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Report number	3
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Date realized	01-11-2020
Description of deliverable, copy from OMS	Research paper "WPT in operation" Rotor sails: putting a new spin on shipping? By David Newman Published in The Naval Architect, November 2020
Evidence material: ***Explanation: Think report produced, report of meeting, concept, service realized, findings of a meeting a presentation given, photo's.***	We uploaded the following documents • This deliverable template • Article

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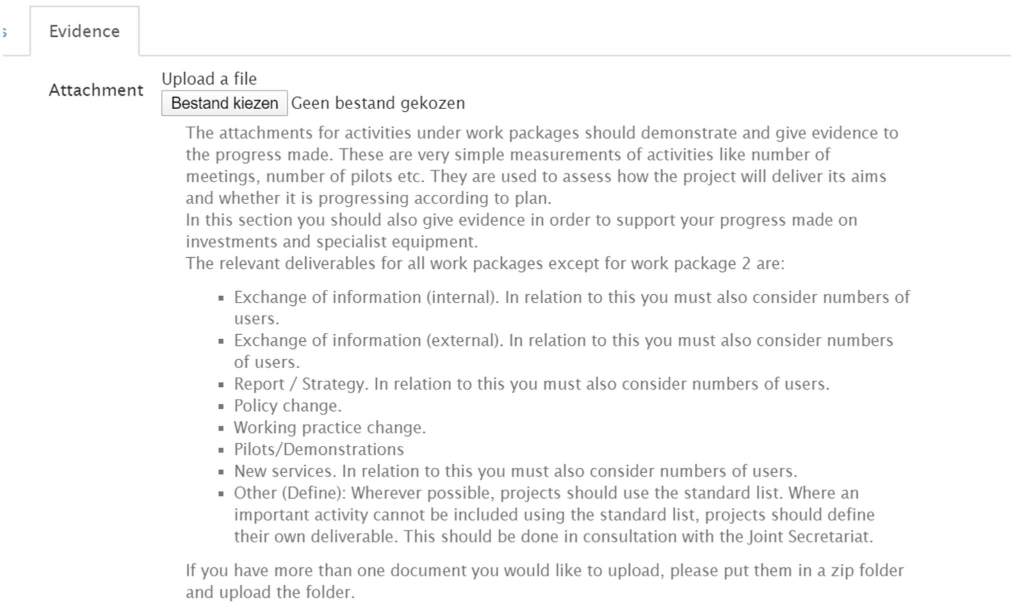
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The attachments for activities under work packages should demonstrate and give evidence to the progress made. These are very simple measurements of activities like number of meetings, number of pilots etc. They are used to assess how the project will deliver its aims and whether it is progressing according to plan.
In this section you should also give evidence in order to support your progress made on investments and specialist equipment.
The relevant deliverables for all work packages except for work package 2 are:

- Exchange of information (internal). In relation to this you must also consider numbers of users.
- Exchange of information (external). In relation to this you must also consider numbers of users.
- Report / Strategy. In relation to this you must also consider numbers of users.
- Policy change.
- Working practice change.
- Pilots/Demonstrations
- New services. In relation to this you must also consider numbers of users.
- Other (Define): Wherever possible, projects should use the standard list. Where an important activity cannot be included using the standard list, projects should define their own deliverable. This should be done in consultation with the Joint Secretariat.

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Rotor sails: putting a new spin on shipping?

In early March, an interview study with shipowners, technology providers and the crew of a rotor ship was performed to investigate the impact of wind propulsion on operations and crew and uncover clues to unlocking the full potential of this technology. David Newman reports on the findings

A number of wind devices have seen renewed interest in recent years due to their potential to future-proof vessels by considerably reducing fuel consumption, such as hard and soft sails, turbosails and kites. Rotor sails have been the most widespread solution so far, being now operational on seven vessels worldwide, with up to four rotors per vessel.

From the small cargo coaster, *Fehn Pollux*, to large vessels such as the 110,000dwt LR tanker, *Maersk Pelican* and 64,000dwt geared bulk carrier *MV Afros*, the rotor sail is establishing a reputation as a proven technology, offering reliable, simple, efficient and low-maintenance wind propulsion tailored to specific vessel needs. As one interviewee put it: "they are not rocket science".

Despite these advantages, the promising technology is held back by a policy landscape that continues to favour traditional fossil fuel propulsion and design choices which fail to recognise the human element in operation.

A master's student project was recently completed at the maritime consultancy SSPA Sweden AB as part of the Interreg North Sea Europe's project Wind-Assisted Ship Propulsion (WASP), investigating the state of the art in this sector's innovation and to gain insight into the human factors influencing their operation and performance.

What are rotor sails?

Developed in Germany by Anton Flettner in 1922, rotor sails are electrically powered rotating columns which exploit renewable wind energy using the Magnus Effect to provide forward propulsion to a vessel. The same effect used by a tennis player who 'slices' or 'curves' the ball by spinning it to change its trajectory can be applied to the sail which, when spinning, transfers perpendicular wind force into forward propulsion. The resulting auxiliary thrust reduces main engine fuel consumption.

Figure 1: *Viking Grace* was retrofitted with a rotor sail in 2018

Rotor sails saw a brief and limited deployment at sea when first invented but were swiftly made obsolete by cheap oil, seemingly dooming the device to the dustbin of failed maritime contraptions. However, we live in fast-changing and challenging times and Anton's long-forgotten device has re-emerged revamped for the digital age, to alleviate both the environmental impact of international shipping and the financial woes of unpredictable oil prices.

With proven fuel savings ranging between 300 and 920tonnes annually, rotor sails offer shipowners hundreds of thousands of dollars in savings each year and considerable reductions in carbon emissions and air pollutants. The technology is a potential co-solution for shipowners to meet coming regulations such as EEDI (and possibly EEXI) energy efficiency requirements while simultaneously lowering fuel spending. As stand-alone systems, rotor sails can be retrofitted easily onto existing vessels or integrated into the design of new builds.

Achieving self-sustaining innovation

Interviews with key shipowners and rotor sail manufacturers revealed an innovation trend in this blossoming sector. By analysing key innovation indicators centred around the creation and sharing of technical knowledge, a cyclical interaction was identified: (1) full-scale installations acquire funding, (2) creating valuable operational experience and learning by doing, (3) in-turn increasing the general awareness of rotor sails and raising shipowner expectations which, finally, (4) validates interest groups who lobby for more funding, and so on. The cyclical innovation loop is shown in Figure 2.

This cycle has been instrumental in the early uptake of the rotor sail but illustrates the sector's reliance on outside funding. To date, every rotor sail installation has received government subsidy in some form, confining the technology in a pre-commercial snare. Rotor sail manufacturers struggle to offer affordable payback times, or returns of investment, to operators of large vessels. Attractive returns on large vessels remain elusive because of the large overall fuel costs despite substantial absolute fuel savings.

Even hundreds of tonnes of fuel saved per year may only translate to a few percent of overall costs. For ro-pax, ro-ro and tankers, the payback period has not yet quite reached a 'sweet spot' of under five years. Anything under this and the short leases and high insurance fees on vessels make rotor sail capex unviable for shipowners. One solution to drive down payback times is to increase the fuel saving performance of rotor sails.

Ramping up performance with human factors

On a Monday morning, I arrived at Stockholm's Stadsgårdskajen terminal to interview the crew of the *M/S Viking Grace*, which has entered into a small but fast-growing group of vessels that hail a promising new trend in international shipping: the return of wind power. Since 2018, the 57,000gt luxury RoPax ferry has operated a single Norsepower rotor sail on its route between the Swedish capital and Turku, Finland via the complex Åland Archipelago. While the engine crew reported very little change in their tasks and no complaints, the navigators and Master provided special insight into rotor sail operation.

Many might assume that humans are designed out of rotor sail operation through automation, but this was found not to be true. Granted, all rotor sails do function automatically. Onboard or onshore software controls their speed and rotation direction to extract the maximum thrust available from the existing wind conditions, based on real-time data for wind speed and direction. But, decisions by the bridge crew about when to reduce main engine power are entirely manual and can greatly impact fuel saving performance.

If this is left unacknowledged, bridge crews will be frustrated by not being able to access fuel savings data or calculation methodologies which could help improve their understanding of the system and their navigational decisions. Giving the bridge the best possible information for their decision making is key to ensuring that rotor sails are used to their full potential while simultaneously reducing the burden of their already-demanding workload.

A myriad of quite simple solutions exist which can help to achieve this. Shipowner investment in high-quality, in-depth training ensures the crew's understanding of sailing to save fuel. Supporting this, proper design of user interfaces can instruct crew on how much main engine power can be reduced while maintaining speed. Such initiatives increase bridge crew motivation, as do the introduction of financial or competitive incentives for crews of vessels with low fuel consumption. Finally, improvements in communication between crew and technology providers is generally an invaluable measure to improve the usage of any automatic technology.

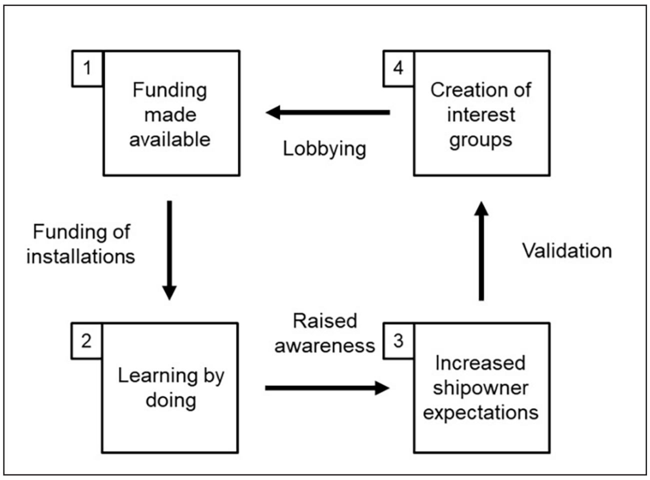

Figure 2: The cyclical innovation loop

These relatively simple measures are low-hanging fruit and should be adopted before further complex technological solutions are implemented, such as route optimisation. The stacking of ever more disjointed and fragmented systems atop one another risks harming usability and can result in misuse. A successful Fourth Industrial Revolution for shipping must rely on automated and smart technologies being transparent and integrated and human factor issues should be addressed first, before ever more complexity is introduced.

Towards zero-emission shipping

The IMO's target of 50% GHG emissions reduction by 2050 will help ensure that a catastrophic 2°C of warming is not reached. Despite the benefits of rotor sails, they alone cannot reach this target or meet the power demands of modern ocean-going vessels. To develop truly zero-carbon vessels, main propulsion using hydrogen or sustainable e-fuels to power fuel cells must be coupled with auxiliary thrust from wind systems and/or batteries. The European Parliament's recent decision to include shipping in the Emission Trading Scheme is an important signal that environmental regulation anticipated by shipowners will come into force. Carbon prices must now rise and marine fuel tax exemptions scrapped.

Rotor sails are already proven to cause immediate carbon emissions reductions and, with the right collaboration between actors and operational improvements in human factors, they can fill a technological niche between energy efficiency measures and expensive zero-emissions fuels. Access to such a solution, especially in developing countries, small island states and remote areas, will be key to international shipping tackling the climate crisis on a truly global scale.

It is hoped that this study will add to the growing effort to facilitate the transition of shipping towards a sustainable future in line with IMO strategy and Paris Agreement commitments. Analysis of rotor sail innovation trends showed that the length of return-of-investment periods prevents widespread uptake. One solution to drive down payback times is to increase fuel saving performance through the acknowledgement and understanding of human factors. By implementing in-depth training for bridge crews, improving the user interface and generally maintaining strong communication with crews, technology providers can maximise fuel savings to bring rotor sails closer to commercialisation and widespread uptake.

About the author

David Newman is a graduate of the MESPOM master's program, completing his thesis at Lund University in Environmental Science, Policy and Management, in collaboration with SSPA Sweden AB under the WASP project. He now works for the Zero Emissions Ship Technology Association (ZESTAs) and is compiling a compendium of regulations, standards and policies for zero-emission ship technologies. *NA*