The Arctic Tern: AI + Soft Values = Save Fuel

Lennart Cederberg, NoorCare AB, Norrköping/Sweden, Lennart.Cederberg@noorcare.se
Eleonor Marmefelt, NoorCare AB, Norrköping/Sweden, Eleonor.Marmefelt@noorcare.se
Jan Snöberg, Linnaeus University, Kalmar/Sweden, jan.snoberg@lnu.se

Abstract

This paper summaries three years of technical development and research in close collaboration with several major shipping companies. Besides the technical AI-based decision support systems, the project has focused on soft values, how the support systems become efficient support for real, both ashore and onboard. It is important to create knowledge among technical-, commercial- and operation-departments within the organisations on how to implement new methods. Different types of vessels operate under vastly different commercial realities that impact the performance and energy effectiveness. Technical systems must be adapted to each actor's reality to achieve a change and drive more climate-friendly transportation. The Arctic Tern shows fuel savings of 2-14%.

1. Introduction

This is not the first time a new and innovative tool within "Weather routing" is introduced. AI is an impressive and efficient technique to handle large amount of data, but it is neither the first nor the last. For instance, wave models were introduced in the early 1990s, with a significant impact on what became possible at that time. This was followed by naval architect-based ship models that relied on noon reports and could calculate the impact of winds, waves, and currents on ships in the 1990s and early 2000s, using the best technology available at that time. When new models and systems for calculating ship movements and parametric roll were introduced around the same time, many in the industry believed this would revolutionise the market.

The advancements in weather and ocean current forecasts over the past 30 years, where the accuracy of long-term forecasts has greatly improved, have been crucial for enabling today's applications that rely not only on current but also future winds, waves, ocean currents, ship movements, and more. However, despite these advancements, the perception persists, even in academia in 2023, that forecasts beyond +72 hours are hardly considered useful.

10-20 years ago, client-based onboard systems for route planning gained widespread popularity. Now, these systems are partially being replaced by many even better online-based apps and other functionalities that offer high-quality (sometimes even free) weather forecasts. The visualisation of weather forecasts has also played a significant role. This proliferation has contributed to the increased trust in the forecasts among users onboard ships who have access to these modern systems today. Rightfully so.

In the 2020s, AI-based systems are being introduced to better optimise short and long sea passages for individual vessels and entire fleets. Ship models based on ANN (Artificial Neural Networks) and supervised machine learning are utilised. These models which rely on robust sensor data from the ship, collected every minute or even every 10 seconds. This has proven to be a groundbreaking development, surpassing previous methods in terms of accuracy and efficiency.

However, introducing new tools is not just about technical aspects. It also involves building trust and understanding of what the new tools actually can do and what they cannot. A broader understanding is needed throughout the organisation or the entire chain of actors who are all affected. Users of these now transparent systems come from different departments with different roles and expertise, both within their own organisation and others. These soft values and communication certainly involve the onboard team, the navigational and the engineering officers. But also includes the entire technical, operational, and commercial departments of the shore organisation, sometimes with watertight compartments in between, as well as additional actors in the customer or logistics chain. No longer is it solely the Master's responsibility to find the silver bullet for this issue. Even within traditional shipowner and charterer organisations, it is common for technological advancements to not immediately resonate with all individuals or the entire organisation. Both technology and people may need time to adapt to the change. Timing is crucial.

Ten years ago, there were approximately 10 service providers in the traditional weather routing/optimisation field. Around 5 of these were more prominent in bidding processes with major shipping companies. Today, there are hundreds of system providers that, in one way or another, "optimise" what is considered best, often using AI, today's state-of-the-art technology. Soon to be replaced by something new and more advanced.

Notably, several of these early prominent traditional service providers in weather optimisation at sea seem to struggle with building something new. Likely because innovation takes a lot of time and effort while maintaining and operating the existing 24/7 service is a heavy daily workload. It is much easier for start-ups to emerge and deliver. However, when today's start-up companies grow and eventually face a major technological generational shift, they are likely to encounter the same challenge. Many have experienced this journey, and more will undoubtedly follow.

Introducing new technologies on the global maritime market is one of NoorCares' core business. By actively exploring and testing new ideas and methods from a pragmatic perspective, NoorCare identify what works. Being receptive and understanding even the unspoken needs, regularly engaging with our valuable network of +60 shipowners/operators in Europe and Asia, as well as partners and competitors, is the key. This approach has been our practice for over 30 years. Additionally, contributing to the education of new captains and engineers by showcasing the latest market developments and gaining a better understanding of what the next generation of seafarers truly needs and expects allows further contribution to the future of maritime industry. It is an iterative process, and NoorCare are certainly still learning.

2. Background

For three years, the research and development project, The Arctic Tern, (Swe: Tärna) has been focusing on route optimisation using Artificial Intelligence. The project has been carried out by a consortium consisting of NoorCare AB, Möller Data Workflow Systems AB (Molflow), Linnaeus University, and the Swedish Maritime Administration. The consortium has extensive experience in sea voyage optimisation, both in theory and practice, from the perspectives of both the ships and the shore organisations.

Four reputable shipping companies, headquartered in Europe and Asia, took active part with vessels in the project. Three of these companies have fleets of 50 ships or more and operate both short and long sea passages across the world's oceans, representing both liner service and tramp shipping.

Molflow´s route planning tool, Slipstream, were set up and run by the shipping companies and Linnaeus University. Slipstream utilises multiple neural networks to estimate the vessel's performance. The networks are trained on ship data logs in combination with state-of-the-art Met-Ocean data that is collected multiple times every day. Slipstream continuously monitors the vessel's condition, including hull condition, and provides updated and precise status information. It has global coverage and considers factors such as tidal currents and water depths. The system includes Digital Twins for each vessel, accessible to users through a graphical user interface or via API. The optimisation tool also incorporates performance monitoring, including biofouling.

Energy efficiency and reduced environmental impact of shipping is a fundamental part of our shared responsibility to contribute to a better life on our planet for future generations for a long time to come. The optimisation tool Slipstream is based on machine learning and unique solutions that can use significantly more details and parameters compared to the traditionally available tools that dominate the market. This enables a new way to frequently be updated on the optimal result of any operation or machine settings that is the best considering all small and large changes that occur during the voyage. This is especially important for shorter sea passages where the traditional and less precise tools are rarely useful or relevant.

Alongside with the technical development of the AI-based support system, a large part of the project has been focused on soft values and the challenges the traditional and commercial drivers in international shipping meet. The focus has been on ensuring that users understand how the new precision tools should be used, preferably in combination with other already existing systems. Within the Arctic Tern project NoorCare has trained both the teams on commercial ships and the land organisation on how to better use new data. People with long practical experience. The Arctic Tern project has also carried out practical experiments for aspiring ship officers to become better equipped for the increasing demand of energy efficient sea transport before they start their professional career. The Arctic Tern project shows how a transparent and precise tool can be used for the whole organisation to obtain energy-efficient sea transports, for shorter as well as longer voyages, with a reduced environmental impact. The NoorCare Advicory concept shows results of fuel savings/reduced emissions between 2-14%.

Table I: Fuel savings indicated in the The Arctic Tern project

Type of vessel	**Sea passage length**	**Fuel saving**
Liner service	1-2 days	10-13%
Liner service	2-6 days	2-4%
Liner service	10-14 days	10-14%
Crude oil tankers	+20 days	3-5%
Students experiments at The Maritime Academy (Liner service)	10-12 days	12-25%

3. Soft Values – Our strength in combination with AI

One of the most crucial aspects of succeeding in energy efficiency can be summarised as attitude and willingness. Add perseverance and you may reach or even exceed your goals. This applies not only to the personnel onboard but also to the entire shore organisation within a shipping company and the surrounding maritime cluster that influences the vessel's chartering and port logistics.

3.1. Introducing Innovation to the Maritime Industry - The devil is in the details

Artificial Neural Networks (ANN) with supervised deep learning, including a naval architect ship model, are, truth be told, a black box where it is not always clear why the results turn out as they do. You may accept the result, but not always fully understand. In some situations, you may understand more afterwards. That’s learning. With old technique, it was necessary to filter out a significant amount of data points before plotting a graph based on a few points only. Assuming a robust flow of data from sensors, AI can handle a large amount of data with multiple precision and efficiency, which is remarkable. Even so, it is crucial to understand the bigger picture and be able to distinguish significant information from trivial - from the customer´s perspective.

For a larger high consuming vessel on shorter sea passages, minor unplanned deviations, such as a half-hour engine stop, can easily disrupt the optimisation of a smooth shaft power and completely negate the intended fuel savings since they are of the same magnitude as what is needed to compensate for the lost half-hour or so. Similarly, a delay due to unexpected traffic congestion in a busy area like the Singapore Strait can have the same impact on the energy consumption. Also, such details as a large vessel requires time for acceleration and deceleration at the beginning and end of the sea passage will affect the detailed setting of the system. The squat effect in shallow water, all examples of things that were never an issue during longer deep-sea passages, can suddenly become highly relevant and sometimes decisive. On a longer sea passage, there is often enough time for things to even out before the vessel reaches its destination. This can also apply to the end of a long voyage when regular or daily monitoring requires more details towards the end of the passage to be accurate. It is a different perspective to consider more details and have the ambition to reduce unnecessary margins when appropriate. The handling of modern precision tools, therefore, differs from what many have learned over the years.

So even though with the new tools, decimals are handled to diligently save fuel and reduce emissions, suddenly something bigger can disrupt everything, such as a very poor weather forecast or diversion to a new destination. Or just a modified piece of information about when the berth that is being aimed for will be available.

3.2. Learning by Doing - Towards more Climate-Smart operations

Personnel onboard and ashore that use the result from an AI-based tool like Slipstream must be given the opportunity to understand the tool and critically review the results. They should be allowed to use it sensibly, experiment, and sometimes fail in order to learn. They should be able to feel involved in a larger process with a common direction. As a next step, based on the new experiences and conclusions, new Standard Operating Procedures (SOPs) can be established with the aim of finding the efficient method that best suits the specific organisation.

In the Artic Tern project, experienced captains occasionally discovered and questioned the results of Slipstream. For example, before a voyage with unusual draft/trim, Slipstream had never been trained on such extreme loading data and simply did not know how the ship would behave, despite being based on supervised deep learning and having a ship model in the background. On another occasion, a completely different ship was going to round South Africa for the first time. The digital twin, the model for this particular ship was not trained on the very long and high swell from abeam, resulting in the output not matching reality. In practice, the ship rolled more than what the untrained Slipstream had calculated, and the speed was consequently lower. In both cases, the model learned quickly after the first passage and new data from the sensors automatically trained the ANN. However, it was important for the project to prevent similar mistakes from happening again for any other ship at any other time. And there are some good methods to ensure that this never happens. But the truth is that the more reliable data you have, the better the results will be. The amount of reliable data is crucial.

But AI and machine learning can be so beautiful when they provide new detailed explanations and insights. For example, when the model helps discover and explain details in a specific ship's behaviour in varying wind and sea conditions from the stern. Behaviours that both the captain and an experienced marine meteorologist previously attributed to "perhaps some minor variation in the ocean current," due to a lack of better explanations. Or the example where it's finally possible to measure/quantify biofouling in a way that traditional methods based on noon reports and old-school mathematics have never quite succeeded in despite more than 20 years of work. But with good AI tools and reliable high-frequency data, this is suddenly achievable.

These and many other examples build genuine and solid trust in new detailed AI-based tools like Slipstream. When users gain trust in how the new precision tool works, they can more easily reduce their margins in a different and improved way compared to before. By transparently sharing this information throughout the organisation, the risk is distributed, whether it's either some excessive fuel saving or the just-in-time performance not being entirely perfect. In an encouraging and tolerant corporate culture, it becomes natural for the Master not to bear the entire responsibility alone. As is often still the case today.

3.3. The NoorCare Advisory concept

The NoorCare Advisory concept has been demonstrated and “tested” at numerous shipping companies, with the ambition to encourage more shipowners and charterers to find methods for operating in a more environmentally friendly manner that suit their specific needs. It is striking how significant the differences are between different shipping companies with the same types of ships and similar operating methods, depending on where they are in the process. Often, the realisation is that robust high-frequency data must first be generated before moving on to the next step. The International Maritime Organisation's latest global regulations regarding EEXI and CII, as well as the European Union's new ETS (Emission Trading System), which will be implemented in 2024, are all in line with the current transformative process for the entire industry. All opportunities and contributions that help society move towards even better energy efficiency and completely ceasing the release of carbon dioxide into the atmosphere are welcome. The expectations for the industry to deliver are increasing.

There are today thousands of vessels that still rely on traditional suppliers in weather routing. Many of them do so out of tradition, even though they often need only a small portion of the traditional and partly outdated concept. Many shipowners and charterers are also in a transition period, where they realise they would benefit from an upgrade of at least some of their used methods/ algorithms/ systems. But time is a valuable asset, and the market offers a wide range of options, and it is now harder than ever to distinguish between excellent and subpar providers and solutions.

3.4. The Shipping Industry's future decision-makers

Within the Arctic Tern project, three cohorts of students in the maritime captaincy program have been able to use Slipstream during a real-time project voyage between Gothenburg/Sweden and New York/US, during winter season.

It can be summarised that the system has provided good decision support on how to set the speed considering the current weather, forecasts, and the required ETA given to the students.

The students who frequently performed updated optimisations achieved the lowest fuel consumption and minimised environmental impact. It was also noted that the students who used Slipstream instead of solely relying on conventional methods based on available weather data were able to carry out the project voyage in a significantly more energy-efficient manner.

4. Conclusions

AI-based route optimisation systems with ANN and supervised machine learning for ships that have robust and high-frequency sensor data are a prerequisite for more detailed calculations/ optimisations of set values for speed and machinery.

These modern and much more precise tools for faster and easier decision-making regarding speed and engine settings for a particular vessel on a specific route with an unique loading condition are highly significant for the ability to operate ships more energy-efficiently and in a climate-smart manner on a broad scale.

Introducing these AI-based decision systems into shipping has significant similarities to the introduction of previous groundbreaking technologies over the past thirty years, primarily targeting the ship's captain.

The similarity lies in the fact that it takes time to build trust and understanding among users regarding what the new optimisation system can or cannot do. People need time to adjust.

The difference in introducing AI in the 2020s is that there are more people involved in the onshore organisation, and the systems today are more complex. Small changes during the sea passage can have a greater impact on the results when current margins and tolerances are streamlined.

The Arctic Tern project deliberately selected some vessels/companies that have commercial conditions that make it significantly more challenging to save fuel compared to many others.

1. Large container ships in liner service, on short sea passages of 2-6 days, in a part of the world where it is practically almost impossible to obtain a reliable berth slot time closer than 1-2 days in advance. During the same sea passage, the required ETA and thus speed can vary anywhere between maximum and min/eco speed, sometimes multiple times.
2. Crude oil tankers on the spot market, on long voyages for several weeks across the world's oceans, where the commercial aspect requires that speed and fuel consumption on a 24-hour basis are within very tight ranges. Therefore, it is almost never possible to optimise the entire sea passage.

Both examples illustrate different instances of "Hurry up and wait" behaviour deeply ingrained in the shipping companies because it is the best way to make money. At least it has been so far. Despite this, the project demonstrates fuel savings. Of course, the savings would have been even greater without these commercial realities.

Knowing when the berth at the destination port will become available already at commence of the sea passage (1) and replacing the outdated Charter Party contract system with a more transparent and reliable system that creates sufficient trust for both shipowners and charterers (2) are two things with enormous potential for significant energy efficiency improvements in maritime transportation.

It is also desirable to introduce more industry standards and common regulations that facilitate all service providers in creating and encouraging “proper behaviour" regarding overall energy efficiency and smoother traffic flow. This can facilitate better interaction between different systems and thereby reduce the number of stand-alone systems. It may involve the format of route exchange, class-approved methods for calculating ships' expected impacts on weather and traffic situations, common standards for acceptable safety levels or risks at sea, in the ports, and at the terminals etc. This may help ensure that the Safety-Environment-Economy requirements within the maritime and transportation sectors develop in a harmonious balance between feasibility and desirability.

Calculating and optimising a single sea passage and thereby contributing to smoothing out the traffic flow between Port A and Port B is relatively straightforward in this context, especially now in 2023 with systems based on the latest technology, including AI, Artificial Intelligence.

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