre are in general jointly used by NTNU's (Department of Marine Technology, CeSOS and AMOS) and Marintek. NTNU uses the laboratories for research and teaching, while Marintek uses the laboratories for contract research. NTNU's use of laboratories is mainly linked to some specific laboratories student activities and basic research (master theses, PhD and PostDocs works). They only use the big laboratories to a limited extent.

Other examples: If NTNU asks for access to Marintek operated laboratories, the students can do their courses here. The university is invoiced for their use of the labs. Some PhD students and PostDocs also do some research linked to projects carried out by Marintek. Students may have projects financed from external sources (e.g. their PhD grants or some other research projects), and may then pay for their use of the labs. There is one small tank operated fully by the PhD students/PostDocs, primarily focusing on limited and small scale phenomena. The students don't need the full scale facilities in this range of research.

Singapore Maritime Institute

The rules for this cooperation have not been set up yet.

The Netherlands - MARIN

Most of the research organizations have their own facilities. When external research organizations or individual researchers use the infrastructure of MARIN, it is in cooperation. They work together on research projects with MARIN researchers and gain access to the infrastructure. In most cases they have to pay some fee, but then it is mostly organized via commonly allocated research funds. An example is the Knowledge Stimulating Fund (KSF).

USA – OTRC

Many of the experts and researchers who work with OTRC are also tenured professors in many of TAMU's engineering schools. As such, they are not full-time employees of OTRC but make substantial use of its facilities as investigators and advisors on research projects therein. In addition, a number of the employees of OTRC are part-time student workers who focus on daily administrative tasks or technological support.

Increasingly collaborative efforts between OTRC and other education institutions produce a system for both researchers and financing to be built into the OTRC model.

2.2 Market size and budget

The biggest market share of the centres in scope shall be attributed to the European actors and Oceanic in Canada. It shall be differentiated from the budget size, where the Asiatic centres will definitely be leading with large scale national funded projects. In terms of market operations clearly the leading centres are MARIN, Marintek and HSVA, followed by Oceanic.

The comparative information about the size and budgets of the institutes has been presented in the table below.

Table 3: Size and turnover of the centres

Name	Employees (expressed in full-time equivalent –FTE)	Dedicated R&D employees (FTEs)	Annual Turnover (Euro) (2013)	Exports (% of turnover) (2013)
LabOceano Brazil	57	30	2 500 000	20%
Oceanic Canada	Not disclosed, internet articles inform about 45	Not disclosed, internet articles inform about 13	Not disclosed, Approx.. annual revenue 2 500 000 *	Not disclosed
NRC and MUN Canada	Separate figures not available – part of NRC structures, Oceanic subcontracts NRC-IOT and the Faculty of Engineering and Applied Science on Memorial University's main campus, for projects involving the infrastructure in scope. ¶			
CSSRC China	Approx. 1000	324 (this including 2 academicians of Chinese Academy of Engineering, 84 professors and 240 senior engineers).	Not disclosed	5%
HSVA Germany	95 (2012: 89)	56 (2012: 51)	Approx. 13 000 000 (2012: 12 336 000)	60 – 65 %
Insean, Italy	117	41	9 300 000	10%
KIOST Korea (total figures for all institutes)**	473	283	142 000 000	0 %
Marintek Norway	210	185	38 400 000 (2012)	31 %
Marin Netherlands	352	21 (180)***	42 000 000	55-60 %
Singapore	Total commitment of the governmental agencies for this project is currently at the level of 200 million EUR. No other figures available at the moment. Interviewees did however indicate that with regards to researchers and total number of employees it would be similar to that of MARIN's activities related to their seakeeping and manoeuvring basin.			
OTRC USA	7 FTE of permanent staff (1 director, 4 wave basin technicians, 2 administrative staff) Many of the experts and researchers who work with OTRC are also tenured professors in many of TAMU's engineering schools. As such, they are not full-time employees of OTRC but make substantial use of its facilities as investigators and advisors on research projects therein. In addition, a number of the employees of OTRC are part-time student workers who focus on daily administrative tasks or technological support. Detailed figures were not disclosed.			
<p>Source: Oxford Research AS. FTE- Full time equivalent * Information from http://www.manta.com/ic/mt62c29/ca/oceanic-consulting-corporation re-calculated from CAD ** Source KIOST annual report 2012, the detailed split of budget between all KIOST institutes and divisions was not available. *** At MARIN all academic employees spend a part of the time performing research. the mentioned 21 fte are the people that are fulltime working on the R&D department of MARIN, rest of the employees are asked to spend two months in the two years to R&D activities and further has to do their tasks like monitoring, tests, etc.</p>				

2.3 Historical and current sources of the infrastructure financing. Income and profit distribution

In most cases the research centres have built their infrastructure over the years using full or large direct governmental financing.

There are examples where centres actually contributed recently to infrastructure investment from its own resources. Below we describe the case of German HSVA and Norwegian Marintek that shall be seen in this context.

Initially also Italian Insean in the beginning was financed by the industry, but this situation was only due to the monopolistic nature of its initial activities (certification). From the 70s onwards, investments in infrastructure were undertaken with government grants.

LabOceano, Brazil

In the first stage of building LabOceano, € 5 million (2003 euros) from the oil royalties were invested, passed by FINEP, through CT-Petro Sectorial Fund, from the Ministry of Science, Technology and Innovation, and € 1 million granted by the government of Rio de Janeiro state, by Carlos Chagas Filho Foundation for Research Support of the State of Rio de Janeiro (FAPERJ)

Since its foundation, the overall investment made at LabOceano is estimated in €23 million (not considering the cost of the land at the Rio Technological Park, since it was already owned by UFRJ).

The main investments for the centre infrastructure are expected to come from the government. The industry will use the LabOceano on contract research projects, covering the labour and operations costs.

LabOceano has no basic grant allocation of any kind to cover its turnover. The institute is constantly competing in the market, against other national and international research institutes.

The profit is redistributed to competence development, infrastructure and research equipment. The same applies with COPPE.

NRC and MUN infrastructure (Oceanic) Canada

NRC infrastructure has been funded almost exclusively by government investment. The Centre was

approved by the Canada Treasury Board at a final cost of \$55.6 million in the late 70s.

MUN infrastructure has been funded almost exclusively by government investment.

NRC's primary source of funding is the Government of Canada. Between 2006 and 2011, the Government of Canada invested \$76.2 million in the Centre, primarily through programs of other government departments (e.g. National Defence, Transport Canada, Canadian Coast Guard, etc.). NRC also earns some revenue from the provision of research and infrastructure to third parties.

MUN's primary source of funding is the Government of Newfoundland and Labrador. MUN also applies for and receives grants and other research funding from the Government of Canada and non-public sources. In addition, MUN earns some revenue from the provision of research and infrastructure to third parties.

NRC revenues are reinvested or applied against expenses to reduce net funding required from public sources. It is unlikely that NRC has ever generated "operating profit".

Similarly, MUN revenues are reinvested or applied against expenses to reduce net funding required from public sources.

Oceanic is a private for-profit corporation. No public information is available regarding Oceanic's cost structure, revenue mix, or profitability.

CSSRC China

Historically, CSSRC has been owned and managed by different government bodies.

All scientific research infrastructure is financed by public funding allocated to CSSRC. Depending on the purpose of the infrastructure and the research divisions, public funding comes from various ministries and local government bodies.

CSSRC has a yearly basic grant allocation from the government, covering 10 % of the total turnover. For the rest the institute is competing within the market with other national and international research institutes. CSSRC operates all the commercial sales. The average level of research financed by government is around 20%.

The profit is redistributed to China Shipbuilding Industry Corporation, local government, infrastructure and research equipment.

HSVA Germany

It's important to bear in mind that the HSVA is more than a 100 years old and that most of its facilities are rather old (although mostly rebuilt after WW2). The most modern facilities have been financed as follows:

HYKAT:

- 30 % financed by the State of Hamburg (Local Government)
- 30 % financed by the Federal Government (Bund)
- 40 % financed by HSVA itself (not through owners, but from built-up equity)

The Side Wave Generator (2011):

The State of Hamburg contributed with the buildings, the HSVA itself financed the machinery.

HSVA itself is the main financier of its investments. The HSVA utilizes existing possibilities of co-financing investments through large R&D programs (EU or national) and seeks support from local government when possible, e.g. for financing buildings.

HSVA is a non-profit organization, although having restructured to becoming a much more commercially oriented entity in the late 90s. Its owners do not receive dividends, rather, the profit is retained in the company and used for investments

Insean, Italy

The contribution by the State towards the infrastructure at the very beginning was very little (10% of total funding) in the 70s due to the fact that shipbuilders needed to perform the testing activities at Insean in order to obtain a certification. It was a monopoly. At the end of the 70s, following the crisis of shipyards and the norms introduced by the EU that removed the necessity of being certified by Insean, the majority of funding was raised through public funding and only the 10% derived from industry sources of funding. There are two main forms of public funding: 1) general funding dedicated to public bodies; 2) funding on specific projects. At the end of the 90s, the Institute started receiving less general public funding due to the State's budget cuts. To address this issue, research activities increased meaningfully at both the national and international level providing additional sources of funding for

Insean. Research activities have represented in the last years 2/3 of all activities carried out by Insean.

Funding sources of Insean are:

- Grants from participation to research projects within EU Framework Programs and initiatives from other national and international bodies; Insean receives public funding from the CNR that covers the cost of full-time permanent employees. Main sources of funding are represented by European projects, national projects, industry (e.g. Finmeccanica, Airbus), projects financed by ESA and EDA (EU), and projects financed by the ONR (USA). For the rest the Institute competes in the markets against other international research centres.
- Income from testing and consultancy activities towards shipbuilders and ship owners.

Profits are redistributed to infrastructure and equipment. All earnings serve the purpose of financing the activities of the Institute.

MOERI KIOST - Korea

Most of the income of KIOST is generated from national research projects financed by different government ministries. This includes Ministry of Land, Transport and Maritime Affairs, Ministry of Education, Science and Technology, Korea Meteorological Administration and Ministry of Knowledge Economy

Private financing contributed only to around 7 % of annual KIOST project-related turnover. Additionally to R&D project financing KIOST received block financing on the level of 35 % of total annual budget.

The expenditure covers mostly project related costs. The institute is fully national; therefore all eventual surplus is redistributed to infrastructure financing.

The institute's infrastructure was funded by national government sources.

The yearly division of KIOST expenditure includes:

Salaries / Wages	18 %
Direct Expenses	67 %
Major Projects	15 %
Public-sector Projects	46 %
Private-sector Projects	4 %
Others	2 %
General Operation	6 %
Others	10 %
Equipment / Facilities	7 %

Loan Payments / Interests	1 %
Others	2 %
Total	100 %

Norway – Marintek

Historically Ocean Basin was built by the RCN. The ship model basin financing was 50 % government and 50 % industry. The centre was 75% financed by the ministry, Ocean Basin was fully financed by RCN.

In terms of yearly income structure, Marintek has a yearly basic grant allocation from the Research Council RCN, covering 4,5 % of the total turnover. For the rest the institute is competing in the market, against other national and international research institutes (public research funds incl. EU as well as industry orders). The average level of research financed by RCN or EU is around 5-10%, this being very low grade compared to other branches. Among all institutes Marintek has one of the lowest levels of basic grant shares.

All the profit is redistributed to competence development, infrastructure and research equipment. This is a regular practice for all other institutes in the entire SINTEF.

The Netherlands - MARIN

Historically, the government financed 100% of the infrastructure (like the basins) including basic equipment. In the case of further investments in equipment, at the moment MARIN is the single investor, including operations and maintenance costs. MARIN also financed approximately 25% of its most recent investment in infrastructure undertaken in 2011.

MARIN's own share of investment in equipment and infrastructure is covered from its own profits and financial reserves. Next to its own financial means, the government still financed investments in research infrastructure. The office buildings are financed entirely by MARIN.

In 2013 8,8% of MARIN's operations was financed by block financing (€ 3,733,000). This part is mostly intended to do fundamental maritime research that contributes to the well being of society as a whole. With years of investment the government provided more financial means, for example in 2011 the block financing was € 8,301,000. The public financing also can be extended by project financing. MARIN's task in this case is to propose interesting research ideas which the government assesses and can decide to provide project financing. In this case it is subject to competition with other institutes.

MARIN's profit is mostly directed towards the MARIN Academy and is also intended to make investments in office building and equipment, for instance.

MARIN is a so-called not-for-profit organization. The profits of the research projects are invested in MARIN itself, especially in the MARIN academy. The MARIN Academy is MARIN's way to accelerate (hydrodynamic and nautical) knowledge and sharing it through cooperation with international universities, research institutes and companies.

Singapore Maritime Institute

All infrastructure for the new marine research centre in Singapore will be financed with public funds solely originating from National Research Foundation (NRF), A-STAR, NUS and other public agencies. The project in general is also open for Public Private Partnership (PPP).

The centre will be 100% financed by Government agencies. Operational costs are indicated to be secured over two 5 year terms (5+5). Depending on commercial activity, the centre is hoped to be partially or fully self-financing with regards to the operational costs envisaged.

The division of the operational budget between the block and project funding is not known at the moment.

USA OTRC

OTRC was established with a one-time state level donation/grant providing all expenses related to the building of a wave basin and its surrounding infrastructure. Currently additional funding flows come from commercial research projects.

Any profit is redeployed to OTRC, to be allocated towards the centre's facilities.

2.4 Pricing

In all cases analysed the capital invested in the infrastructure was NOT calculated into the final market price offered to the market clients.

The only opposite example here is Canada where the research Council imposed an obligation to calculate price including the cost of infrastructure. This seems to cause a difficult situation for Oceanic, facing a less competitive situation in the market, compared to its European and American competitors.

Brazil LabOceano

The implementation of the LabOceano centre was the result of State aid operations, therefore the price for the research services could be defined to cover only operational costs, with no need to pay back for the infrastructure.

The labour and operations costs are fully reflected in the market prices, plus a small overhead fee that varies from 2% to 8%. The market prices do not include capital costs in any term. This is a globally subsidized market in the way that capital costs are not included in the pricing.

Canada - Oceanic

The Government of Canada requires NRC to price the use of its facilities based on full costs (i.e. including allocated facility maintenance and infrastructure costs). As a result, pricing is not competitive with other centres that price services based on variable operational costs or sell services below cost (e.g. certain European facilities).

Specific pricing details for commercial sales through the Oceanic-NRC contractual arrangements are confidential. NRC staff denied our request for details.

From a commercial perspective, the low temperature/ice tank facilities of NRC are the Centre's most "unique" asset. Details of Oceanic's revenues from use of NRC facilities are confidential and unavailable.

China -CSSRC

CSSRS is a nationally owned and financed centre with infrastructure built over last 60 years using full public funding support.

CSSRC operates the commercial sales entirely. The price does not reflect the costs of the infrastructure.

The indicative division between costs reflected in the price offered on the market is: 30% for direct project expenses, 35 % for staff costs and 35% for other operating costs.

Germany HSVA

The HSVA approach towards commercial clients is based on a full cost calculation. Still, since most of the facilities are very old, the investment costs are only to a very small degree reflected in the prices.

Resulting from this is the fact that price offered on the market contains almost no trace of the original large capital investment.

All facilities are fully booked out for 2014.

Italy - Insean

The price does not include any proportion of infrastructure cost, only labour and operations costs are being taken into consideration. Attention is paid, when deciding the market price, to remaining competitive on the market.

Korea - MOERI (part of KIOST)

The institute is mostly operating with nationally financed projects and therefore is not heavily dedicated to selling its services on a commercial basis. The infrastructure cost was covered by national government investment and the capital cost does not influence market prices offered to privately financed projects, being in the minority for all centre operations.

Norway – Marintek

Marintek only includes the labour and operational costs, being fully reflected in the final prices offered on the market. The market prices do not include capital costs in any term.

In terms of the infrastructure use, Marintek only covers the costs of the infrastructure use. The ownership of the infrastructure does not by any means influence the price offered on the commercial market.

The Netherlands - MARIN

The prices for services offered to external clients include a substantial part of infrastructure costs. This concerns at least the costs for equipment used, as well as labour and operations, which are taken into account in the price setting process. MARIN also uses different tariffs for calculating the costs of labour and facilities, depending on the project type.

With regards to the cost of the core infrastructure, there is no agreement to pay back the costs of the capital invested by the government. MARIN is allowed to use the infrastructure and is only responsible for maintenance and operation costs.

Singapore Maritime Institute

The price will be based on operational cost calculations only. Infrastructure/capital costs will not be taken into consideration in the pricing model. A clear statement was made by interviewees, that it is impossible to do so and still be competitive.

Even when considering the case of a commercial operator of the infrastructure, it will only be charged for the use of the infrastructure. No capital cost will be included in the final prices offered.

USA - OTRC

Firms using the facilities enter into a fixed contract based on calculations of costs for the use of labor, time, facilities and other miscellaneous anticipated costs. Costs run a flat rate of US\$400 per hour for the basin alone. Construction of models to be tested is contracted out to a dedicated modelling construction firm. Up until 2014, OTRC had not raised their rates for the use of their facilities since the use of

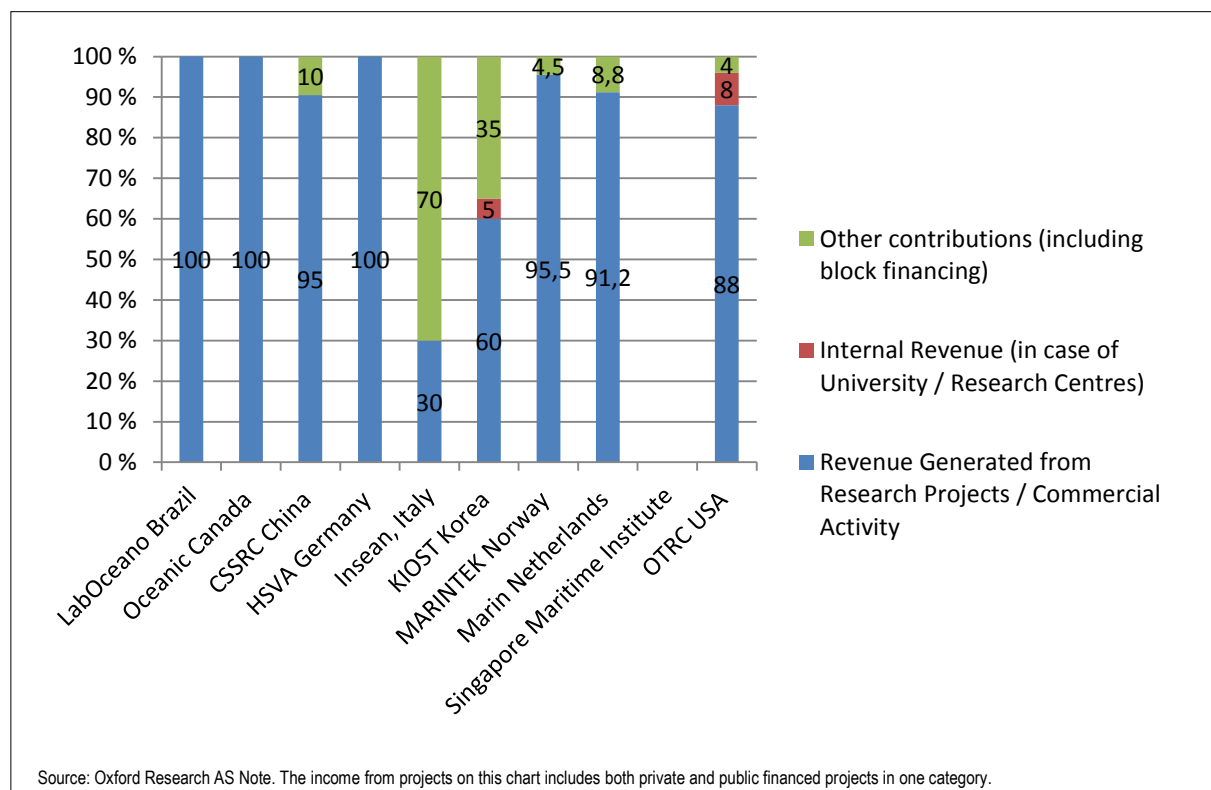
the basin by commercial players was enough to cover the gap in financing between commercial activity and public financing. This flat fee is applied to contracts regardless of who the firm is. Part of this is due to regulations on research done on behalf of the federal government, wherein the federal government demands the best rates possible. A flat fee means that this concern is addressed before the fact rather than after the fact.

Rates were calculated with the opening of OTRC to include the cost of maintaining and expanding research infrastructure in the future.

2.5 Budgets

Most of the analysed centres income depends on commercial or publicly funded projects/grants. Only four of the analysed public institutes receive block funding on a regular basis, with Italian Insean being here the most privileged.

Figure 6: Income structure

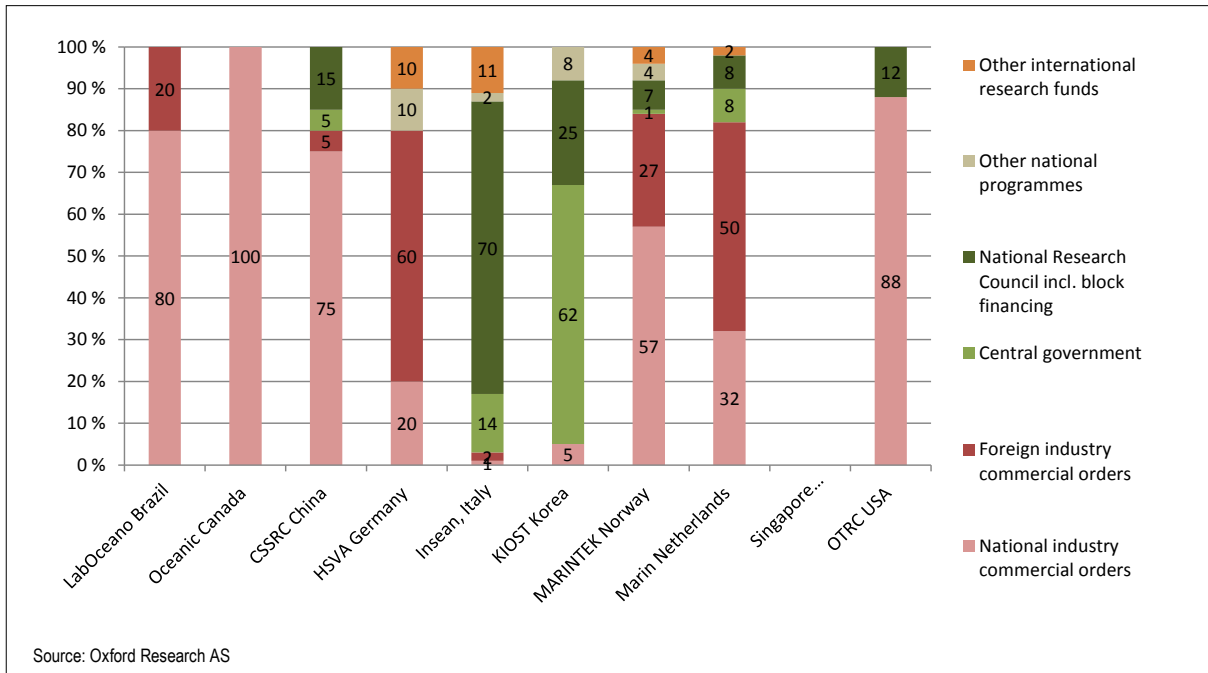


In terms of sources of income, there is a balanced division between institutes being fully or largely commercial-oriented (including those with clear commercial focus being Oceanic, Marintek, MARIN, HSVA and university-type centres like OTRC and LabOceano) and those operating with most public financed research projects with especially MOERI and Insean.

There was not precise data confirmed for CSSRC. It might be assumed that due to its public financing and public structure, the focus is dedicated to public funded projects with large block financing.

The two sets of colours in the chart below (shades of red and shades of green) present the general division between national public funding of different types and commercial activity. Orange introduces the separate category - international funds, represented mostly by European Union Framework Programme 7, and available to institutes based in EU.

Figure 7: Income source – comparative view



Comments:

Canada:

Budget details are not available for the St. John's, NL NRC facilities. NRC discloses its budget figures in aggregate, and the St. John's, NL facilities are a small portion of that total budget. As a result, providing full-organization numbers would not be helpful. Oceanic sales are purely commercial projects, nevertheless precise division was not revealed. Therefore 100% was allocated to national industry commercial sales in the chart.

USA OTRC:

The division of public / private project expenditure was not revealed during the interviews, due to confidentiality reasons. The information in the table is therefore based on provided income structure information and contains a total % for all research projects (not distinguishing between national / foreign and private / public).

Information regarding Korean KIOST are produced based on annual report 2012 covering all institutes in the group.

Data on Singapore are not available (project under construction).

The structure of expenditures is very differently calculated. Therefore the chart below represents perspective overview, resulting from interviews or sometimes from the estimated data received.

As regards Figure 8, representing costs structure, the accounting practices in the data set obtained seem to differ between the institutes. Some of them, like LabOceano, OTRC and MOERI/KIOST report their expenditures mostly connected with implemented projects, keeping staff costs and other operating costs below 40% of their budgets. Other institutes for which the data are available like Insean, HSVA and Marintek, operate with higher staff and operating costs, allocating the costs of staff not to projects, but to a separate category.

Only Insean and Marintek revealed expenses in the category of "Depreciation and value adjustments on non-financial assets" being directly linked to infrastructure refinancing in their financial accounting practice.

Figure 8: Structure of expenditures

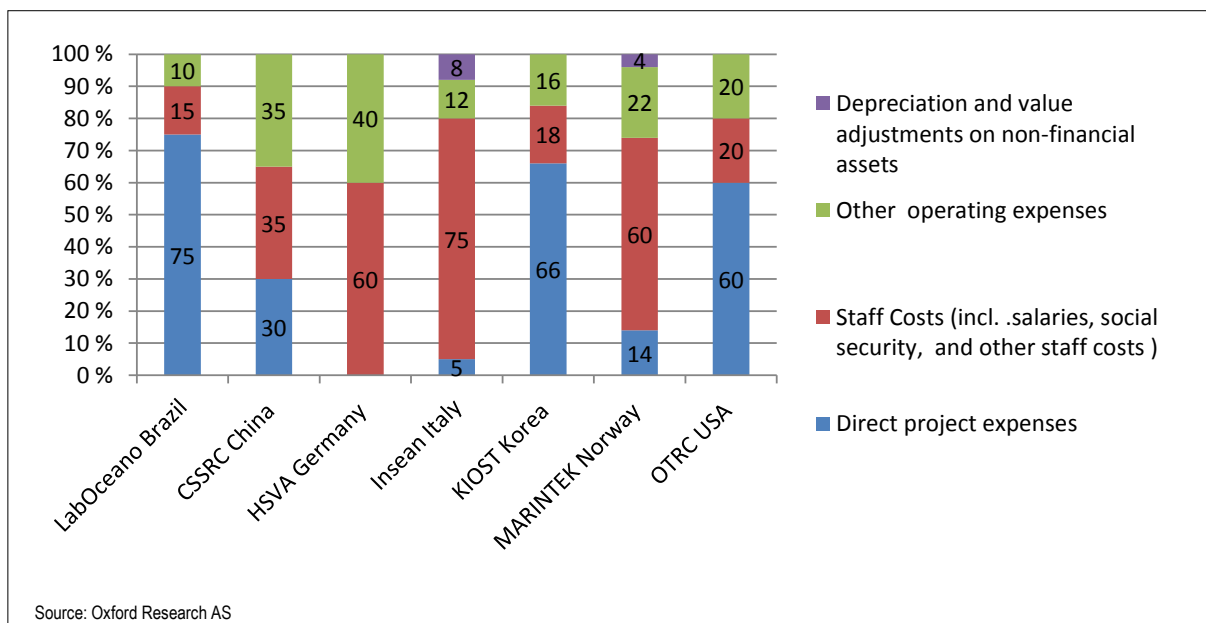
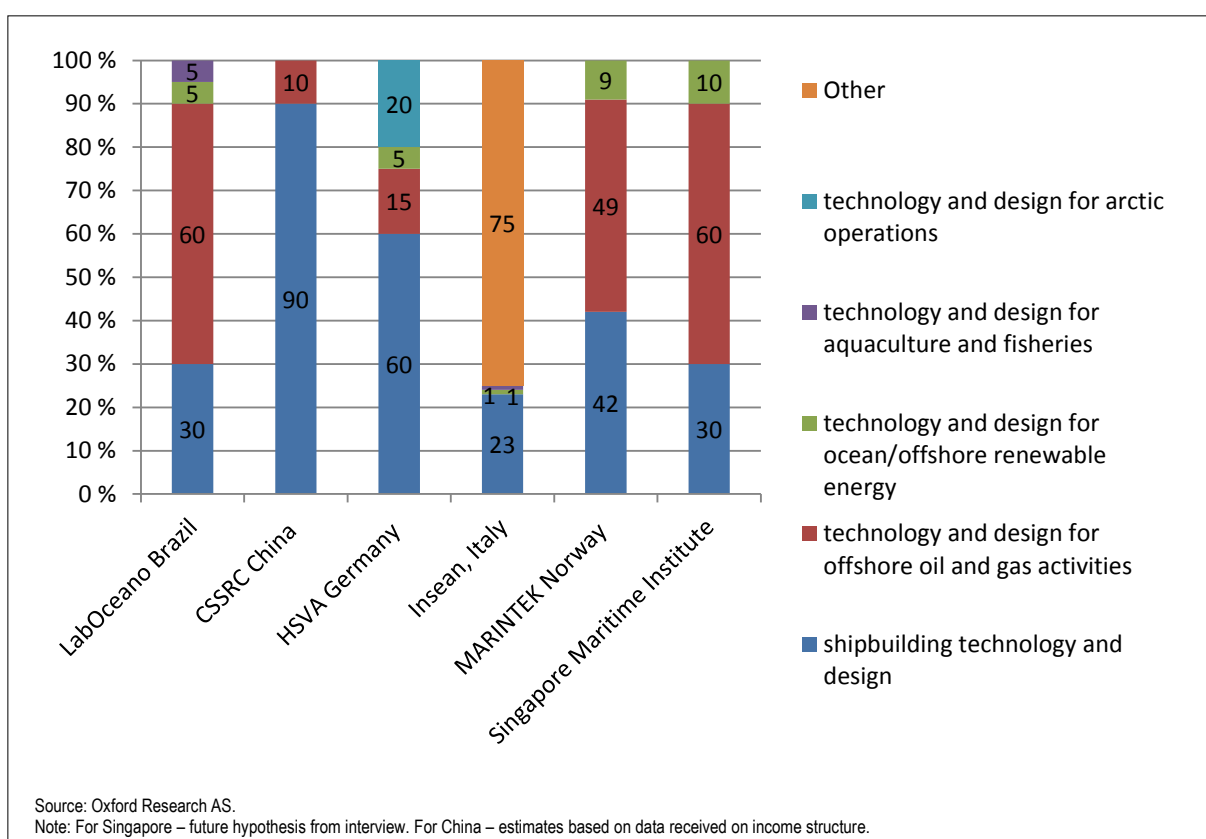


Figure 9: Turnover per market segment



Data obtained reflecting the structure of turnover per market segment indicate that for most of the institutes operating commercially, two categories seem to be the most significant. These are technology and design for offshore oil and gas activities as well as shipbuilding technology and design.

HSVA also has in its budget services for technology and design for arctic operations, being a direct result of the infrastructure available there.

2.6 Infrastructure overview

A short overview is presented in the table below.

The institutes operate with a wide portfolio of different laboratories and equipment.

Table 4: Infrastructure overview

Institute name	Ocean Wave Basin	Towing Tank	Seakeeping Carriage	Cavitation tunnel	Sloshing Lab	Circulating Water Tunnel	Ice tank	Modeling facilities	Other facilities and labs
LabOceano Brazil									
Oceanic Canada									
CSSRC China									
HSVA Germany									
Insean, Italy									
MOERI Korea									
Marintek Norway									
MARIN-Netherlands									
Singapore									
OTRC USA									

Source: Oxford Research AS

More information about the infrastructure available is presented below, in cases where detailed technical specifications or more information on the infrastructure are available online, the relevant links were provided.

Brazil - LabOceano

<http://www.laboceano.coppe.ufrj.br/en/laboceano/laboceano.php>

Ocean Wave basin with a 15m depth and a central pit with 10 additional metres, the deepest basin in the world used for the development of deep-water technology, equipped with sophisticated multidirectional wave, wind and current generation systems.



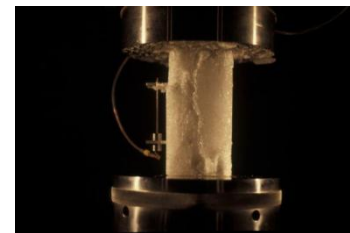
Canada - Oceanic

Infrastructure operated commercially by Oceanic is divided between two owners.

NRC:

http://www.nrc-cnrc.gc.ca/eng/solutions/facilities/marine_performance/towing_tank.html

- marine dynamic test facility and planar motion mechanism;
- 200 metre wave/towing tank;
- 90 metre ice/towing tank;
- cavitation tunnel (vertical plane, closed recirculation tunnel; working section 2.2 metres long by 0.5 metres square);
- cold room laboratories;
- offshore engineering basin (75 metres by 32 metres);
- model preparation facilities (boring mill; model milling machine); and
- associated instrumentation and equipment.



MUN:

<http://www.mi.mun.ca/facilities/marinebases/>

- 22 metre flume tank;
- 58 metre wave/towing tank;
- 88,000 litre underwater acoustic laboratory;
- aquaculture facility (5 independent recirculating systems – salt water or fresh water, live food culture laboratory, quarantine laboratory, necropsy laboratory, bacteriology laboratory, and histopathology laboratory)
- ballast control and cargo handling simulator;
- 3 dynamic positioning simulators;
- electronic chart display and information systems simulator;
- fast-time manoeuvring simulator;
- fire fighting facility and outdoor test tank;
- food processing pilot plant;
- full mission ship's bridge simulator and tug simulator;
- global maritime distress and safety system simulator;
- indoor training tank HUET and environmental theatre (wind, waves, rain, lightning, sound control, helicopter underwater escape trainer, and helicopter underwater emergency breathing apparatus and training chair);
- lifeboat launch simulator;
- marine bioprocessing facility;
- training and research vessels;
- hydrostatic test chamber (70 litres, simulating depths up to 1800 metres);
- propulsion plant simulator; and
- remote operated vehicle simulator.

China – CSSRC



<http://www.cssrc.com/channel.asp?id=39>

- Deep water towing tank laboratory;
- Depressurised towing tank laboratory;
- Low-speed wind tunnel laboratory;
- Cavitation tunnel laboratory;
- Rotating-arm basin laboratory;
- Sea-keeping basin laboratory;
- Sea-propelled model tank;
- Integrated control system of mass and centre-of-mass;
- Integrated simulation turntable laboratory;
- Large cavitation channel laboratory;
- Small floating shock platform;
- Series fall weight impact tester;
- Vibration & Structural noise laboratory;
- Structural strength fatigue laboratory;
- Underwater engineering structural laboratory;
- Optical Measurement mechanics laboratory;
- Propeller model workshop;
- Ship model workshop;
- Explosive tank laboratory;
- Outdoor water tank laboratory;
- Tunnel noise laboratory.



Germany – HSVA

<http://www.hsva.de/>

- Large Towing Tank – with new Side Wave Generator;
- Ice Tank;
- HYKAT – Hydrodynamics and Cavitation Tunnel;
- Environmental Tank;
- Two Cavitation Tunnels;

- Small Towing Tank (virtually unused commercially)

Italy - Insean

<http://www.insean.cnr.it/en/content/overview-test-facilities>

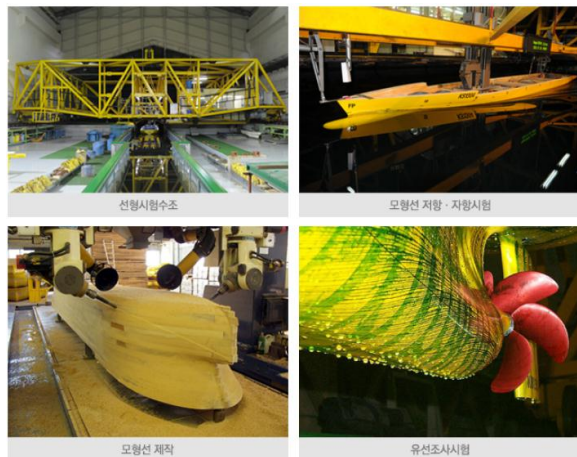
1. Towing tanks: INSEAN has two towing tanks. Tank no. 1 (“Umberto Pugliese”) is today one of the largest worldwide equipped with a towing carriage capable of a maximum speed of 15m/s, is used for all calm water tests, even with large-sized models. It is 470 m long, 13.5 m wide and has a depth of 6.5 m. Tank no. 2 (“Emilio Castagneto”) is equipped with a towing carriage capable of a maximum speed of 10m/s and an oscillating bulkhead wave generator able to replicate spectra of regular and irregular sea for the study of safety and the comfort of marine vessels.
2. Circulating water channel: The test section is 10 m long, 3.6 m wide with a depth of 2.2 m. It has test section 10m long, It is the only facility of this kind in the world having a free surface and capable of a minimum pressure of 4kPa. Used, for example, for the study of cavitation, induced pressure and noise.
3. CEIMM Cavitation tunnel: has a squared (0.6 m side), 2.6 m long, closed jet type test section. The nozzle contraction ratio is 5.96 and the speed range is 3-12 m/s. Static pressure can be controlled in the range 300-1500 mbar.
4. Maneuvering basin: for maneuverability tests INSEAN uses the nearby volcanic lake Nemi that offers good weather for a number of weeks per year. The area used for the tests (1300m x 1800m) has a depth of about 34m.
5. Hydraulic channel: 27 m long, with a 0,6 m 0,6 m cross section. The test section 10 m long.
6. Sloshing lab: the facility is dedicated to the study of fluid structure interactions or simulations of tankers or gas carriers.
7. Vibration Lab: under construction, will be equipped to identify structural addressed to the Model Updating and to the relief of structural damage.

8. Erosion Lab: to be completed, it is a water tunnel with test section of 80×80mm², temperature control, with a test speed up to 50m/s for cavitation erosion tests on specimens of materials.
9. Impact test facility: completed in 2013, funded by a European grant (SMAES project, 7th Framework Programme), is used to study the impact (up to a speed of 50m/s) of aircraft parts in phase of ditching.
10. Computing Center: INSEAN has three different clusters for parallel computing, with a total of about 850 CPU.

Korea - MOERI/KRISO

<http://www.moeri.re.kr/html/location.php?depth=study/institution01>

- 1) Hull shape test water tank
 - Size: 200 x 16 x 7m (L x W x D)



- 2) Large cavitation tunnel
 - Size: L60 x W19.5 x D22.5 m

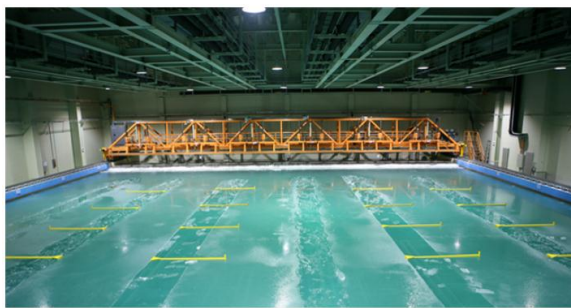


대형 캐비테이션터널 관측부



대형 캐비테이션터널

- 3) Size: L12 x W 2 x D 8 m (Middle-sized cavitation tunnel)
- 4) Marine engineering water tank
 - Size: L56 x W30 x D4.5
- 5) Icy water tank
 - Size: L32 x W32m



빙해수조



모형빙



모형선 시험

- 6) Full Mission Bridge Simulator
- 7) Seabed mineral collection test lab
 - Size : L30 x W6 x D5 m
- 8) High pressure chamber

Norway - Marintek

<http://www.sintef.no/home/MARINTEK/Laboratories/>

- The Ocean Basin Laboratory- A total environmental simulation including wind, waves and current offers a unique possibility for testing of models in realistic conditions. With a depth of 0 - 10 meters and a water surface of 50x80m. Maximum current velocity in wave surface: 0.25 m/s at 2 m. water depth, 0.18 m/s at 5 m. water depth. Double flap wave maker, multiflap wave maker and carriage system.
- Towing Tanks. Towing tanks are related to the investigation of hydrodynamic performance of ships. Two carriages: One for towing up to 10 m/s for traditional calm water tests and a second carriage for seakeeping tests and other tests performed with fixed or free-running models. Tank I and III can be used simultaneously and also as one long tank (I+III) by removing a gate. Both regular and irregular waves can be simulated. In tank I+III either of the two carriages can be used.
- Seakeeping Carriage - Maximum speed: 5 m/s Full crane coverage, two movable work platforms, optical position measurement, and 6 DOF motion platforms. The multi-purpose carriage includes a 6 degrees-of-freedom motion platform, enabling the possibility of performing forced oscillation tests, including large amplitude PMM tests for manoeuvring studies.
- Cavitation tunnel: Diameter of working section: 1.20 m. Length of working section: 2.08 m. Maximum water velocity: 18 m/sec. Maximum propeller RPM: 3000.
- Marine Structures Laboratory- testing of structures, structural components and materials. Actuators: A range of servohydraulic actuators for static and dynamic testing, from 100 kN load capacity to a maximum load/stroke of 4000 kN/1000 mm. Dynamic test rigs for static, dynamic and fatigue testing of slender marine structures. The dimensions of the test specimen are typically 15m flange to flange, and applied loads include internal pressure, dynamic bending ($\pm 30^\circ$) and tension (3000 kN).
- Energy-/Machinery Laboratory. Test area foundation for rigs, process equipment and full scale set-up. Engines and auxiliary machinery. Exhaust gas cleaning systems. Fuel treatment and combustion technology. Instrumentation for laboratory and on-site use.
- Sloshing Laboratory. For investigating liquid loads in tanks and on custom geometries, in-

cluding two motion platforms and a drop rig for deterministic water impacts. Includes: the 6 DOF vessel motion simulator, the 2 DOF vessel motion simulator, the drop rig.

Singapore Maritime Institute

Ocean Engineering Basin is the only major infrastructure planned so far. Towing tank and other infrastructure might be added later once the centre is already in operation.

Not being directly in the portfolio of the centre, there are laboratories and infrastructure available from A-STAR and institutions of higher learning.

Refer to

http://www.maritimeinstitute.sg/RD_Resources/Maritime_RD_Capabilities.aspx

Institute of High Performance Computing (IHPC) was especially mentioned as a key infrastructure partner.

The Netherlands – MARIN

<http://www.marin.nl/web/Facilities-Tools.htm>

- Seakeeping and Manoeuvring Basin: (170 x 40 m)
- Offshore Basin: (10.2 m deep).
- High-speed Basin: With its strong carriage and long length (220 m),
- The Deepwater Towing Tank: (252 x 10.5 x 5.5 m)
- Shallow Water Basin: The depth of the Shallow Water Basin (220 x 15.75 m)
- Depressurised Wave Basin: (240 x 18 x 8 m).
- Cavitation Tunnel
- Full-mission Bridge Simulators
- VTS Simulator: Vessel Traffic Services (VTS)

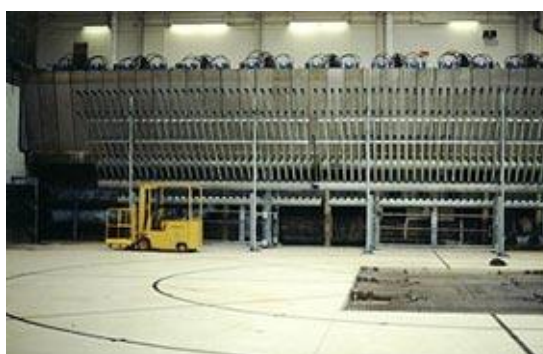


Almost all the infrastructure mentioned is fully occupied throughout the year. Exceptions to this list are the High Speed Basin and the Cavitation Tunnel.

USA – OTRC

<http://otrc.tamu.edu/Pages/basinspecs.htm>

OTRC has direct control of a wave basin with the capability for scalable depth testing via an adjustable floor in the pit. The wave basin also features capabilities for testing currents and wind patterns through a modular fan system that can be located at various points around the basin. Due to its relationship with TEES and other offices at Texas A&M University, OTRC has access to numerous laboratories and offices on campus, pending agreement from other offices.



The wave basin is about 43 m long and 30,5 m wide, with a depth of 5,8 m. The pit located in the centre of the basin has a depth of 55 ft. With 48 individual controlled paddles, the wavemaker can generate a variety of wave conditions, including unidirectional and multidirectional regular and irregular (random) waves.

2.7 Markets

2.7.1 Overview of current main activities

Even with sometimes scarce information from institutes it was nevertheless possible to generate an overview of their types of engagement per subsector. More information in this regard is also provided in chapter 2.7.2 presenting main customers.

Table 5: Current market activities overview

Subsector	Marin the Netherlands	OTCR USA	HSVA Germany	CSSRC China	Insean Italy	Marintek Norway
shipbuilding technology and design	Improving the quality of vessels regarding all hull resistance, propulsion, sea-keeping and maneuvering aspects.	Limited testing in the past, never a substantial share of the research conducted by OTRC	Green shipping, new slow container ships, propulsion in rough sea	Ship hydrodynamics- performance prediction and optimization design Ship Structural Mechanics- external loads acting on ships and the bearing capacity of various structures Ship Propulsion Ship Vibration and Noise	Energy and environment, Ship performance and response, Effective and safe operations, Simulation based design, Laboratory testing	Energy and environment Ship performance and response Technical operations and maintenance Effective and safe operations Infrastructure, transport systems and logistics Laboratory testing and field services
technology and design for offshore oil and gas activities	Mooring systems, Dynamic Positioning, complex installations, towing of structures, riser behavior, dredging equipment in waves, floating civil works, wave run up problems at fixed structures, launching, human comfort, downtime analysis and impact loading (slamming and greenwater); the integration of hydrodynamic aspects in the total scope of the project. knowledge available on FPSOs, CALM buoys, TLPs, Semi-submersibles and Spars	Use of the wave basin and affiliated expertise of faculty to test various models of offshore platforms of various classifications	Open waters: Ships and Platforms, more Offshore Wind Installations (less oil and gas)	Testing and analyzing the parameters of motion, the external loads, the strength and fatigue of offshore structures and special constructions, inspecting and assessing offshore platforms for safety as well as designing and optimizing ocean work stations and global systems	no activity in this field	Floating and Fixed Production Systems Slender Offshore Structures Marine Operations Production Facility Operations Laboratory testing and field services
technology and design for ocean/offshore renewable energy	Tidal, waves and the wind energy sectors.	Limited testing in the past by offshore renewable energy firms, never a substantial share of the research conducted by OTRC	Energy from the ocean	no information	Laboratory services and model testing, Simulation and analyses	Laboratory services and model testing Simulation and analyses Full scale measurements
technology and design for aquaculture and fisheries	no activity in this field	no activity in this field	no activity in this field	no information	no activity in this field	Floating cage systems Marine Operations Laboratory testing
technology and design for arctic operations	The Trials & Monitoring Group carries out measurement campaigns at sea on board ships and offshore platforms. It is usually done on behalf of shipyards, owners or operating companies. A fair share of the work is done in the form of Joint Industry Projects (JIP's)..	A request for conducting research using simulated ice in wave basin, was turned down. OTRC did not wish to invest into a field of testing they were not yet recognized as a centre of excellence in.	Exploration, transport, new ice research vessels	no information	no activity in this field	Safe and sustainable ship operations Offshore oil & gas and mineral exploitation; autonomous systems Infrastructure, Safety at sea, Search and Rescue

Source: Oxford Research AS

2.7.2 Customers of centres analysed

The customers of the analysed marine research centres might be divided to two main categories. These are public institutions and commercial companies. Most of the centres service a mixture of these two. The research centres which are directly linked to higher education institutions or being pub-

lic research centres, administrated and subsidised by the state budget, are simultaneously largely focused (or “dependent”) on public financing. Those institutes operating in the free market of research services and compete for clients, presenting generally a lower share of publicly financed projects in their annual turnover.

Table 6: Overview of main customers / categories of customers

Centre	Clients
LabOceano Brazil	In addition to Petrobras, are among the major customers of the laboratory companies like Shell, Floatec, SSP, FMC, Bluewater, SBM Offshore, Lockheed-Martin, Subsintec, Acergy, Technip, ENGEVIX / Ecovix, Subsea7, USC, MMX, LTS, Viking and Vale
Oceanic Canada	<p>Off shore industry clients: Agip Kazakhstan North Caspian Operating Company, Exxon Mobil, Coflexip Stena Offshore, Single Buoy Moorings, Kvaerner Masa Marine, Seascope Systems Limited, Vertias DGC, Husky Energy, Deepstar Consortium, Noble Denton and Associates, BP Amoco, AIMS International, Atlantia Offshore, Bluewater Offshore, Conoco Phillips, Mobil Technology, Marathon Upstream Sakhalin Services, Halliburton Brown & Root, Virtual Marine Technology, Technip</p> <p>Shipping industry clients: CT Marine, Halter Marine Group, Lockheed Martin, Maersk Contractors, Fleetway Inc., BMT Fluid Mechanics, Friede Goldman Ltd., British Columbia Ferry Corporation, Fleet Technology, Austal Ships, Bender Shipbuilding, Naiad Marine Systems, Bollinger Shipyards, Tidewater Marine, Alaska Ship & Drydock, Allswater Marine Consultants, Sparkman & Stephens, Genoa Design International Ltd., Global Maritime A/S, Atlantic Pilotage Authority, Marine Atlantic</p> <p>Yacht industry clients: John J. McMullen Associates Inc., Trinity Yachts, Farr Yachts, Oracle BMW Racing, Sharp Design Yachts, Peter Hatfield Limited, Guido Perla and Associates, Alan C. McClure and Associates, Robert Allen Ltd., Alinghi</p> <p>Arctic offshore industry clients: Agip Kazakhstan North Caspian Operating Company, Exxon Mobil, Coflexip Stena Offshore, Single Buoy Moorings, Kvaerner Masa Marine, Seascope Systems Limited, Vertias DGC, Husky Energy, Technip</p> <p>Arctic ship industry clients: Lockheed Martin, Maersk Contractors, Fleetway Inc., BMT Fluid Mechanics, Alaska Ship & Drydock, Global Maritime A/S, Atlantic Pilotage Authority, Marine Atlantic</p>
CSSRC China	Most of the institute income is generated by 4 main groups /customers: Design Institute with 20 % of the income, China State Shipbuilding Corporation (15% of all income), oil companies and other shipyards (with 10 % of the income in each of these groups), the remaining 30 % of commercial income comes from other national industry clients and 5 % from foreign industry commercial orders.
HSVA Germany	Only four main categories indicated: Ship builders and yards, Shipping lines, Sub-deliverers of propulsion and other equipment, Authorities
Insean, Italy	<p>Only categories indicated :</p> <ul style="list-style-type: none"> • Within shipbuilding technology and design Shipping companies (owners and shipyards); Supplier and equipment industry; Consultants and design offices; Authorities • Within technology and design for ocean/offshore renewable energy: Field development companies, Supplier and equipment industry, Consultants
MOERI Korea	<p>Servicing mostly different government ministries and national projects.</p> <p>Most important projects:</p> <ul style="list-style-type: none"> • Cavitation function control technology on environment friendly propeller ; Sponsored by Ministry of Trade, Industry and Energy; Period: June 2011~ May 2016 (5 years); Budget: 5,7 mill EUR . • Development of ship drag reduction and propulsion efficiency improvement technology; Sponsored by Ministry of Trade, Industry and Energy; Period: June 2011~ May 2016 (5 years); Budget: 5,7 mill EUR . • Navigational aide simulator technology ; Sponsored by Ministry of Oceans & Fisheries; Period: December 2011 ~ December 2014 (3 years);Budget: 2 mill EUR • Intelligent unmanned ship technology; Sponsored by Ministry of Oceans & Fisheries; Period: July 2011 ~ July 2016 (5 years); Budget: 14, 2 mill EUR • Wave power generation technology; Sponsored by Ministry of Oceans & Fisheries; Period: August 2003 ~ June 2015 (11.5 years), Budget: 16,7 mill EUR • Installation engineering technology for subsea and offshore production plant ; Sponsored by Ministry of Trade, Industry and Energy; Period: December 2010 ~ November 2015 (5 years); Budget: 2,3 mill EUR • Ships and offshore plant production technology based on simulation; Sponsored by Ministry of Trade, Industry and Energy; Period: April 2010 ~ May 2015 (5 years); Budget: 6,9 mill EUR • Co2 offshore storage technology; Sponsored by Ministry of Oceans & Fisheries; Period: June 2005 ~ December 2015 (10 years); Budget: 28,5 mill EUR

	<ul style="list-style-type: none"> Establishment of offshore plant industry support centre and operations; Sponsored by Ministry of Oceans & Fisheries; Period: July 2013 ~ June 2016 (3 years); Budget: 18 mill EUR .- Deepsea engineering water tank infrastructure; Sponsored by Ministry of Oceans & Fisheries, Ministry of Oceans & Fisheries Period: October 2013 ~ November 2016 (3 years) Budget 63,3 mill EUR . 	
Marintek Norway	<p>shipbuilding technology and design</p> <ul style="list-style-type: none"> Shipping companies (owners and operators) Supplier and equipment industry Consultants and design offices Authorities <p>technology and design for offshore oil and gas activities</p> <ul style="list-style-type: none"> Oil companies Supplier and equipment industry Classification societies Engineering companies Authorities <p>technology and design for ocean/offshore renewable energy</p> <ul style="list-style-type: none"> Field development companies Supplier and equipment industry Installation and vessel operator companies 	<ul style="list-style-type: none"> Consultants Electric power companies Authorities <p>technology and design for aquaculture and fisheries</p> <ul style="list-style-type: none"> Fish farming companies Fishing vessel operators Supplier and equipment industry Consultants and engineering companies Authorities <p>technology and design for arctic operations</p> <ul style="list-style-type: none"> Oil companies Engineering companies Yards and design offices Maritime industry Authorities
MARIN Netherlands	<p>Several relationships are important to the operations of MARIN:</p> <ul style="list-style-type: none"> Cooperations in Houston, Brazil and Shanghai (SSSRI China) International Towing Tanks Conference (ITTC) European Council for Maritime Applied R&D (ECMAR) <p>MARIN's role in the development of maritime knowledge is also shared with the market through participation in forums such as the Cooperative Research Ships (CRS), the Cooperative Research Navies (CRNAV) and the FPSO Research Forum.</p> <p>The key customers are: governments (navy included), yards, oil companies and (indirect) the International Maritime Organization (IMO). Clients come from the following categories:</p>	<p>shipbuilding technology and design</p> <ul style="list-style-type: none"> Original equipment manufacturers (OEMs) Yards Engineering companies <p>technology and design for offshore oil and gas activities</p> <ul style="list-style-type: none"> Yards Oil companies Engineering companies <p>technology and design for ocean/offshore renewable energy</p> <ul style="list-style-type: none"> Various: important are private customers and OEMs <p>technology and design for arctic operations</p> <ul style="list-style-type: none"> Oil companies Operators <p>port and fairway design and shipping safety clients:</p> <ul style="list-style-type: none"> yards, shipping companies, authorities, pilots organisations
Singapore	<p>Not known at the moment. Clients are foreseen among:</p> <p>shipbuilding technology and design</p> <ul style="list-style-type: none"> Local ship yards Industry research entities Shipping companies (owners and operators) Government entities Institutions of higher learning 	<p>technology and design for offshore oil and gas activities</p> <ul style="list-style-type: none"> Local ship yards (rigs and FPSOs) Industry research entities Supplier and equipment industry Engineering companies Government entities Institutions of higher learning
OTRC USA	<p>The overwhelming amount of research facility use is done by private oil exploration companies testing designs for offshore platforms. Shell, Technip and SBM Offshore are the most frequent users of OTRC research infrastructure. Other clients include MODEC, FloaTEC, and Houston Offshore Engineering. Offshore renewable energy remains a niche market utilizing the wave tank at OTRC. These clients include organizations such as Atargis Energy Corporation and Ocean Power Technologies. In addition, OTRC has done work with NASA on modelling for space capsules that would return to earth via splash-down methodology and can list NASA and United Space Alliance as their key clients in this area. Limited testing for the US Navy has taken place, as well.</p>	

Source: Oxford Research AS

2.7.3 Key factors shaping the market

No small business focus

Most of the relationships the businesses had with the marine research centres were through working

on **large, government-funded projects with multiple participants** from various countries.

The technology businesses interviewed strongly indicated the importance of **internationally embedded relationships** and saw them as the key to their

international venturing. However, marine technology centres have neither played a significant role in SME's business nor in their R&D. It should be noted that many marine technology companies are small. On average, Nordic marine tech companies have less than 50 employees and are quite specialized in one particular solution.

Shipbuilding - minor improvements don't call for simulations

Most often, private business technology development is done in **incremental steps with minor changes to existing designs**. These projects are in general too minor to justify the costs involved with simulation testing, tank testing, etc. at marine research centres.

In the shipbuilding technology and design sector, most companies in this field have had limited relations with the marine technology centres, due to their size of operations. Even with established relations with large research centres and willing to use their great experience the companies are often too small to afford or be able to present themselves as a valid cooperation partner.

Trefjar Ltd. develops and markets various types of boats for tourism, fishing and leisure industries. Managing director, Hogni Bergthorsson, says the company is familiar with Marintek, HSVA and MARIN. Trefjar has cooperated with SINTEF on various projects and has on several occasions considered utilising simulation tanks at Marintek but has concluded that **the process was too costly**. Most of the company's product development has involved minor modifications to existing designs and a simulation test would be somewhat irrelevant.

Nevertheless, Trefjar has been growing steadily for the past few years and while no large projects that call for the services of marine research centres are in the pipeline, Bergthorsson does not rule out that Trefjar may utilise the centres in the future, especially with new innovations in boat design and a growing tourism industry.

Focus on oil and gas

The Fisheries sector is not in the focus of large marine technology centres. Even though fisheries technology may be mentioned as a part of the original mission of large ocean/marine tech centres, the focus is much more on large profitable fields such as offshore energy, oil and gas and maritime transport.

A need for a public-private initiative

Several opinions confirm the need for a truly market focused centre with strong industry linkages. "We need a marine tech institute which is not solely public. Many of the government bodies are established with great intentions to initiate public and private collaboration but many have become isolated from the industry and are solely focused on academic work – paper publishing."

The new institution can be a **real public-private initiative** or even a spin-off factory – a business incubator.

Questions regarding efficiency and the environment seem also to be a potential market-shaping factor. The most significant opportunities in that field are related to fuel efficiency on board vessels, new fishing ship designs and ocean surveillance (tracking of fish resources). A strong collaboration between public and private entities could lead to huge benefits to the industry. A new institution with a clear edge in terms of stronger collaboration between public and private entities and a clearer vision regarding these fields could be very beneficial to the industry.

The CEO of a company that markets technology solutions for the fisheries and aquaculture industries remarked:

"We have been working with OCEANIC in St John's and the Marine Institute on a project concerning technology for lobster and shellfish fisheries. The project is not finalised but we have been over a year preparing documents and seeking more partners. It was very important that from the initial start-up we have had the same contact person at the Marine Institute, which has made our relationships more effective. In this case it has been much more difficult to get industry on board the project and I feel the institute in NL has less connections with industry than we have in our country. We had one working meeting that was thought to be a meeting with industry but the majority of participants were from the public sector. There are **significant grant money available** and these institutes as I see it seem to survive mostly on these grants. The grant program is very professional and has been a learning process for us. The Marine Institute/Oceanic has functioned as a middleman, finding the correct grant channels and potential partners within government."

A technology manager at a company that develops solutions to decrease energy consumptions on board ships remarked:

"Our tests are generally made on actual ships at sea. Our work with marine research centres is always part of large development projects, usually funded by European and Nordic funds.

We have worked directly with Marin and Marintek on large cooperative development projects. We have had some relationships with other centres like HSVA (through partners in Norway, Jötun and Grieg), MPA in Singapore and SSPA in Sweden. Both Marin and Marintek are very professional and capable in terms of knowledge. The only negative thing I can mention is that we sometimes get the feeling that the institutions, being public and not market-orientated, care mostly about putting in their hours and getting their share of the project budget. But in general, we have been pleased with them and satisfied with our cooperation."

National versus international cooperation

A noticeable trend emerged in the interviews regarding the relationships technology firms have with marine research centres, as a common form of business interaction with marine research centres is through institutions and firms that specialise in the services offered by the institutions, which **in most cases operate in the same country as the respective research centre.**

Three ship design firms indicated that their way of working with the marine research centres is always through engineering firms and shipyards in the same country as the respective research centre.

The small naval engineering firm's inexperience with using marine technology centres causes them to cooperate with other international firms that have access to marine research centres and the required experience.

Transport and logistics in the case of test models seem also to be problematic when negotiating international cooperation.

The importance of introducers

Although strong internationally embedded relationships are the most valued relationships, they are scarce. There are countless weak international and domestic relationships which are the ones that most often lead to international opportunities. In the interviews, we find many of the entrepreneurs have used government agencies or academics to act as 'introducers', providing introductions to overseas

opportunity presenting contacts, such as potentially useful international organisations and in some cases well connected business people.

Interestingly, **academics and fund managers seem to play an important role in making connections** between entrepreneurs and the marine technology centres. This is probably due to the fact that the marine tech centre's staff have similar background to those of the domestic academics or fund specialists, often PhD or other academic degrees and they have done research together. The domestic academics sometimes provide introductions to others that could link the entrepreneurs to the marine tech centres.

There is a **significant absence of relationships between many academic institutes and tech firms.** The only relationships seem to have been initiated by the requirements public funding institutions put on public project funding. In many cases such funding needs to include both private and public entities which have created the necessary incentives for the entrepreneurs and academics to collaborate. Sadly, few cases were mentioned where projects of this kind led to the establishment of new ventures. The entrepreneurs indicated this might be due to the fact that these projects were often initiated by public agencies making it difficult for them to actually turn them into business.

Using business clusters as introducers between marine technology centres and SMEs could be one way to strengthen relationships between SMEs and many of these large research centres. Small and medium sized marine tech companies have limited resources to invest in relationships with these centres on their own. Here, clusters and other networks of companies can play an important role.

"Word-of-mouth is definitely what has contributed most to our relationships with the centres. Our clients refer to us and our competencies when a development project is searching for participants and vice versa. When we decide to work with a certain marine centre, we look at their track record, the projects that they have been involved with and consult our clients and colleagues."

2.7.4 Trends shaping the demand

The development of oil and gas technologies is clearly on the top of market exploration. Another historically important part of the market and still with growth prognosis in terms of turnover volume is ship building technology and design. These two are gen-

erally shaped by large clients on the market, who are able to invest proportionally large budgets into research, development and testing, supported with public funds. Environmental efficiency issues are emerging as the most significant trend for smaller innovators, indicated in interviews.

Subsea engineering is the definitive driver of current basin use by universities and public institutions, and a definitive trend for the future. A growing number of students emerging in programs focusing on offshore engineering will be a focus for firms hoping to establish forward-looking programs associated with subsea engineering.

For university-based institutions, collaborative ventures will become the norm as universities attempt to minimize cost and maximize effort by creating strategic partnerships where assets held by one institution cover gaps in capabilities at another.

Issues regarding green marine technology were clearly on top of the list in the interviews including fuel-efficient vessels, new green technology on board ships etc.

As most research projects that rely on marine technology centres are government funded, the availability of government funding allocated into marine R&D can be an important factor in shaping the demand of the market. Many European countries are facing serious government budget deficits in the years to come due to ageing of the population and increased health and welfare costs, which is likely to decrease government funding in marine R&D.

2.7.5 Main customers

The key customers or clients of marine technology centres worldwide seem to be governments (including navy and national security orders), other research institutions and agencies, technology companies with a high development focus (and budgets) especially within the oil and gas sector, firms specialising in research, measurements and simulations, and large marine technology corporations. This includes indirectly the International Maritime Organization (IMO), definitely an important stakeholder in terms of policy making and regulations.

Most of the relationships the small businesses had with the marine research centres were through working on large, government-funded projects with multiple participants from various countries.

It is apparent that SMEs, which occupy a major part of the fisheries and aquaculture technology industries are not clients of the marine research centres. A potential opportunity could be involved in a marine research centre's focusing on SMEs. An important vehicle here could be the growing clustering of SMEs in various countries and the formation of new clusters worldwide. A new and underutilised customer base for marine centres may therefore be clusters of small and medium sized marine tech companies which have limited resources to invest in relationships with these centres on their own.

2.7.6 Competitors perception

The European centres indicated mostly their neighbouring European counterparts as main competitors. Apart from those located in Western Europe (HSVA, Insean, Marin, Marintek) Oceanic was also mentioned on the list in the context of international competitive market projects.

Other European institutes mentioned on the list were Danish FORCE Technology

(<http://www.forcetechnology.com/no/Menu/Services/Ships-and-offshore/>)

and Swedish SSPA (<http://www.sspa.se/>).

From HSVA perspective MARIN and SSPA were mentioned as having a strong position within shipbuilding technology and design. Within technology and design for offshore oil and gas activities the key players listed were MARINTEK and MARIN.

The institutes from other parts of the globe (Asia and Brazil) have not been underlined directly, although indicated as existing.

Other important competitors are yard owned test labs that serve a part of the market (mainly their own, close to yard, market).

Within the technology and design for arctic operations – a strong position of the Finnish Aker Arctic <http://www.akerarctic.fi/services.htm> as well as Oceanic in Canada were mentioned, along with HSVA facilities.

US based OTRC indicated Marin, Marintek and Oceanic as main competitors.

2.7.7 The main barriers to entry

The first and foremost barrier to market entry for new research institute is obviously the expensive infrastructure. Testing and research cannot be undertaken without the facilities in place.

Connected to this is the **lack of experienced technicians and researchers with tacit knowledge** of best practices and phenomena associated with testing are the primary barrier to entry for new research centres. New facilities may be built with state of the art equipment, but it takes years to develop and build a strong complement of professional, skilled personnel to work in these facilities.

Other barriers seem to be secondary when compared to above two most important factors.

The major barrier for a new marine centre may be the lack of knowledge the industry has on the way such centres operate and the lack of experience the industry has with such centres. **A new centre could be perceived as just another academic institution.** Breaking barriers between public and private is key.

Furthermore, as often in business, **cross-border relationships can prove challenging to create.** In most cases, businesses not local to the marine technology centres utilise the services of firms local to the centres, which possess the required knowledge, experience and relationships. Again, cross-border

cooperation between business clusters can be beneficial for the marine technology centres in this respect.

The sector is characterized by **low propensity to innovate.** The testing is frequently more important than research. The main explanation for this is the difficulty to standardise the product as in other industries so to obtain economies of scale.

The **market is also extremely fragmented** with lots of owners and shipbuilders, consolidation (as in the case of the automotive industry) could help increase the propensity toward innovation.

Another issue that may be high on the agenda in a new centre is to find **ways for technology transfer between different fields in the ocean related areas.** One example includes the opportunities to utilise knowledge in fisheries in the seismic industry or vice versa are an example. Another example would be to use fishing fleets for ocean surveillance and research.

In the table below, all key points from the interviewees with relation to market related study questions were presented. This list should not be considered a complete market analysis, but rather specific factors that interviewees considered important.

Table 7: Summative market trends and factors

Question	Factors
What are the key customers shaping the market of marine technology Centres globally?	<ul style="list-style-type: none"> ● Public research institutions ● Researchers local to the centres ● Businesses specialising in simulations, testing and calculations ● Large corporations in marine technology and design ● Firms with large focus on developing new technologies and innovation
What trends will shape the demand of the market in the future?	<p>General factors:</p> <ul style="list-style-type: none"> ● Increasing population ● Climate ● Need for food and energy <p>Detailed factors:</p> <ul style="list-style-type: none"> ● Lack of metals and minerals from land based resources will put pressure on the exploitation from ocean based resources. ● Oil & gas prices and shale gas discussion are factors that may influence the market for offshore oil and gas. ● Public funding of research infrastructure globally and new similar research centres to be built. ● Public funding for renewable ocean energy incl. offshore wind to meet the expectations of the EU 2020 strategy. ● Increasing population and the need for food requires more food to be harvested and produced in the oceans. ● New international regulations and norms (e.g. EEDI introduced by IMO) for the improve-

	<p>ment of the ship efficiency</p> <ul style="list-style-type: none"> • The current and medium term lack of public resources dedicated to driving innovation in the marine sector • Computational Fluid Dynamics (CFD) and databases • Availability of public grants for technology development • Demand for environmentally friendly solutions • Pace of innovation • Industry investments • The increasing globalisation and delocalisation of the production phase in remote places will affect the market significantly putting maritime at the heart of the world's trade flows more and more.
Can you define the key factors shaping the market (in each market segments listed) as of today?	
In shipbuilding technology and design	<ul style="list-style-type: none"> • Green shipping, • Slow steaming container freighters, • Propulsion in rough seas • Changes in market competencies: Demand moving from Europe to China • Environmental issues • Increased competitiveness
Technology and design for offshore oil and gas activities	<ul style="list-style-type: none"> • Result of the "end of easy oil" era - more innovation and harsher environments • Open waters: Ships and Platforms, • More offshore wind installations (less oil and gas) • Increased offshore exploitation near Greenland, Jan Mayen and elsewhere in the Arctic • Demand for more eco-friendly solutions • Demand for technology solutions for challenging conditions
Technology and design for ocean/offshore renewable energy	<ul style="list-style-type: none"> • As above • result of the "end of easy oil" era – more innovation. More complex systems
Technology and design for aquaculture and fisheries	<ul style="list-style-type: none"> • Environmental issues • Investments in fisheries in Russia, China and developing countries • Increased aquaculture in Asia and South America • Increased fishing in the Arctic
Technology and design for arctic operations	<ul style="list-style-type: none"> • Arctic research will be driven by oil companies willing to explore extreme environments. • Another discussion will be transport of energy for geopolitical reasons. e.g. if Ukraine situation will get more complicated, the arctic will suffer from this as Russia is a big player in Arctic and also controls most of the "North-Eastern Sea Route" • Exploration, transport, new ice research vessels • Pace of environmental changes in the Arctic • Arctic geopolitics • Investments in Arctic operations • Environmental issues
What are the main barriers to Marine Technology Research market entry? (in case of establishing new centre)	<ul style="list-style-type: none"> • Expensive infrastructure • Customer relationship takes a long time to establish and yields the incumbents a large advantage. Such relationships yield large databases, which are valuable in themselves for research purposes. • Experience and competence, specific innovative knowledge - competence must be available to operate any lab infrastructure, not only budget for investment in the infrastructure is important. • Market knowledge. Marketing - word of mouth and track record important • Relatively few large, specialised clients
Source: Oxford Research AS	

Annex - List of interviewees

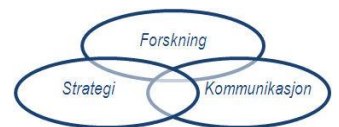
Research centres interviews

Name	Organisation	Position	Interview Date
Paulo de Tarso T. Esperança ptarso@laboceano.coppe.ufrj.br	LABOCEANO	Executive Director	20/3/2014
Lucimar Carvalho lucimar@laboceano.coppe.ufrj.br	LABOCEANO	Institutional Relations Manager	20/3/2014
Dr. James P. Millan, Ph.D, P.Eng.	(a) National Research Council Canada; (b) Memorial University of Newfoundland & Labrador	Researcher; Adjunct Professor (Faculty of Engineering and Applied Science)	2013-03-07
Norman Brown	Fleetway Inc. (parent company of Oceanic Consulting Corporation)	Vice President	2014-03-17
Herr Friesch	HSVA	CEO	04.04.2014
Terry Lindstrom	National Research Council Canada	General Manager – Ocean, Coastal and River Engineering (NRC-OCRE)	2014-03-21
Emilio Fortunato Campana	INSEAN	Director (CEO)	13/03/2014
Giacomo Grande	INSEAN	CFO	13/03/2014
Oddvar Inge Eide <Oddvar.Eide@marintek.sintef.no>;	MARINTEK	President	4/3/2014
Atle Minsaas <Atle.Minsaas@marintek.sintef.no>	MARINTEK	Special Adviser	4/3/2014
Birger Åldstedt <Birger.Aldstedt@marintek.sintef.no>	MARINTEK	Vice President	4/3/2014
Professor Chan Eng Soon ceeces@nus.edu.sg	National University of Singapore	Dean, Faculty of Engineering; Chairman of Working Committee on marine and offshore testing facilities	31.3.2014
Daniel Zhang danielzhang@maritimeinstitute.sg	Singapore Maritime Institute	Manager	31.3.2014
Mr Heng Chiang Gnee cgheng@maritimeinstitute.sg	Singapore Maritime Institute	Executive Director	Email correspondence
Mr Thomas Ting thomas@maritimeinstitute.sg	Singapore Maritime Institute	Assistant Director	Email + phone correspondence
Mr. Ir. Johan H. De Jong j.h.de.jong@marin.nl	MARIN	Manager international relations (former manager business unit ships)	12/3/2014
Rick Mercier	OTRC	Director	21 March 2014

Industry interviews

Interviewed sample consists of : managers at 5 ship design and engineering companies, 3 fish processing technology companies, 2 shipbuilding companies, 2 freight shipping companies, one fishing gear manufacturer, one aquaculture equipment company and one large fishery, two specialists employed at government agencies, a specialist and consultant in fisheries and aquaculture as well as a specialist in logistics and transportation. All individuals are well known in their fields and have significant professional experience and a higher-level education in their respective fields. All the companies interviewed are exporting their technology to the global markets. Of the tech companies, one is defined as a large player in the global market with over 2000 employees while the others are within the same range as the majority of industries in their field. The government institutions are in the field of marine research and supporting services for the fisheries or aquaculture industries and ocean surveillance.

Organization	Name	Position
Eimskip	Gylfi Sigfusson	CEO
FAO	Ami M. Mathiesen	Assistant Director-General of Fisheries and Aquaculture
Hampidjan	Gudmundur Gunnarsson	Director of development
HB Grandi	Lofnur Bjarni Gislason	Director of demersal fisheries
Iceland's Ministry of Industries and Innovation	Grimur Valdimarsson	Consultant
LIU	Kristjan Thorarinsson	Research director
Maine Technology Institute	Scott Burnett	Director of marketing
Marel	Jon Birgir Gunnarsson	Director of fish industry centre
Marorka	Leifur A. Kristjansson	Technical Development
MIT Centre for Transportation and Logistics	Dr. Yossi Sheffi	Director
Navis	Hjortur Emilsson	CEO
Ocean Excellence	Pall Gislason	CEO
Polar Trawl Doors	Atli Mar Josafatsson	CEO
Rafnar / OK Hull	Bjorn Jonsson	CEO
Simek A/S	Kenneth Harald Hansen	Technical Director
Sjavarutvegsthjonustan	Valdimar Gunnarsson	Managing Director
Skipataekni	Stefan Gudsteinsson	Technical Director
Star-Oddi	Sigmar Gudbjornsson	CEO
Teledyne Gavia	Arnar Steingrimsson	Research engineer
Thor Ice	Thorsteinn Viglundsson	CEO
Trefjar	Hogni Bergthorsson	CEO



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