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# Onboard Competence for Optimal Application of WAPS Systems

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ABSTRACT: UN's Sustainably goal 13 (Climate action) addresses the need to reduce harmful emissions from all types of industrial and transport activities [1]. The Fourth IMO GHG Study 2020 estimated that GHG emissions from shipping in 2018 accounted for some 2.89% of global anthropogenic GHG emissions [2]. As well as for other transport sectors, national and international maritime regulatory bodies have defined goals for reduction of greenhouse gases within given time limits (2030 and 2050). Many of these goals have been defined from an optimistic view of introduction of new hull designs and propulsion technologies, fuels and operational measures such as fleet capability utilization and routing. The present economic reality indicates that it may be difficult, if not impossible, to reach the goals in time. Wind-Assisted Propulsion Systems (WAPS) have been recognised as an essential contributor to a sustainable maritime energy transition. WAPS offer a cost-efficient carbon free source of propulsion, contributing to energy efficiency and eventually limiting the cost and volume burden of upcoming zero-carbon fuels. Maximising the potential of this technology in operation requires skilled seafarers and effective training programs.

## 1 INTRODUCTION

Work is ongoing in all fields related to minimizing energy consumption for ships. This includes reduction of ship resistance, improvement of propulsion efficiency, utilization of wind and wave energy for ship propulsion, weather routing and logistics optimization. The objective of the paper is to show that safe, efficient and cost-effective operation of WAPS ships requires additional operational competence, both onboard and onshore. Highly skilled crews and onshore managers are needed to harvest the potential of WAPS, and to convince the maritime industry to invest in upscaling WAPS for a future high environmental impact.

This paper is based on a study where the combination of human, technology and organizational aspects ensures successful implementation and operation of Wind-Assisted Propulsion Systems (WAPS). WAPS is forecasted to have a substantial impact on reduction of energy consumption and the associated GHG emissions from ships. There is an increasing interest amongst Norwegian ship owners to invest in different systems aimed at reduction of greenhouse gasses (GHG) as ways to meet stronger IMO (Net-Zero Framework [3]), European [4] and Norwegian [5] goals to move to a zero/low emission maritime industry. In addition to improved hull and superstructure designs (to reduce resistance), more efficient propulsion systems and hull/rudder/propulsion unit interaction, air lubrication (ALS) and Wind-Assisted Propulsion Systems (WAPS) are introduced and tested on all types of ships.

Harnessing the available wind energy requires skilled seafarers that understands the working principles of these technologies and can adapt and improve existing navigation and ship handling procedures accordingly. Experience from the ship SC Connector shows that the harnessed power of their Flettner rotor system can vary between 0-10 MW for a specific wind condition - depending on the crew's ability to operate the rotors and ship. Considering the rapidly growing interest and adoption of wind-propulsion technology – and the foreseen doubling of WAPS vessels every year for the next decade, the required WAPS-training will need to be efficient, scalable, standardized and transferable. Today there is no maritime education and training institution (MET) offering a dedicated competence development scheme for energy efficient and safe operation of WAPS. Instead, training in safe and efficient operation of WAPS vessels relies on extensive, practical onboard experience transfer with more experienced mentors. This is a difficult process to scale up and as technology continues to develop, the competence requirements will also change. WAPS-IT acknowledges the essential role of seafarers and operators for implementing new technologies towards the decarbonization of shipping. It is crucial that the end-users receive proper training so that the promised potential of green technologies might be utilized. The project aims to ensure necessary competence onboard and onshore for optimal and safe operation of WAPS ships, enabling the industry to invest in and upscale WAPS for a high environmental impact.

The first part of the paper will give a summary of present-day wind assisted propulsion systems and some examples of estimated emission reduction for sailing ships and specific voyage patterns. The second part will describe how WAPS concepts are/will be applied by Norwegian ship owners and the focus they have on defining the need for competence enhancement within their organization, onboard and onshore, to be able to maximize the potential commercial outcomes from operating a fleet of WAPS-equipped vessels. The final part of the paper describes an ongoing work by Norwegian shipowners/management companies, WAPS providers, research organizations and maritime education and training institutions to develop a generic WAPS competence matrix. This matrix will be the baseline for company specific training activities including classroom teaching, online learning modules and hands-on system specific training on board. The need to develop an Industry standard for competence requirements for safe and efficient application of WAPS is a question for further investigation in collaboration with other international projects studying competence requirements and learning tools for maritime personnel (on board and onshore).

## 2 WHY WAPS?

Wind-Assisted Propulsion Systems (WAPS) harnesses wind through sails on ships and offers an undeniable contribution to reducing energy consumption by providing reliable alternative propulsion and eventually reducing the cost and volume burden of upcoming alternative fuels. The combination of operational performance improvement and a retrofittable technology will contribute to short-term greenhouse gas (GHG) reductions essential for sustainable maritime energy transition.

Exploiting the wind directly for propulsion is 7 times more efficient than exploiting wind energy to produce the necessary green electricity for e-fuels production [6]. At a global fleet scale, a 20% reduction in marine fuel consumption can reduce $CO_2$ from shipping by 100 Mt $CO_2$ (0,3% of global emissions), but it also contributes to reducing the need for e-fuels and freeing green electricity equivalent to 700Mt $CO_2$ emissions from fossil-based e-production.

Wind-propulsion contributes towards reaching IMO goal of 40% reduced carbon intensity by 2030 and net zero by 2050. Considering the potential $CO_2$ savings from current technology around 20-30% [7], and the market forecasts reported by the International Wind Ship Association (IWSA) [8], the total annual GHG reduction from shipping is estimated around 20 to 90 mt by 2030 and 2050. Considering the largest polluter, the world Deepsea fleet (650mtGHG /y), the theoretical maximum potential would be 130mt.

In addition to energy savings during transit, enhanced operability through optimal use of WAPS and improved seaworthiness of the vessel give additional value in terms of improved navigation safety, reduced idle time, and improved service reliability.

Good seamanship is necessary to realize this potential, as secure skilled seafarers and efficient familiarisation, safe and optimal utilisation of the system will contribute to increasing the effect of the installed sails, improving payback time on investments in sail technology and reduce investment risks.

## 3 PRESENT DAY WAPS SYSTEMS

The main types of WAPS is illustrated in figure 1. Pros and cons for the distinct types are listed in Table 1.

### 3.1 *Rotor Sails (Flettner Rotors)*

How it works: Uses the Magnus effect—spinning cylinders generate lift perpendicular to the apparent wind

Rotor sail for ships started in the 1920-ties (Flettner rotor). The vertical cylinder is spinning and creates a Magnus effect delivering an aerodynamic force. An early prototype was installed on a ship crossing the Atlantic in 1925. The focus on emission reduction led to a renewed interest for the rotor sail and demonstration systems were introduced shortly after the millennium. Today several manufacturers deliver rotor sail systems. One such company is Norsepower, more information is presented in section 4.

### 3.2 *Soft Sails (e.g., DynaRig, traditional sails)*

How it works: Uses flexible fabric or composite sails on masts.

Modern soft sail solutions are based on experience from earlier yacht design. One of the most advanced (with some installations on commercial ships) is Dynarig which has an advanced deploying and trimming system to optimize wind-assisted propulsion.

### 3.2.1 *Rigid Sails (Wing Sails)*

How it works: Fixed or articulated aerofoils similar to airplane wings.

Rigid sails have developed from the yacht industry. The Wing sail concept for commercial shipping is linked to an U.S. government commissioned study of the economics of wind-assisted propulsion to compensate for the high fuel costs back in the 1980-ties.

## 3.3 *Suction Wings (Ventifoils, e.g., Econowind)*

How it works: Uses suction inside wing-shaped structures to improve lift.

Suction sails for shipping were developed in the 1980-ties by the French Cousteau Foundation. At that time, the interest in WAPS was very low due to the low fuel price in the mid 1980-ties. A prototype system was installed on the Cousteau Society vessel Alcyone in 1985.

## 3.4 *Kites (e.g., SkySails)*

How it works: A large kite flies ahead of the ship and pulls it like a parachute.

The first installation of a kite system on a commercial ship took place late 2021 on the Ro.Ro vessel Ville de Bordeaux. A six-month testing period started early 2022, it was a collaboration with Bureau Veritas.


Figure 1. Different types of WAPS [7]

Table 1. Pros and cons for specific types of WAPS systems

| System type | Pros | Cons |
|---|---|---|
| Rotor | High thrust vs size of sail.<br>Automated.<br>Effective in a wide range of wind angles.<br>Proven technology with multiple commercial installations. | Requires power input to rotate the cylinders.<br>High structure—impacts air draft and crane operations.<br>Complex retrofitting depending on vessel layout.<br>Can interfere with radar and deck equipment like crane<br>Restrict a view from the bridge |
| Soft sail | Relatively lightweight<br>Passive system—doesn't require energy input for propulsion.<br>Potential for good lift if well-trimmed. | Manual or semi-automated operation can increase crew workload.<br>Upfront investment for modern rigging (like DynaRig) can be high.<br>Susceptible to wear and tear in adverse weather. |
| Rigid sail | High aerodynamic efficiency.<br>Better durability and shape control than soft sails.<br>Fully automated systems available. | Bulky and rigid—limits flexibility and stowage.<br>Installation can be expensive and complex.<br>Sensitive to damage from port handling equipment or cargo operations. |
| Suction wings | High lift-to-drag ratio with compact design.<br>Less limitation towards Angle of Attack. | Requires fans to create suction—needs energy input.<br>Still relatively new<br>Higher maintenance complexity due to moving parts and airflow systems. |
| Kites | Doesn't take up deck space.<br>Can generate high thrust in favourable wind conditions.<br>Easy retrofit with minimal structural changes. | Limited usability—needs consistent wind from stern.<br>Challenging to launch and retrieve in poor weather.<br>Not suitable for all routes or ship types |

# 4 WAPS UPTAKE BY SHIPOWNERS

## 4.1 *Norway*

At present there is only one Norwegian shipowner that has experience from operation of a WAPS vessel, SeaTrans Group. Their ship, SC Connector, see figure 2, has two Flettner rotors provided by Norsepower. The rotors can be tilted to allow the vessel to pass under low bridge. The vessel has been in operation for nearly five years. Operational experience will be presented in subsection 6.2.

Figure 2. SC Connector – tilted rotors (Courtesy: SeaTrans Group)

Several Norwegian shipowners will test WAPS on a variety of vessels starting in 2025. An overview of published data on WAPS installation on new buildings and as retrofit is given in Table 2.

Table 2. WAPS ships operated by Norwegian shipowners (N – Newbuilding, R – Retrofit)

| Ship owner | Ship type | WAPS type | N/R | Operational date |
|---|---|---|---|---|
| Sea-Cargo | Cargo | Rotor | R | 2023 |
| Odfjell Tankers | Tanker | Sail | R | March 2025 |
| Klaveness | Bulk | Sail | N | Q3 2026 |
| Wilson | Bulk | Sail | N | 2025 |
| Wallenius-Wilhelmsen | Car carrier | Sail | R | Q3 2025 |
| Northern Light | $CO_2$ tanker | Sail | R | 2024 |
| Berge rederi | Bulk | Rotor | N | 2026 |
| Halten Bulk | Cargo | Rotor | N | 2027?? |
| Hurtigruten | Passenger | Sail | N | 2030 |

Odfjell's five-year-old chemical tanker Bow Olympus was retrofitted with four 22 m high suction sails, Figure 3. Its maiden commercial voyage started in March 2025 from Antwerp to Texas, USA. Experience from this vessel will be used by the company to plan further WAPS installations, both on new buildings and retrofit for sailing vessels.

Figure 3. Bow Olympus – suction sails from Bound4blue installed (Courtesy Odfjell)

### 4.2 *Internationally*

IWSA estimates that vessels with WAPS increases to 40,000 in 2050, as illustrated in Figure 4 below.

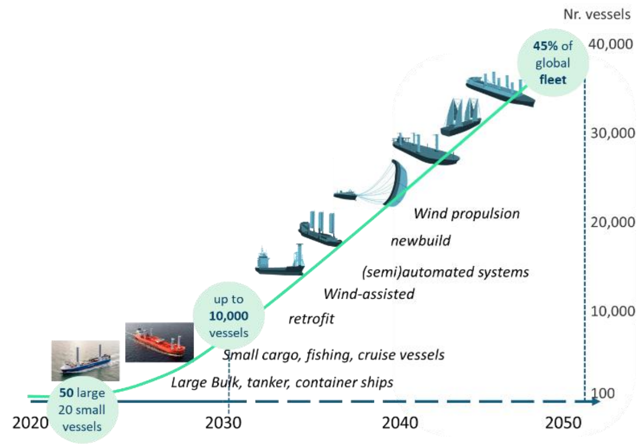


Figure 4. Estimated uptake of WAPS, adapted from IWSA's wind propulsion white paper 2023 [8]

A state-of-the-art presentation of research and innovation on WAPS is given by RINA/IWSA's submission paper to MEPC83 [9].

Since WAPS systems are expanding these days in the maritime sector, with a rapid adoption of sail systems on several vessels in the years to come, training need to be made by external centres due to capacity. So far has on board upskilling taken place in house and on board, since just a few vessels have been in operation. But, when booming and the need for upscaling is necessary, it will be essential for external training centres have to be included.

## 5 THE WAPS-IT PROJECT

WAPS technology radically changes how ships are operated and maintained. For the crew, WAPS implies new tasks, new task combinations, new ways of performing tasks (e.g. sailing plan), as well as changes in the division of tasks between crew members and between crew members and onshore personnel. To ensure and improve operational efficiency, safety, crew comfort and maximize fuel reduction with WAPS, it is crucial that the organization and its members can acquire necessary and relevant knowledge, understanding and skills and apply them in actual work practice. The industry is challenged by a lack of understanding of competence needs let alone solutions for achieving them. To answer these challenges, the Seatrans Group and SINTEF prepared a proposal for a Research Council of Norway funded industry innovation project. The proposal was accepted and the project Wind-Assisted Propulsion Systems International Training Program (WAPS-IT) started in January 2025.

The primary objective of WAPS-IT is to develop a rapidly scalable international WAPS competence program for onboard and onshore personnel, enabling maximum safety and energy efficiency. The project structure is shown in figure 5. Partners come from many parts of the maritime cluster; shipowners/management companies, technology providers, maritime training providers and research organisations. The project has a reference group with participation from International Windship Association, Norwegian Maritime Authority, Norwegian Coastal Administration and DNV. The project will review legal aspects and operational aspects related to safe and efficient operation of the integrated hydro- and aerodynamic propulsion systems.

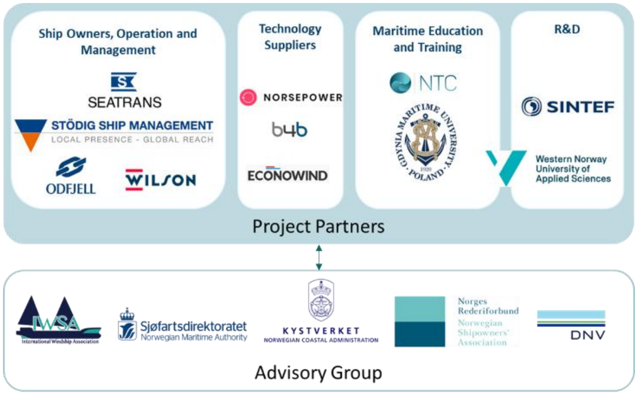


Figure 5. The WAPS-IT project structure and participants

## 6 PRESENT WAPS SPECIFIC TRAINING

### 6.1 *System suppliers' familiarization*

We choose in this paper to highlight the three system suppliers that is part of the WAPS-IT project; Norsepower, Bound4Blue and Econowind. The overall aim with this operation is to see to what extent the suppliers own training of their system, influence the uptake on board the vessels. The fully answer to this question will be given during the duration of the WAPS-IT project, when the first-hand experience is gained on board the vessels, but we may have idea how smooth the implementation can be after looking at the supplier's own reflection on WAPS training.

Supplier familiarization process focuses on their system itself not on the vessel equipped with their WAPS.

#### 6.1.1 *Norsepower*

Norsepower offer basic familiarization in how to operate the so-called Norsepower Rotor Sail (NPRS) system. Officially these training modules are designed to take the seafarer through the most relevant topic and support the progress towards a familiarization with the different aspects of the NPRS. It is five training modules: NPRS Basics, NPRS Project Components, NPRS Operation, NPRS Maintenance and NPRS Safety. It is a variation in how hands-on these modules are, but when the seafarers are being exposed to these modules one should be able to work safely with the NPRS and moreover learn:

- How to troubleshoot different situations that might develop
- How to perform maintenance checks and that the system will require
- How to be able to report and system issues and malfunctions
- How to contribute to emergency situations that may erupt

### 6.1.2 *Bound4blue*

Bound4Blue's system eSAIL® is designed with an integrated control system that ensures "optimal technology operation with zero crew workload or training" [10]. In a perspective of FuelEU Maritime compliance strategy, such autonomous system implies a very low threshold for implementation; but in a context of upscaling, specific training and deeper understanding of the principles behind the sail technology would contribute to expend the ship's operability and performance.

### 6.1.3 *Econowind*

The overall aim for Econowind is to ensure that their sail system, the co-called VentoFoil, is operated in a safe and correct manner, today and in the future. Then is important to go through a specific training activity, that is based on different elements such as:

- User manuals – including operational limits and emergency procedures that this information I available onboard.
- Real life situations – including best practices and actions to avoid are well documented
- Maintenance – including maintenance schedule, inspection list and lubrication and trouble shooting
- Establishing of emergency procedures – including how to lower and secure the sails in case of loss of propulsion
- To identity and communicate any other critical information now and the future

## 6.2 *Seatrans Group's specific competence development program*

Wind-Assisted Propulsion Systems (WAPS) represent a significant advance in marine technology, offering significant environmental and economic benefits. However, successful implementation of WAPS requires additional knowledge and skills. This document summarizes Seatrans Group's efforts to increase seafarer competence through training programs focused on the safety, operation and optimization of vessels with WAPS. Personnel of a ship equipped with the modern sails need to have basic knowledge and skills in the following areas: ship behavior, the sails physics and functionality, operation modes and control panel, wind and weather analysis, route planning and optimization, stability and cargo securing, maintenance and troubleshooting. Their ship SC Connector (Figure 6) is used as a case ship for development of the company specific training program.

Figure 6. SC Connector in the North Sea

### 6.2.1 *Training Programs Overview*

The company has developed a series of training modules, each addressing different aspects of WAPS operation. These modules are delivered through theoretical classroom learning, yacht tailored made sailing course developed together with Sailing and Watersports Center – Gdynia Maritime University, on board training and e-learning modules in Online Learning Management System (LMS).

The WAPS training program is designed to equip maritime personnel with the necessary skills to operate rotor sail-equipped vessels efficiently and safely and shore personnel to improve knowledge and awareness of ship personnel decisions and seaworthiness of the vessel. It covers key aspects such as ship behavior, sail physics, operational modes, weather analysis, route planning, stability, cargo securing, maintenance, and troubleshooting. The training also emphasizes the Magnus effect, external forces affecting ship propulsion, and the environmental benefits of wind-assisted systems.

### 6.2.2 *Learning objectives, Training Program and Methods*

The training programs are designed to achieve the following objectives:

- Understanding the principles of WAPS technology and its interaction with the ship's propulsion system and navigation equipment.
- Developing proficiency in operating rotor sails and integrating them into daily operations.
- Enhancing skills in route planning and optimization to maximize the benefits of WAPS.
- Ensuring compliance with safety procedures and regulations related to WAPS.
- Promoting environmental sustainability through reduced fuel consumption and emissions.

### 6.2.3 *WAPS sailing program*

The WAPS sailing program covers a range of topics including WAPS technology and sailing theory as applied to ships in a setting. The course begins with an overview of the company's objectives and requirements while emphasizing the significance of WAPS technology.

During the course crews are familiar with sailing practices. Also explore the distinctions between WAPS and traditional sails. They also learn about types of WAPS and how it works. They delve into the aerodynamics and sail forces, understanding how wind interacts with sails to generate lift. They explore sail shapes and vs different WAPS type, angles of attack, and techniques for adjusting sails for optimal performance. The course includes practical exercises on tacking and jibbing, as well as adjusting sails for different points of sail, such as beam reach, close-hauled, and broad reach.

The course also includes topics on boat dynamics and stability such as understanding the keel and hydrodynamics impact on stability. It delves into how engine sails and WAPS interact while also including exercises on plotting the center of effort and lateral resistance. Participants study the angle of attack, for sailing boats and WAPS ships to enhance their comprehension of sailboat and WAPS ship performance.

Practical exercises and teamwork are integral to the course, with sessions on reading wind and weather forecasts, adjusting sailing strategies for varying conditions, and advanced sail handling.

The class ends by delving into wind patterns and rotor sails— focus on wind dynamics and rotor sails, exploring wind speeds over water, steady versus gusty wind, jet effect, and cape effect.

The training program combines concepts with applications in real world scenarios to assist seafarers using WAPS effectively. The objective is to enhance seafarers' WAPS operation skills to improve fuel efficiency and reduce emissions while enhancing vessel performance.

Theoretical Classroom Learning

The theoretical part of the training programs offers a foundation in the principles and ideas of WAPS technology through classroom sessions that consist of lectures and discussions focusing on various topics such as the Magnus effect and wind propulsion systems, as well as discussions on environmental benefits and applicable regulations. The classroom sessions also delve into aspects related to rotor sails, such as their design features and how they operate and are maintained. Interactive activities and quizzes are used to help participants reinforce their learning and ensure that they have thoroughly understood the content.

Onboard training

Training on board plays a role in training schemes as it enables learners to put their knowledge into practice effectively. It involves tasks like managing rotor sails; overseeing system efficiency; and carrying out maintenance and problem solving. Participants learn how to integrate rotor sails into daily operations, optimize their performance, and ensure compliance with safety procedures and regulations. The on-board training also covers the impact of rotor sails on ship stability and cargo securing, ensuring that participants are well-prepared to handle the unique challenges posed by WAPS.

E-Learning Modules

E-learning modules provide participants with flexible and convenient access to training materials, allowing them to learn at their own pace. This includes video lessons, interactive exercises, and quizzes on topics such as the Magnus effect, wind propulsion systems, environmental benefits, and relevant regulations. The e-learning modules also cover the technical aspects of rotor sails, including their design, operation, and maintenance. Participants will learn how to integrate rotor sails into daily operations, optimize their performance, and ensure compliance with safety procedures and regulations.

All in all, the training programs provided by Seatrans Group play a role in assisting seafarers effectively embrace the use of WAPS in the sector. Through equipping seafarers, with competencies and insights required to operate rotor sail equipped ships efficiently. These training programs not only enhance operational efficiency but also contribute to the broader goal of sustainable maritime practices.

### 6.3 *MET training courses*

Western Norway University of Applied Sciences (Høgskulen på Vestlandet - HVL) provides maritime education and training within field as: maritime law and regulations, technology development and integration, nautical sciences and engineering and human factors. Also, an active involvement of their students is a crucial part of HVL's involvement in field of WAPS. Everything from doctoral theses related to WAPS training and safety and simulator testing and evaluation of training tools, is an important contribution from HVL. In addition, to pave the way for a student's collaboration with the industry and involvement with real-world applications, is also something HVL contribute into this field. In addition, the university could offer WAPS training as a part of the maritime education and simulation, an decisive service into the field of WAPS. HVL and SINTEF are both R&D institutions in the project.

Gdynia Maritime University (GMU) is the oldest maritime university in Poland. Since 1920 the institution has been educating personnel for the maritime sector, including officers on board and land-based personnel to the shipping companies on shore. GMU's offer lectures within five faculties; Electrical Engineering; Computer Science, Marine Engineering, Navigation and Management and Quality Science. GMU is also collaborating closely with Stødig Ship Management in Bergen, by offering practical sailing training for their crew. Included in this training comes knowledge of sailing theory and its practical application. This activity is part of the GMU's aim for a specialization for WAPS technology, optimisation, safety, and the idea is that it should include all bridge crew and some shore personnel.

The Norwegian Training Center – Manila (NTC-M) is a major maritime and offshore training partner to the global shipping community, located in the vibrating business district of Pasay, Manila. It was started in 1990, as an initiative from the Norwegian Shipowners´ Association (NSA), and it is charitable foundation, non-stock and nonprofit. It was the first maritime training center in the world to be certified by Det Norske Veritas (DNV) and is the preferred maritime and offshore training partner to the global shipping community. Over the years more than 200.000 seafarers have received high skilled and targeted competence. With more than 40 maritime simulators, mostly Kongsberg brand, NTC-M is a key player in securing seafarer's essential training for a safer voyage and port operations. An important part of NTC's activities is to offer a free of charge scholarship cadet program. More than 6500 cadets have received this opportunity and work now on-board international fleets as officers. At NTC we stand for excellence. One of the ideas by including NTC into the project is that they can develop a specific WAPS training course which they can offer to the maritime sector.

### 6.4 *Other initiatives*

Several introduction courses are being made available to interested seafarers and maritime professional. Example of these training modules are offers by Marine Insight Academy [11] (online course), Enkhuizen Nautical College[12], - 3-day technical course reported as a reference course in the sector, according to a recent IWSA survey of small wind propulsion vessel segment [13] -, and the basic online training tool for safe and optimal operation developed by Crewind and made available on IMO's e-learning module page[14].

Worth mentioning are also in-depth training program introduced recently in France:

The French Maritime Academy (ENSM) newly launched 40 hours training program completing the online Crewind training module [15], consisting of Lectures and practical sessions, followed by practice on sailboats and demonstrators.

The Engineering School Centrale Nantes offers a certified training course [16] intended for naval engineers and architects, R&D personnel and professionals in the maritime and renewable energy sectors. The course consists of 3 training modules, over 15 days (105 hours). The training objectives are: based on a ship operation profile, defining performance specifications for the wind-assisted ship and drafting the technical specifications for the wind propulsion system; ensuring the technical integration of the wind propulsion system on the ship; and finally evaluating the predictive performance.

## 7 GENERIC WAPS COMPETENCE MATRIX

As introduced in section 5, the project WAPS-IT aims to support the development of a rapidly scalable international WAPS competence program for onboard and onshore personnel, enabling maximum safety and energy efficiency. Based on experience and insight from ship owners, operators, seafarers and WAPS system suppliers, the project will identify generic competence needs and requirements. This will form the basis to establish a competence matrix, which will serve to design training activities and course material, which will further be tested in the project. This matrix will also be the baseline for company specific training activities and hands-on system specific training on board.

### 7.1 *Competence needs and requirements*

Early experience with wind-assisted propulsion for merchant points out towards the following need for WAPS training and skills requirements for personnel:

Purpose of WAPS training:

- Understanding the principles of WAPS technology and how it interacts with the ship's propulsion system and navigation equipment.
- Being able to monitor and adjust the speed, direction and angle of the sails according to the wind conditions and the ship's course.
- Being able to perform routine maintenance and troubleshooting of the sails and their components.
- Being aware of the environmental benefits and limitations of WAPS technology, as well as the relevant regulations and standards for its use.
- Being able to communicate effectively with other crew members, port authorities and service providers regarding the operation, limitations and performance of the rotor sails.

By understanding these aspects, crew members can effectively integrate WAPS operations into the ship's overall operation, contributing to a safer, more efficient, and environmentally friendly voyage.

Skills requirements for personnel:

Based on experience from ship owners and system suppliers participating in the WAPS-IT project, the following competence and training needs and requirement for WAPS have been identified.

The crew of ships equipped with WAPS need to have a good understanding of:

- safety and optimization of utilizing the wind for propulsion of the ship
- different operation modes and control panel of the sails and be able to use them in various wind and navigational conditions.
- heeling moment and lateral force generated by the sails, and how they affect the ship's course, drift speed, and draft.
- maintenance and troubleshooting of the sails.
- plan the route and execute the voyage with due regard to the wind conditions, the restricted zones, the cross-track distance, and the overhead obstructions that may require lowering the sails.

### 7.2 *Holistic approach to maritime competence development for specific WAPS operations*

It is common to refer to a merchant marine vessel as an example of a "total institution" [17]. There is no division between work, leisure and sleep in such an institution, all activities take place on the same arena and in front of the same audience. A ship could thus be treated as a closed entity, the seafarers live in only few square meters and together with the same people month after month. "The seafarers themselves see the "ship society" as a deprived and secluded universe; a place which might leave you with a sense of being kept separate form real life" [18].

In other words, all the different parts on board constitutes together an entire universe, an intrinsic combination of technical and organizational elements. Phrased differently, an introduction of any new element on board should take the totality into consideration when it is installed.

For example, when the WAPS are installed on board a vessel, one should pay attention not solely to the effect the sails have on reduced fuel consumption, but also to factors as stability, comfort and maintenance. It might be so that some system providers in this field does not include this totality in their activities. They pay solely attention to their tool or their instrument's impact towards gas and fuel consumption, and not on the entire context the instrument is located in.

Such a holistic approach is also valid when competence is discussed. A useful method when it comes to competence requirements, is to apply a Human, Technological, Organizational (HTO) approach. HTO make use of a complexity of intertwined factors as individual work performance and competence, technological aspects and organizational elements. The methods to reveal these organizational areas goes through several solutions and approaches, everything from qualitative interviews, observations of work performances, surveys and literature reviews could be applied. After all, the competence discussed in this paper is linked to secure skilled seafarers and optimal utilisation of the WAPS systems, through training. The sail system provider can offer a digital solution in operation of the sail system, but when the aim is to establish an optimal use of the sails – to eventually have a skilled and experienced crew on board - training comes in a vast important activity.

This HTO approach is perfectly fitted to work on competence development. It ensures that both the seafarers onboard acquire the competence and skills needed to operate a WAPS vessel, and the land organization adjust their expectations and practices to support successful WAPS operations. On board, the crew must get used to actual operate a sail ship. This includes that the vessel has some degrees of heeling, it can cross up against the wind and they need to undergo maintenance operations during their time on board, as part of the daily operations. In general, WAPS operation include new task practices among the crew members, and some new relationships towards the land organization. It is highly important that the whole organization can understand and gain experience of what it means to operate WAPS vessel, since this is a "game changer" as one phrased it, to illustrate the genuinely new and the potential of optimal impact from training in this trade. To acquire necessary and relevant knowledge, through job performance and training, is crucial for the seafarers when facing the rapid expansion of WAPS solutions in the maritime sector.

## 8 CONCLUSIONS

WAPS systems are receiving increased interest as one of the solutions for reducing the environmental footprint of maritime transport. National and international requirements to emission reductions propose gradual reductions toward a net-zero society by 2050. To obtain maximum outcomes of all WAPS systems they should be used in an optimal way. Integration of wind – and hydrodynamic propulsion the WAPS suppliers are developing joint control systems. Despite this activity, it is important that seafarers operating WAPS ship have specific skills in tuning the combined propulsion systems for optimal efficiency, safety for cargo and crew as well as comfort for the crewmembers/passengers. It is important to involve seafarers with operational experience when competence requirements (knowledge and skills). In the WAPS-IT project, this is done by applying an holistic human-technology-organisation perspective when collecting, analysing and developing a WAPS specific competence matrix. From project participants and discussions with other stakeholder, a request for an international competence standard has been raised. Development of possible competence elements may follow a similar approach as used by the IMO Maritime Safety Committee (MSC) related to specific requirements for seafarers on ships powered by unconventional fuels. A close collaboration between IMO MSC and its sub-committee HTW would be similarly beneficial to speed up the process of introducing new WASP specific competence requirements into the revised STCW Convention.

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