SFI Smart Maritime in 2017

Summary 2017

2017 has been an active and productive year at SFI Smart Maritime. The Centre is now in its 3rd year, with a high activity tempo and an increasing number and variety of deliverables (publications, case studies, workshops, tools). The dialog between the research team and industry participants is very constructive. Today Smart Maritime works as a relatively important meeting place and cooperation platform within energy efficiency and environment-friendly shipping. In addition, the Centre has worked as a springboard for new initiatives and further cooperation.

In 2017 the SFI has focused on maintaining the balance between long-term scientific research and more short-term applied research and value creation for industry partners. Direct and regular cooperation has contributed to a first version of a tool for simulation-based design, but also the use of ship operators' own fleet as test case or lab.

The activity list in Smart Maritime has been further sharpened, with effort put on more integration among the various disciplines (WP). This has been achieved through a common project – *SP7 Simulation based concept design* – that takes input from each discipline by integrating models developed in each WP into a common platform.

Communication and documentation have been improved in 2017. Smart Maritime proposes now Webinars that contribute to more scientific discussion between research team and industry partners. Furthermore, the dialog between the SFI Management and Board is open and constructive.

Two Network meetings have been arranged: in Mars at Rolls-Royce Marine in Ålesund and in October in Værnes hosted by SINTEF Ocean. These have been important meeting places and have contributed to active participation from SFI partners.

SFI Smart Maritime has launched the discussion and documentation of the innovation potential and possibilities for applications of results in industry. This is a point on the SFI's priority list for 2018, which first step is a patent landscape analysis currently being carried out by the Norwegian Industrial Property Office.

The involvement and participation of industry partners is crucial for ensuring value creation for the Norwegian maritime industry. This is another priority point for 2018; the SFI management will work systematically to ensure that all competences and opinions among the Consortium come to light and contribute in refining the Centre's strategy.

The involvement of industry participants in Smart Maritime include the following:
- Laboratory or test ship made available for research
- Direct involvement in research work
- Cooperation on model and tool development
- Participation at workshops and webinars
- Scientific discussion, knowledge sharing, competence development
- Associated projects, joint initiatives for spin-off projects
- Dissemination, cooperation on scientific publication

Results and highlights from 2017

Dialog and cooperation with industry actors

The Centre has arranged two Network meetings, one in the Spring with focus on scientific work, and one in the Fall with focus on prioritization and planning of 2018 activities. Each network meeting has hosted around 50 participants. These are two-day meetings, with emphasis on exchange between industry representatives and the research team.

In addition, the SFI management arranges one-to-one partner visit throughout the year, aiming at maintaining a good dialog and cooperation.

The webinars launched in 2017 have been welcome by industry partners as an effective way to keep scientific discussion going.

- Webinar June 2017: LNG-fuelled vessels
- Webinar September 2017: Hybrid propulsion systems

SoA study on potential for reducing GHG emissions from shipping

A review article from WP5/WP1 (Bouman, Lindstad, Rialland & Strømman) published in Transportation Research Part D has received a lot of interest from industry and academia. It provides an overview of technologies, measures and potential for reducing GHG emissions and increase energy efficiency from shipping. This review has contributed to discussion in the SFI, as background information for activity prioritization, and reference material for several industry partners.

Simulation-based concept design

The application Gymir for simulation of integrated ship system has been further developed in 2017, in cooperation between SINTEF Ocean, Vard, Havyard, Rolls-Royce, DNV GL and NTNU. The 2017-version has been tested in several case studies at ship operator SFI partners (test of new concept design), as part of the sub-project *SP7 Simulation-based concept design*. It has also been applied by design partners both in the design process and in communication with own business partners. The application targets the early stage design phase, and enables simulation of long-term performance of new ship technology and design solutions in realistic operational conditions. It integrates models for design and optimization of various sub-systems: hull and propulsion models from WP2, and power system models from WP3. The vision is to reach a platform for virtual ship design. The Gymir application has received a lot of attention from SFI partners, both as an important simulation tool, but also as a multidisciplinary activity in the SFI that integrates tools and models from all five scientific focus areas (WPs).

Flapping Foil – towards commercialization

PhD student John Martin Godø has developed a concept for propulsion system – Flapping Foil - with strong efficiency improvement potential, particularly for high speed catamarans. Flapping Foil can reduce energy need for high speed ships by 30-50 % and make ferry transportation much more environmentally friendly. Godø cooperates with NTNU Technology Transfer (TTO) for the commercialization of the concept.

Open loop Exhaust Gas Cleaning system

An open loop Exhaust Gas Cleaning system (EGC) composed of sea water scrubber and wash water cleaning system – produced by Wärsilä Moss – has been further developed in Smart Maritime by including Exhaust Gas Recirculation system. Results from tests carried out onboard the test ship - Solvang's LPG ship Clipper Harald - show that the existing emission limit requirements (IMO Tier III) are fulfilled together with requirements on quality of wash water. The scrubbing system with EGR will be commercialized and installed on four new ships ordered by Solvang.

Shipping and climate change

While *WP1 Feasibility Studies* aims at exploring and screening potential alternative solutions, *WP5 Economic and Environmental Due Diligence* has another important role in the SFI; to put the research activity and results in a

context of global environmental and climate change. The solutions, designs and technologies developed in *WP2 Hull and propeller optimization* and *WP3 Power systems and fuel*, and integrated and simulated in *WP4 Ship system integration and validation*, are further evaluated in WP5 from an economic and environmental perspective.

The development of the analysis tool MariTEAM has progressed in 2017. Industry partners are looking forward to seeing the output of analyses and be involved in MariTEAM studies when the tool is more mature. The model can calculate location-specific operation emissions form ships. SFI industry partners have contributed with engine emissions data so that regression analyses can be integrated in the model. The SFI Consortium has expressed an increasing need and interest for understanding the impact of shipping on climate change, and the possibility for Smart Maritime to contribute to policy development.

New initiatives

In cooperation between SFI industry actors and research teams, SFI Smart Maritime has been involved in several new initiatives throughout 2017, including several project applications to MAROFF program in the Fall. Main topics include: energy efficient shipping, zero emission, H2 Fuel Cell system, Virtual ship design and optimization, ship performance monitoring. To date, the outcomes of these efforts are the following:

- Researcher project *Shifting cargo to sea by autonomous ships* (SATS), lead by SINTEF Ocean
- Knowledge-Building Project (KPN) *Digital twin for vessel life cycle services* (DIGTWIN), lead by NTNU

It can also be mentioned that SFI partners are working towards the establishment of a Joint Industry Project (JIP) on Open Simulation Platform.

Postdoc and PhD projects

Short status information on Smart Maritime's PhD and Postdocs.

- **Lokukaluge Prasad Perera** completed his postdoctoral research project on *data analytics for ship performance monitoring* in the summer 2017. His work consisted of developing data analytics to capture ship performance under full economic conditions. Prasad recently moved to Tromsø to work at UiT The Arctic University of Norway as Associate Professor in Advanced Maritime Vessel Operations.

- **Torstein Ingebrigtsen Bø** is currently completing his postdoctoral research project. He is submitting two journal papers, one on combined control of gas engines and batteries and one on simplified loss models of synchronous machines. In addition, together with Elizabeth Lindstad, he is submitting a paper on abatement options for a tanker to meet EEDI requirements. In Februar 2018, Torstein will join SINTEF Ocean and continue his contribution to Smart Maritime.

- **PhD student Endre Sandvik** works on validation of simulation models in WP4 Ship system integration and validation, with specific focus on Gymir. His project focuses on *Simulation Based Design of Ships with Regards to System Performance*. Endre has recently submitted a conference article IMDC 2018, which will be followed by a scientific paper in 2108.

- **PhD student Jørgen Nielsen** works on *Energy recovery and harvesting in hybrid power systems.* His PhD evolves around energy utilization in marine power systems looking at possibilities emerging with hybrid power technology and energy harvesting. Jørgen has recently returned from paternity leave and will continue his work in WP3 on *Modeling and simulation for power systems* in 2018.

- **PhD student Vladimir Krivopolianskii** works on Fuel injection and combustion processes in marine diesel engine. He has recently submitted a journal article entitled "Experimental study of ignition delay, combustion and NO emission characteristics of hydrogenated vegetable oil (HVO)". In parallel, Vladimir is working on early-developed high-pressure gas injector. In 2018, he will continue his work in WP3 on *Advanced combustion control for alternative fuels*.

- **Renato Skejic** launched his Postdoc project within *Computation of added resistance due to waves - using potential flow methods* in 2017. The aim is to develop potential flow methods that are less complicated, faster and more robust than full 3-D non-linear panel methods while still being more accurate than the current linear potential flow methods implemented in ShipX and applied in Gymir. The methods he is aiming at will be computationally fast, but will require input of 3-D hull geometry. Renato had a first meeting with industry partners in October.

- **PhD student Jon Martin Godø** is currently in part-time leave for focusing on commercialization of the propulsion system concept Flapping foil for high speed ships, as a contribution to zero emissions in Trondheimsfjorden.

- **PhD student Jon C. Mossige** started his PhD project on *Calm water performance and Friction reduction* in September 2017. His supervisor at NTNU is Prof. Lars Erik Holmedal. Jon's contribution to WP2 in 2018 will include experimental work in collaboration with Jotun.

National cooperation

- Smart Maritime cooperates with SFF AMOS, SFI EXPOSED, SFI MOVE and SFI SAMCoT through *Ocean School of Innovation*. The mal goal is to increase innovation and value creation of the research centres by strengthening the awareness and competence on innovation and entreneurship among PhD students.
- Henning Borgen from SINTEF Ålesund has been appointed as coordinator for SFI Smart Maritime, SFI MOVE and EXPOSED. The coordination will focus primarily on tool and model development.
- SFI Smart Maritime has ongoing cooperation with Patentstyret on a Patent landscape analysis. The work has been introduced to SFI partnerns in Værnes in October and used as starting point for discussion on relevant innovation areas and future prioritization of Smart Maritime activities.

International cooperation

Scientific Advisory Committee

The SFI has had two meetings with its Scientific Advisory Committee, which resulted in valuable scientific discussion and advice on further work. The Committee members are: Professor Osman Turan from Strathclyde University, Professor Harilaos Psaraftis from Technical University of Denmark, Professor Karin Andersson and Rickard Benzow from Chalmers University of Technology, and Professor Friedrich Wirz from TU Hamburg.

Horizon 2020

The EU H2020 project HOLISHIP is ongoing, with the participation of Smart Maritime partners MARINTEK, DNV GL and Rolls Royce (UK). The project is dedicated to *HOLIstic optimisation of SHIP design and operation for life cycle*. One of its activities is directed to the development and testing of a Virtual Vessel Framework for optimization of design and concept validation. This is highly relevant for Smart Maritime WP4 Ship Design Integration and Validation, and Sub-Project SP7 Simulation based concept design.

Cooperation NTNU / DTU (Denmark) on common PhD program

Cooperating on funding of 4 PhDs within hydrodynamics (WP2) and fuel and machinery (WP3)

Cooperation with Chalmers University of Technology, Sweden

Cooperation with WP2 (and joint work with JOTUN) within fouling and anti-fouling for reduction of friction.

SNAME - Fellowship for Dr Lindstad

In 2017, Dr Elizabeth Lindstad from SINTEF Ocean (WP1) has been awarded Fellowship from SNAME, The International Community for Maritime and Ocean Professionals.

Smart Maritime Team

During 2017, the following changes in the team have taken place.

- **Anna Ringvold** joined the WP5 in September 2017, to continue the work of Evert Bouman in further development of the MariTEAM model.

- **Bjørn Egil Asbjørnslett** has taken over the board membership for NTNU after Ingrid Schjølberg.

- **Helene Muri** recently joined the WP5 team, with focus on shipping and climate change.

- **Jon S. Dæhlen** joined SINTEF Ocean and the WP4 team in august 2017, to continue the work of Mathias Nowak within data simulations and optimization and the further development of Gymir.

- **Kevin Koosup Yum**, defended his PhD thesis in August 2017, with the title *Transient Performance and Emissions of a Turbocharged Diesel Engine for Marine Power Plants*. He is now working full time at SINTEF Ocean, and continues his contribution to Smart Maritime.

- **Kjell Morten Urke** has taken over the board membership for VARD Design after Henning Borgen.

- **Lars Dessen** has taken over the board membership for WWL after Per Brinchmann.

- **Roar Fanebust** has taken over the role of Coordinator of the Technical Advisory Committee after Gunnar Gamlem from WWL.

- **Sergey Ushakov** has taken over the management of WP3 Power system and fuels after Prof Eilif Pedersen from NTNU.

- **Stian Skjong,** PhD student from project ViProMa, defended his PhD thesis in December 2017. He will joint SINTEF Ocean in 2018, and work a.o. with Smart Maritime within Simulation and design.

MSc Students

Summer internship

In the summer 2017, Smart Maritime and SINTEF Ocean hosted two MSc students from NTNU – Astrid Vamråk Solheim and Joakim Tveiten Vigsnes. They worked on a parameter study based on the ship type, trade and size relevant to Star Lysefjord, which served as input for developing the alternative vessel concept in *SP7 Simulation-based concept design*. Results are published in a paper by Lindstad et al. (2017) entitled "Open Hatch Carriers - Future Vessel Designs & Operations", presented in SNAME in October 2017.

MSc theses

MSc theses submitted in 2017 linked to Smart Maritime ([access to publications online](#))

Name	NTNU Dpt.	MSc thesis
Anna Karina Magnussen	Marine Technology	Rational calculation of sea margin
Jens Christoffer Gjølme	Marine Technology	Estimation of Speed Loss due to Current, Wind and Waves
Sigbjørn Wiik*	Marine Technology	Voluntary speed loss
Fredrik Gyberg	Marine Technology	Design, modelling and control of a generic crane for marine application
Thomas Haraldsen Evang	Marine Technology	Marine Crane Dynamics Lab - Modelling and experimental validation
Jan Olav Øksnes	Marine Technology	Regeneration in Crane Operation
Anna Ringvold	Industrial Ecology	Prospective life cycle assessment of container shipping
Mafalda Silva	Industrial Ecology	Life cycle assessment of marine fuel production
Peter Tenjord	Marine Technology	Simulation-based analysis of ship performance
Martin Bakke	Marine Technology	Simulation-based analysis of ship performance

* Gratitude to ship operators Grieg, KGJS and WWL for their contribution to Wiik's MSc thesis on voluntary speed reductions.

2018

Activity plan and budget 2018

The activity plan & budget for 2018 has been set up by SFI Management in cooperation with the Board and dialog with industry partners at the October network meeting. This plan was presented to the General Assembly and approved on December 6th 2017. It can be underline consulted on the website.

Priorities 2018

- Increase involvement from industry participants and clarification of participation from each partner in various research activities.
- Improved coordination toward new initiatives and spin-offs from Smart Maritime. This includes project applications to RCN MAROFF and EU H2020 (LC-MG-1-8-2019: Retrofit Solutions and Next Generation Propulsion for Waterborne, og MG-BG-02-2019: Ship emission control scenarios, marine environmental impact and mitigation).
- Early information and coordination on MSc theses.
- Improved overview of models and tools developed in Smart Maritime, their interoperability and possible connection with tools from other SFIs (EXPOSED, MOVE).
- Smart Maritime to be more represented in the medias and to take a clearer role in the debate on shipping and climate change.
- Increase applicability of output, by making Smart Maritime tools and models more available for testing by industry partners.
- More frequent webinars and scientific update.
- First version of an innovation plan, established in collaboration with industry partners
- Deliverables from Smart Maritime – models, tools, reports, publications – to show clearly how they contribute to the overall goals of the SFI: Competitiveness of the Norwegian maritime sector, Reduction of harmful emissions from ships, improved energy efficiency.

SFI Smart Maritime

December 20th 2017