YRKESHÖGSKOLAN
NOVIA

Shall we be sailing again?

Sail Cargo – The future of Sail Shipping

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Bachelor's thesis

Degree Program, Sea Captain

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EXAMENSARBETE

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Titel: Framtid om segel lastfartyg

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Abstrakt

I det här arbetet ska jag studera framtiden för segelfartyg som transporterar last. Jag presenterar nuvarande segelfartyg projekt. Syftet med det här arbetet är att bekanta sig med den betydelsen av segel i modern sjöfart. Jag också berätta sig vilka tankar *Sail Cargo* -människor har.

Segel lastfartyget kan delas in i tre kategorier: segel hjälpkraft fartyg, hybrid-fartyg och rent segel fartyg. Segel hjälpkraft fartyg använder vindkraft för att minska maskin- och bränsleförbrukningen. Detta sparar pengar och utsläpp. Rent segelfartyg kan ha motor för hamn-, kanal- och nödstyrning. Det finns en handfull segel hjälpkraft fartyg medan hybrid fartyg bara väntar på imorgon. Det finns också en handfull rent segel lastfartyg som jag berätta om detta arbeta. Alla det är marginella projekt för sjöfarten, men de har ett starkt budskap: vår livsstil är ohållbar. Vi berövar oss, varandra och planeten. När allt kommer omkring, oavsett hur ren teknik används, åter dagens marknad vår planet och människan oundvikligen.

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Språk: Engelska Nyckelord: segel lastfartyg, ecoliner, hållbar utveckling i sjöfart

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OPINNÄYTETYÖ

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Tiivistelmä

Tässä työssä tutkin rahtia kuljettavien purjelaivojen tulevaisuutta ja esittelen olemassa olevia rahtipurjelaiva-projekteja. Työn tarkoitus on perehdyttää lukija ymmärtämään mikä osa purjevoimalla nykyajan merenkulussa on ja mitä ajatuksia *Sail Cargo* –ilmiön takana olevilla ihmisillä (ja projekteilla) on.

Rahtipurjealukset voidaan jakaa kolmeen kategoriaan: aputuulivoimalla kulkevat, hybridialukset sekä täysin purjevoimalla kulkevat alukset. Aputuulivoimalla kulkevat ja hybridialukset käyttävät purjepropulsiota polttoaineen tai konetehon tarpeen vähentämiseksi, kun taas täysin tuulen varassa kulkevissa aluksissa mahdollinen moottori on satama-, kanava tai muuta tilapäiskäyttöä varten. Aputuulivoimalla kulkevia installaatioita on tehty vajaa kourallinen olemassa oleviin ja nyt myös uusiin aluksiin. Suuremman koon hybridi-aluksia on suunniteltu pitkään (*Ecoliner*), mutta odottavat vielä huomispäivää saapumiselleen. Purjevoimaa pääasiallisena propulsionaan käyttäviä pieniä rahtialuksia on parisenkymmentä, mutta kaikki marginaalisia projekteja, jotka pyörivät lähinnä vapaaehtoisvoimin ja suuresta inspiraatiosta. Näillä projekteilla on kuitenkin suuri viesti maailmalle: elämämme on kestämätöntä ja riistämme sekä kotiplaneettaamme että toisiamme. Loppujen lopuksi ei ole väliä kuinka puhdas teknologia on käytössä, nykyinen systeemi syö vääjäämättä planeettamme ja ihmiset loppuun.

Kieli: Englanti Avainsanat: rahtipurjelaivat, kestävä kehitys, purjepropulsio

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BACHELOR'S THESIS

Author: Jasper Armanto
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Abstract

In this work, I take look into the future of sailing cargo ships and present current existing projects. The aim is to gain understanding on the motivations of sail cargo projects and people beyond, and the aspects that leads the future of the projects.

Sail cargo vessels divides into three categories: auxiliary wind propulsion vessels, hybrid vessels and pure sailing vessels. Auxiliary and hybrid vessels use motor accompanied with the sails for maintaining schedules, but gain benefit from the sails for fuel, emission and cost savings. Pure sailing vessels may have auxiliary engine for temporarily use for port or channel maneuvers, but trade otherwise using nearly only sails. Currently, there are a handful auxiliary wind propulsion vessels (both, retrofitted and soon about new builds), whereas hybrid vessels (like *Ecoliner*) has existed a while on a drawing board but none actually built yet. Pure sailing vessels are mainly small projects and they may sail because of there are lots enthusiasm and volunteer work involved, even though new sustainable business initiatives are born around these adventurous projects. There are a handful of these pure sailing cargo vessels today. Regardless their size, they carry a strong message beyond their cargo: our lifestyle is unsustainable, and we divest the life of our home planet and others far away. No matter how clean technology we have, the current system itself is destructive socially and to the planet.

Language: English Key words: sailing cargo, sustainable shipping, wind propulsion

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Thanks giving's

Thank you for all participants and involved parties to this research:

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He gave me a steel hull sailing boat 2016 that I have lived as my only home ever since; the boat, *s/y Fareata* and all the "businesses" related for surviving times without nearly any incomes, is one of the reasons why it took so long for me to conduct this work. I still have good debt to be paid.

Literally, during these years I have been dreaming about Sailing Cargo and alternative life at the Sea. This work has indeed given me a deep view and learning into the field, making the dream of Sailing Cargo possible for myself, and probably helping many others.

Family, thank you for being so great and many.

A-hoy, a Pirate Life for Me!

Jasper Armanto, 5.5.2019

~*~

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List of Abbreviators and Terms

CEO	Chief Executive Officer
EU	European Union
FAST	Future Automated Sail Technologies
IMO	International Maritime Organization
IWSA	International Windship Association
GDP	Gross Domestic Product
GHG	Greenhouse Gases (emissions)
LNG	Liquefied Natural Gas (“new” fossil fuel that has been adopted for lower emissions from ships. I.e. Passenger vessel Viking Grace uses LNG instead of traditional bunker oil)
m/v	motor vessel
MARPOL	International Convention for the Prevention of Pollution from Ships (short for Maritime Pollution)
s/v	sailing vessel
s/y	sailing yacht
SC	Sail Cargo / Sailing Cargo (vessel)
SCA	Sail Cargo Alliance
SGSA	Smart Green Shipping Alliance
SOLAS	International Convention for the Safety of Life At the Sea (adopted in 1914 for the first time)
STN	Sail Transport Network
TEU	Twenty-foot equivalent unit (size of a standard 20 ft. cargo container)
TOWT	Trans-Oceanic Wind Transport (Company)

List of Pictures

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1 Introduction

When I started my nautical education at Kotka 2011, my teachers told me to forget about the romance of sailing. Cargo carrying windjammers belonged to the history and storybooks. *"There are not a single sailing ships anymore*", they told, "*Seafaring is gone far from it.*"

In that belief I lived the start of my career, and my teachers were right: there are not many opportunities to sail for profession with cargo ships, is there? The only chances to sail for profession is to join a sail training yacht or a chartering company offering deluxe passages for passengers, like *Star Clippers* or *sail trainee yachts*. These ships are great to sail with, but they, however, have little to do with the ultimate need of seafaring: to trade goods over the high seas. Ecologically thinking it is logical to assume that products are shipped far away because it is hard to produce locally. Somewhat true, but there are little things in the game mixing this simplicity.

Modern seafaring is complex and complicated business tied tightly around with the roots of capitalism markets and greediness of human mind and corporations. Olli Tammilehto's study *The Tragedy of Transport - The Earth under Pressure from the Global Transport Net* (Tammilehto, 2008) opened my eyes on this and to the many severe impacts that our modern transportation chain has. This chain, where ships plays a huge role, sustains and creates many environmental as social problems in the global world. Most of the problems are hidden far beyond the eyes of whom the shipping chain serves the most.

In the preface of Tammilehto's study, the Finnish sailing cargo pioneer *s/v Estelle* (built 1922 in Germany) and her actions during 2000-century are presented as an example of an alternative approach to shipping and transportation culture. Estelle really had a strong message beyond her moves: for example, instead of bringing more stuff to the "*global North*", which is empowered by detriment the impoverishing "*global South*", Estelle transported supply materials and goods to impoverished countries rather than bringing stuff to where it is more than enough (opposing the global current material flow directions in the terms of tons). This is a sign how to equalize the increasing and severe "ecological dept.", which is for its part a reason for many global troubles, such as climate change, weather extremes, hunger & poverty, earth's deprivation and so on. The main importance of Tammilehto's study is here: it does not matter how clean

technology we have for transportation, the (capitalism market) system itself by its amounts and trade current flows still destructs the planet and sustains aforementioned problems. There must be a deep social for truly gaining a sustainable way of living. Economical need for continuously growing GDP is majorly destructive overall.

The most visible and loud-spoken problem in today's global world is, however, clearly the climate change and its impacts. This is maybe because it has become a very visible and real threat to all, not only to third world countries who mainly suffers the pay of global over-consuming in the first place. So, when talking about many parts of our transportation chain, it is the emissions and alternatives to fossil fuels that matters, which can be seen in increasing interest in alternative, emission-free fuels and propulsion means.

Sail propulsion, as a "clean" propulsion, have indeed lately being adopted by a few shipping companies, like shipping giant *Maersk* and *Viking Line* to mention a few (they use auxiliary sails called Rotor Sails for around 10 % of auxiliary propulsion power relief for the engines) (Worldmaritimenews 2018). There are also going on many attempts and studies on figuring out how efficiency on ships could be increased, sails propulsion used and what other means there are to achieve emission free shipping. One example of tomorrow's sailing cargo ships is nearly decade old designs of innovative looking hybrid-sailing ships as *Ecoliner* (see Picture 01 for similar design). I saw this kind of drawing 2013 as I was working on a German sailing vessel *Beluga II*. A mate showed the picture to me (he was in the shareholders team to decide about building the ship in the following weeks) and immediately I was inspired about sailing ship's comeback. However, they never build the ship that time, but the image of *Ecoliner* had stuck in my mind.

As a part, there are an increasing number of enthusiastic sailing cargo pioneers shipping goods over oceans completely or near completely under sail, within all the time matters they may have. Although all of them are small-scale projects, they do very important work showing the possibility of sailing cargo and the different baseline for transportation and life. Indeed, sailing cargo and ideas beyond them has spread a worldwide movement where increasing number of volunteers, people and seamen are joining in; and where new business models, researches and lifestyles are born.

The aim of this work is to present a few traditional and innovative sailing cargo projects that there are today and pay a look out to the future of them. I try to find answer to questions like: What motivations there are within the projects? What factors determine the future of these ships? Shall sailing /hybrid ships become common, and potentially by when? I also try to find threats that these projects may have.

I have gathered information by quality interviews, by an interview "questionnaire" on a Facebook group called "Sailing Cargo Club", and by google searches, webpages and through maritime news and articles. The ultimate aim is to create and affect to the future that is sustainable and where shipping chain is transformed from its current basis to serve the world equally stopping over consuming and destruction of the world and people.

Picture 01 – "Flag Ship of the Future", *Photo credit / permitted by Smart Green Shipping Alliance, Diane Gilpin, 22.3.2019*

1.1 Objective and research questions

The aim of the thesis is to introduce sailing cargo (SC) projects of today. I present a few innovative and traditional projects more detailed, as an example of current sailing cargo projects and their targets and aims. In the Appendix 1. I have listed a comprehensive list of all SC projects that I came across within the study. I found them over the internet searches, through maritime articles and news, or through a Facebook groups or SC agents. This list can be used i.e. as a reference for further studies or

looking for opportunities to work or volunteer for SC projects. This is an ideological study; I do not take a step into theory of sailing or technical solutions on the different sail technologies or rig systems.

I also wanted to figure out the future views of sailing cargo ships. I aimed to find answer to questions such: What motivations there are within the projects? What factors determine if sail propulsion or sail ships will become common in the near future (10...30 years)? Shall sailing/hybrid ships become common, and potentially by when? What threats and challenges SC projects/ pioneers have or have had?

1.2 Limitations and definitions

This research takes a look into SC projects that are: 1) pure sailing cargo projects, also those in rebuilding, new building or design side at the moment, 2) projects, associations and other related organizations that shares the vision and participate, develop or else how work with sailing cargo or auxiliary wind propulsion ships, and 3) projects including auxiliary or hybrid wind propulsion systems as wing-, kite- and Flettner Sail (Rotor sails).

I have excluded from the lookout all pure charter ships and clippers, if their primary mission is not on sail cargo. It is true that few of these type of trainee/charter tall ships have recently been into sailing cargo as well (and vice versa, many sail cargo vessels offer "trainee" or "shipmate" positions). In those cases, I have accounted them as a "sail cargo vessel" if I have had confident info on their cargo work, i.e. I have found them through a sailing cargo agent who have provided cargo for them, for example *s/y Bessie Ellen* on the list.

There are also a few charity cargo or other kind of supply sailing projects and very small-scale projects (sailing "cargo" boats); I consider them as "sailing cargo vessels" within the research; I have no size or area limits on this. However, due to many numbers of projects, I likely have not been able to count, list or present all projects there might be. My best regrets if I have missed one great SC project you might have had!

2 Theoretical background

2.1 Research method

I choose quality interviews as my primary investigating method for the future evaluating study. The Future study itself, as manner of an approach, is much complex and rather new scientific field (for example, the Finnish Future Research Centre was established under the University of Turku only as late as in 1992 (Heikkilä, 2014), nearly four hundred years after the University itself was established in 1640 (Utu). I do not take a deep step in the future studies at this point (since it may be very philosophical field of science), but clarify just a few factors about it in the Chapter 2.2 below.

2.2 Future Research

The approach that I look my topic is in Future Research, or Future Studies as it said sometimes. A closer look out is needed to clarify what is future research and what aims there is beyond, since this might not be obvious for most of us. I also have had to consult various sources to clarify myself what is Future Research, about its aims, methods and tools there are to use.

I also want to clarify these because many times the first reaction, when I have talked about my topic "Future of Sailing Cargo Ships", is a question that if I really believe that wind propulsion will be the future for shipping. However, that is not the question of my interest. Future research is active participating and affecting to the future (Heikkilä, 2014). Future research, as much of trying to predict changes, may instead be trying to find out the values beyond our actions, for example, or even trying to affect on these. Future researcher may think questions like "how to prepare for an expected future?", "what would be desirable future?", "what alternatives (future scenarios) there are for the case in investigation?" In this matter, I investigate values and actions that sail-cargo shipping pioneers have. The aim is to affect to the future of sailing cargo ships by presenting their ideas and projects.

Let's say one dreams about working on a sailing cargo vessel or wonders if he/she should invest in a project alike. This presentation may be out of great advantage in the case, or rise awareness of global issues beyond seafaring and transportation culture. Throughout the research, I have also gained an understanding and knowledge on the topic. These things support sail cargo pioneers to achieve great aims.

2.3 Interviews

I interviewed, consulted and discussed directly (phone) or indirectly (by email or online based interview) with 14 professionals on the field. There was SC project enthusiastics, researchers, company CEOs, captains, sail makers, boat builders and other personnel on the field involved. Some of them I contacted intentionally, but most of them responded my online interview questionnaire at the Facebook page "Sailing Cargo Club" without me knowing them beforehand. Yet I had few other more contacts with experts on the field, but due the dynamic represent of the (future) studies, I am not be able to present all of these encounters and their results in this study.

From these 14 interviews 2 was direct discussions with phone and Skype. The other one was with Tuomas Riski, CEO and founder of Norsepower, Rotor sails, Finland, clarifying the future aspects and use of auxiliary wind propulsion systems (Rotor Sails), made by phone 28th of March 2017. The other one was with Dr. Jonathan Köhler, a specialist in sustainable innovation in shipping, currently working in the Dual ports project (EU Interreg North Sea region). Part of the project intends to develop business cases for sail cargo ships and model a sailing cargo network at the North Sea region. European Regional Development Fund (from EU) funds Dual ports project. We made the interview by Skype 25th of February 2019. Since each interview was unique (like free chatting), it is difficult to present fully each response and questions on the outcome. Instead, I highlight the main points and important aspects popped out within the discussions.

I made the rest of the interviews by e-mail discussions and by Google Forms as an online interview. This was an effective solution since I found it hard to get replies on personal interview requests at one point requested by email in 2017. After presenting my research idea on the Sailing Cargo Club Facebook group, there was lot of instant

interest and I found it very effective to publish an online interview form straight away there that any member of the group could take part. There were nine instant replies to this inquiry interview.

The replies on the questionnaire and interviews was quality information rather than quantity. Therefore, I do not have statistics or tables based on any answers. Most of the questions was an "open words" instead of multiple choices – I used a few multiple choose question, but found them irrelevant at the end. The online form was open from 17th of October 2017 until 31.1.2019, but all replies was given 2017.

These kind of questions I asked on the online interviews:

- Name, title and professional experience
- What SC projects they were working with and their task within it?
- What motivations they personally have/had for working with SC project(s)?
- What challenges they have had/ have currently within their project?
- What threats they think SC could have in the future?
- Wild cards and weak signals?
- Evaluations to the future of SC in general

These persons / organizations participated to the interview, apart those who have not mentioned yet at the beginning of this Chapter:

- Baerbel Beuse / Captain, Master of general cargo and sailing ships, (project) Tres Hombres
- Alessia Rosetto / (project) Brigantes
- Alistair Chaplin / Sail designer
- Tobias Blome / Naval architect, (project) Brigantes, experience 10 years in IACS classification and freelancing engineering
- Charles Hardy / Founder of Solent Windship Trust
- Ron de Vos / Captain, Windschip Project
- Ville Linden / boat builder and yacht designer, (projects) Ceiba and others alike
- Sean Parsonage / Master Rigger and experienced mate on sailing ships over a decade, (projects) Topsail Rigging, Schooner Ruth, Tres Hombres, Avontuur, Sail Master B.V., Schooner Opal
- Jussi Mälkiä / Captain, owner and director of Meriaura Group

- Samuel Faucherre / (project) Hawila Project (personal communications and e-mail interview)
- Chris Kozak / (project) Greenheart Project NPO (e-mail interview)
- Diane Gilpin / Founder & CEO of Smart Green Shipping Alliance (e-mail interview)

Thank you very much all participants of giving your effort for the study!

2.4 Other information gathered

Beside interviews, I gathered information on the topic by reading maritime news, searching articles online and discussing with my maritime friends who are keen into sailing or sea transport logistics as well. However, I found most valuable source of information by numerous simple google searches and links that forwarded me scroll from page to page. I followed and discussed at the Sailing Cargo Club at Facebook and other groups. I studied carefully webpages like IWSA (International Wind Shipping Association), SCA (Sail Cargo Alliance) and Sail Transport Network (STN). I have gathered information on each project presented and listed in the Appendix 1 by their own webpages or articles if not other source mentioned.

2.5 The Problem itself

Sea Transportation is doubtlessly the most significant part global shipping chain. Approximate 90% of all stuff have been at the sea at some point of their supply chain (ICS) transported by somewhat 50.000 to nearly 94.000 ships at the world's oceans (UNCTAD, different sources give different numbers and the number depends on the calculation method. 90.000 ships refer often to IMO cargo ships size 100 GT and more). This massive transportation of stuff and energy sustains and creates several major problems, environmental and social, as described above (Tammilehto, 2008), the most visible problem in the global Northern society being the very loud spoken climate change. Energy production in all, emissions and propulsion power are in the centre of

maritime industry's discussions today, indeed, apart unmanned ships, safety issues and automatization.

Naturally, where problem arises, solutions soon appear. LNG, bio-oil, nuclear power, wind, ammonium, hydrogen, electricity, fuel cells, even wave propulsion (and maybe others I have not heard of) have adopted and tested to propel ships as "clean and emission-free" way. Wind propulsion is an interesting option that would potentially bring us close to zero emission ship while help in reducing fuel costs.

However, Tammilehto brings out in his study that no matter how clean means of energy source we have for transportation, the current complete transportation chain still serves major problems causing climate change and other problems related. In aim to achieve truly sustainable transportation link in the world, deeper social interaction need to change. Seaborne transport is already the most efficient and "clean" way of transporting stuff. The ultimate question is what we essentially need to transport, how and why – and for whom. The problem lies in the values and understanding that we base our business related and everyday actions (capitalism culture, markets system). As long as money and GDP growth matters (Gross domestic product), **even 100% technically "clean" ship will not be truly sustainable** (Tammilehto, 2008). The need for perpetual growth is simply non-sense goal since it is eating our planet. The whole system of capitalism markets must be overthrown to sustain liveable planet (Monbiot, 2019). Principles of defining welfare must change, or we need a few more planets to continue this ridiculous, primitive spoiling around. Yet it treats countries and people far away violating and unfairly. I present initiative sailing cargo projects as a response to this non-sense action against the bad sides of capitalism – they hold a spirit that would be wise to follow.

2.6 Previous and other researches on the topic

There are previous investigations and researches on sustainable shipping, rotor sail installation and use, kite sails, wing sails and other auxiliary wind propulsion systems and their capabilities. I searched studies with a few different keywords, such as "sailing

cargo ships", "rotor sail" and "wind propulsion" at Theseus Academic Database and on Google searches. Many relevant studies and reports of the capabilities of sail propulsion I came across also through scrolling sail cargo agents' webpages and reading articles about them online and through maritime communities such as Gcaptain. For example, to the previous, a headword "rotor sail" gave 25 hits on Theseus (date of search: 23.4.2019), where only a few of them were relevant for my topic. Peter Kindberg's Bachelor thesis, available at Theseus: Wind-powered auxiliary propulsion in cargo ships (Kindberg, 2015) provides information on auxiliary sail systems. This study discuss in a brilliant way of adopting auxiliary sails like Rotor Sails, Kite sails and DynaRig concepts and evaluates even a few routes (Helsinki to Rostock and London to Marseille) for sail cargo shipping. Where it is a good technical lookout to such sail shipping and shortly summaries the future possibilities for them, it does not present much of the ideologies beyond sail cargo movement or notice "pure sail cargo" vessels at all.

There are also ongoing studies and researches modelling on how sailing cargo ships could be established on today's logistic infrastructure. Such work is carried out currently at least by the DUAL Ports project at the North Sea region, funded by EU, where they i.e. create business cases for sail cargo ships in aim to build a sail cargo network around North Sea region, potentially preparing for a large-scale sail cargo demonstration also. Also, many companies and communities like Smart Green Shipping Alliance tests and demonstrates the use of auxiliary sails and hybrid ships for actual building or business purposes (case studies for their own projects or for publicity). International Windship Association (IWSA) hosts many researches from decades ago on the use and tests on different wind systems – a good reference "library" for further studies or technical findings.

3 Sailing cargo vessel types

Before we look into sailing cargo (SC) projects, it is good to clarify different types of sailing cargo ships. Because of simplifying the structure of my thesis, I have divided SC projects into three categories:

1) Innovative projects, which consists modern technology in the wind propulsion, mainly auxiliary wind- and hybrid ships;

2) Traditional projects, which are looking more like traditional sailing ships as brigands, schooners, barges etc., and which are many times small SC initiative companies, and;

3) Other projects, which includes very small projects like sailing cargo boats, charity vessels, associations, SC agents and other related projects.

3.1. Categories by IWSA

Sailing cargo vessels are often categorized by the theoretical capability of how much they get actual thrust power (or fuel savings) from the sails or the wind. International Wind-Ships Association (IWSA) presents four categories on this (Wind-ship, 2015):

1) Motorized ships, which are not using wind propulsion at all (regular ship type today),

2) Wind assisted motor ships, or auxiliary wind propulsion ships, having 10-30% of fuel savings due wind propulsion on annual basis (a few demonstrations seen as Rotor Sails and Kite Sails),

3) Hybrid Wind-Motor ships, which reach at least to 50% of fuel savings on annual basis (even reaching to 60-70% in favourable wind conditions) due use of the wind propulsion (if traditional rigging are excluded, not yet demonstrations seen; often designed on high technology and new build vessels), and

4) Pure Wind Cargo Vessel, which potentially have an auxiliary engine for port manoeuvres, channels or emergencies but use otherwise mainly wind propulsion or sails for main propulsion.

These four categories are widely used among the sail shipping community. The categories done by the fuel savings is logical, as it directly gives a reference on the savings on fuel costs and “saved” emissions. The matter actual sailed time (sails in use)

compared to total voyaging time or miles travelled is important when calculating the efficiency of the sails /rigging or for the maintenance cycles, for example.

3.2 Motorized ships

"Motorized ship" is the standard vessel of today. About 90.000 Ocean going vessels (UNCTAD, 2018) of today carries stuff around worldwide. Engines, propelled by steam at first, override sailing ships at the beginning of 20th century. Since engine's revolution of shipping, motors and oil have controlled the world's shipping fleet - with a price of heavy, invisible pollution and noise.

Energy efficiency, fuel savings and reduced emissions on motor ships have achieved by improving hull design, improving or changing fuel qualities, increasing capability of ships, developing engines into more energy efficient and by other modifications and to a limited extent of using renewable ancillary energy on board (wind-ship, 2015). Slow steaming, super slow steaming and improved weather routing have been operational options for getting costs and emissions down. Cargoes with not tied in tight time limits slow steaming especially has been common operational way of reducing fuel costs and emissions, making cargo ships to travel even slower than clipper back in the days. (for example, see McDermott, 2010). The ultimate superiority of motorized ships is their great ability to maintain good service speed and therefore sustain tight schedules.

3.3 Auxiliary wind propulsion ships

Ships using auxiliary wind propulsions systems can achieve up to 30% savings on fuel and emissions. Maybe the most known and further developed example of auxiliary wind propulsion systems is Norsepower's Rotor Sail (Flettner Sail). By the end of 2018, three large commercial ships (a tanker, passenger vessel and a general cargo vessel) were fitted with Norsepower's Rotor Sails, and few more are just about being here (Norsepower). It is well fair to say that Norsepower is the world-leader of auxiliary wind propulsion systems: there are not any other as straight full stories of any auxiliary

wind propulsion systems than what Norsepower has. The company was established only as late as 2012.

CEO of Norsepower, Mr. Riski estimated (personal communication, Riski, Tuomas 29.3.2017) that they could have a thousand ships using their Rotor sails before 2030 ("1000 sails fitted in 10 years"). If one sail delivers an annual mean propulsion of 500kW (as in route on estimated global mean winds), this would mean 500.000 kW (or more) installed sail auxiliary propulsions systems just by Norsepower only, Riski clarifies. This means a hundred or more ships per year from 2020 on. Payback with the two 18-meters high times 3 meters wide Rotor sails for *m/v Bore* was roughly 4 years when they installed the sails during 2014-2015. By the time today, Bore should be making financial benefit from the sails.

A few other companies have gone into retrofitting auxiliary wind propulsions onto cargo vessels as well. One of them is German company Skysails, which has developed tested high altitude flying Kite Sail a decade ago on a general cargo vessel *mv Beluga* and on a few other similar cargo vessels. Some sources say that they goaled the sail to be installed onto 400 ships by 2013 (see for example, NCTV7, 2015). Today Skysails presents 3 installed references (which one of them prototype) on their webpages, and a superyacht using their Skysails (Skysails). It seems there have been some problems with the system, maybe causing the sail to drop and so destroy the expensive canvas sail. This would make the system expensive and unreliable at ships propulsion use (see Chapter 4.2 for closer Skysail description).

Then there are Wing Sails, "windmill" rigs and potentially other wind propulsion systems that I am not yet aware. I do not have details on these technologies, since they are not demonstrated yet in commercial use (on a cargo vessel). However, Smart Green Shipping Alliance (SGSA) and its cooperation partners have plans on retrofitting some type of Wing Sails on an existing cargo ship. Now they are taking feasibility study on the retrofitting progress and/or the potential sail technology, and finding the materials for building the sails ("cost versus performance") (personal communication, Gilpin, Diane, 28.3.2019 by email). If the study shows green light, and the cost calculations are reasonable, commercial demonstration on Wing Sails as retrofitted on a Panamax size bulk vessel (Picture 02) could begin as soon as 2021 (SGSA).

According to Kinthaert, Diane Gilpin has estimated also that there are circa 15.000 ships with enough free deck space for retrofitting auxiliary sails that also operates in

windy enough areas. This is a very broad number, since not all ships will be suitable for wind propulsion – it depends on the area of operations (must be enough wind) and the ship type: container vessels who take all the deck space are not very suitable for retrofitting any type of auxiliary sails. Also, technical suitability does not mean itself commercial desire or political stimuli, Gilpin says in the interview (Kinthaert, 2017).

IWSA suggests that auxiliary wind propulsions systems potentially have other benefits also than only savings in fuel or reduced emissions: they potentially reduce wear and tear on the machinery, improve stability and reduce vibration (wind-ship).

Effective weather routeing are very important factor when steering vessel under auxiliary sails and planning routes. The area of normal operation and its prevailing winds are very important factor when determining if existing ship would benefit (and how much) from retrofitting auxiliary sails. Often sail providers will assist and make a case study for their customer about the suitability of the sail to the intended ship and route. Computers, wind analysts and other weather information, both forecasts and long-term wind charts all plays an increased role in ship handling when adding sail propulsion.

Picture 02. Panamax size Wing Sail retrofit bulk ship may be sailing soon. */Photo credit/permitted by: Smart Green Shipping Alliance, Diane Gilpin,* 22.3.2019

3.4 Hybrid ships

Hybrid ships combine the benefits from increased fuel and emission reductions while sustaining the good speed capabilities of engine ships. Hybrid ships allow good predictability on schedules and fuel savings can exes up to 60-70% (in favourable wind regions). Definition by IWSA, annual basis on fuel savings for hybrid ships are 50% or more (wind-ship). Good weather routeing and understanding the basics of sailing is an important factor when handling hybrid ships, but they do not necessity require additional crew because of automatic handling of sails is achievable.

IWSA have listed 11 companies/organizations developing or planning to build a hybrid wind ship, including organizations as Greenheart Project (Japan), B9 Shipping (Smart Green Shipping Alliance, UK), Vindskip /Lade AS ("hull-aerofoil ship", Norway) and Neoline. Almost all companies on this section develop or are interested in also additional alternatives for fossil- /emission-full fuels that would accompany with the wind propulsion system achieving a "full" emission-free energy solution.

The most typical image of a hybrid-wind ship is maybe ship type of similar to "*Ecoliner"* (see Picture 01 at the Chapter 01). Such ship design has existed nearly if not a decade by now (McadSustainableDesign, 2018). Still, there are not a hybrid ship alike in clear and well in building progress, even though there are a few different kinds of models developed by different parties for similar ship, as far as I am aware. When I asked about the initial building costs for a new build ship design like this, Gilpin said she hasn't made cost calculations for the new build, "fully optimized hybrid ship" since 2012 (personal communication, Gilpin, Diane, 28.3.2019 by email).

Doctor Koehler clarifies that the initial costs for new ship designs are always much higher that what would be building a conventional, "standard" type of ship. Combining this with the fact that nobody tested the new ship type in commercial use yet, it takes brave investors who trust in the technology and market demand. It would be a risk investment (personal communication, Dr. J. Koehler, 25.2.2019). Gilpin clarifies also that the new build is much more efficient than retrofitted, but "the market struggled to be brave enough to go straight to new build." Their next step is to do a retrofit for learning purposes and growing the market capability, which they are working for now.

The baseline for hybrid- and auxiliary wind ships often is that the service speed must remain competitive to motor ships (could mean anything from 12-14 knots to and

above, at least if slow steaming is considered). Computer based weather routing, instant and continuously updated voyage plan for weather routeing will play a major role in hybrid-wind ship handling. It has to be seen what kind of new standards these new designs may bring to training of Crew or safety regulations for sailing these ships, if they ever become real from the table.

3.5 Pure Sailing Vessels (+auxiliary engine as an option)

Pure sailing vessels use wind as their only main propulsion power. These vessels could reach nearly 100% emission and fuel free shipping only by using wind propulsion. However, their disadvantage - and the initial reason why they were replaced by motor ships in the first place more than a hundred years ago - is that they cannot compete in the service speed and manoeuvrability to motor ships. This is why it is easy to think that wind propulsions as *only* mean of propulsion will not replace completely engines in shipping ever. If sailing cargo ships become common, they will be hybrid ships. Only total destruction or lack of resources and technology, or similar reasons, could make some regions or groups depend only on the wind again.

However, there are at least a handful pure sail cargo vessels and organizations sailing cargo today under pure sails; and similar number of projects in the building or reconstruction progress. The most well-known sailing ship among the community, "the icon of the movement" as it fairly sounds, *s/v Tres Hombres* (Picture 03) have shipped cargo across Atlantic since 2009 (the company established 2007) – the last 10 years! She, and the company's other ship, *s/v Nordly*, have no engines at all (Tres Hombres). They occasionally need towing assistance in harbours or for mooring. They however may stay further at anchor, when they can make the passage 100% with sail propulsion "anchorage-to-anchorage". Leaving and arriving only by sails brings a pretty great and silent feeling for the taste of carrying cargo under sail; a deluxe shipping for those who appreciate clean transport and high passion for their products.

Since pure sailing cargo vessels have radical limits for service speed, it is very important factor that the shippers, cargo owners and other involved parties must comprehend closely. Often the variability of schedules is stated in the shipping documents and cargo contracts. Obviously, there is delivered only cargo that is not

essentially limited by delivery time. Weather routing and conditions are a key issue when planning routes and ports-of-calls.

Picture 03 - *S/v Nordlys* – this engineless cargo ship can carry up to 25 tons of goods and has carried cargo at the European and Atlantic waters over 10 years now. *Photo credit /permitted by:* @TresHombresShipping / Saskia Poelman 20.3.2019

4 Innovative projects

Innovative SC projects include auxiliary wind and hybrid ship projects. I give a few detailed presentations as an example of the movement that there is today for sailing cargo. See list of all projects reviewed for the thesis in the Appendix 1.

4.1 Norsepower / Rotor sail

I interviewed Norsepower's CEO Tuomas Riski 28.3.2017 on phone to get an idea of what the project and Rotor Sail is about. Even though the idea of Rotor Sail, or so-called Flettner rotor, is old (invited as early as in the 1920s), I had a little bit blurred idea what is the idea behind it. This chapter is to clarify the use of Rotor Sail on commercial shipping and the current fleet situation.

4.1.1 History of the Flettner Rotor

To make a long story short, Flettner rotor was invented and tested already in 1920's by **Anton Flettner**, where the name "Flettner sail" origins. Flettner sails was installed at least into two cargo vessels, Buckau and Barbara, both having successful sea trials at open waters like Mediterranean, cross Atlantic and at the North Sea. Both ships and their sea trials gave positive reviews by the ships' captains and in publicity, and the sails had operated without any problems even in storm rate winds (Gerke, 2012).

However, although the positive reviews, "the idea of 'unconventional sailing' was no commercial success and the concept was deemed inefficient compared to conventional fossil-fuel-powered naval vessels", Gerke writes. In 1930's the Flettner sails disappeared from the seas until wind power engineering company Enercon presented it again in shipping in the 21th century. Enercon installed four 27-meters high rotating spinning sails onto their ship *E-ship 1* in 2010. (Gerke, 2012). Apparently, E-ship 1 sails yet today with her Flettner sails, but I hardly found other ships using Flettner sails yet (there are some initiatives), any other than the world's leader in auxiliary wind propulsion power supplier, ships using Norsepower's Rotor Sails.

4.1.2 Rotor Sail Today

Soon later, or more precisely, between 2014-2015, Norsepower and Bore introduced first one, soon another rotor sail on Bore's general/roro cargo ship *mv Estraden* (Bore). NAPA has confirmed that these Rotor Sails help Estraden to reach 6,1 % fuel savings with the auxiliary 18 meters tall * 3 meters wide wind rotor sails (Norsepower). "(The Rotor sails) have the largest fuel saving of any efficiency technology NAPA has measured. We talk figures of Rotor Sails being effective 80% of sailing time, 460 kW average propulsion boost and 1,5MW peaking for 10% of the time", Jouni Salo from NAPA reports on Norsepower's webpages (Salo, 2016). The system had a payback time as estimated for Estraden circa 4 years, which depended naturally much on the oil price. The system was retrofitted without any off-hire costs during normal port visits.

In April 2018, Viking Line's **Viking Grace** was installed one Norsepower's Rotor Sail size of 24*4m, making her the first passenger/cruise vessel in the world using the innovation. The LNG ferry will save by the Rotor Sail on annual basis circa 900 tons of carbon emissions and 300 tons of LNG fuel as estimated (Norsepower).

August 2018 one of the biggest shipping company in the world, **Maersk Tankers**, installed two Rotor Sails of the size 30*5m on their 245 meters long, over 100.000 tons of dwt tanker vessel Maersk Pelican (Norsepower). She is the largest vessel where Rotor Sails have been installed, but more is coming. Two 24*4m Rotor Sails will be installed onto Viking Line's new build vessel in Xiamen Shipbuilding Industry Co shipyard in China (planned delivery 2020).

"If the market catches up, there could be 1000 ships using auxiliary wind propulsion in 10 years", Riski said in the interview 2017 (personal communication, 28.3.2017). That means a hundred new Rotor sail ships (or other wind propulsion system) per a year, or more (I suppose there won't be a few hundred new auxiliary wind ships in the following two or three years?). With the high global demand in reducing GHG and sulphur emissions, and interest in fuel cost savings, it's however possible that we will see these kinds of innovations spread in the following years even though other emission free fuels are keenly investigated also.

Riski summaries that whether auxiliary sails will become common or not, it depends on the fuel price. "Companies have strong demand on reducing costs and environmental impact, and since we offer them both, they will invest in the wind propulsion systems, where Rotor Sails is the most viable and salutary solution currently", Riski says. Payback time will of course be considered, but if it remains reasonable (4-5 years roughly in the global mean winds), Rotor Sail is a win-win situation. Maintenance costs are minimal or non-existing, since only minimal or none maintenance are needed. Another option is that fuel prices get so down that it is not practical to invest in auxiliary propulsion. This can happen i.e. by finding so cheap and easily accessible methods on producing bio-oil on a large scale. "Of course, I'd be very happy to see that happen – a breakthrough of 100% emission free fuel", Riski continues. "But the prices for any clean fuels are extremely high yet today."

Riski sees in auxiliary wind propulsion systems a megatrend: CO2 neutral shipping on demand, after installation Rotor Sails will save reasonable amount of costs and consumption of fuel. Yet Rotor Sail fits even perfectly to autonomous ships since these sails does not need any crew – they are fully automatized.

The only critics I've came across towards installation of auxiliary sails is who pays the installation, if the vessel is time-chartered, let's say for 3 or 5 years, and operator pays

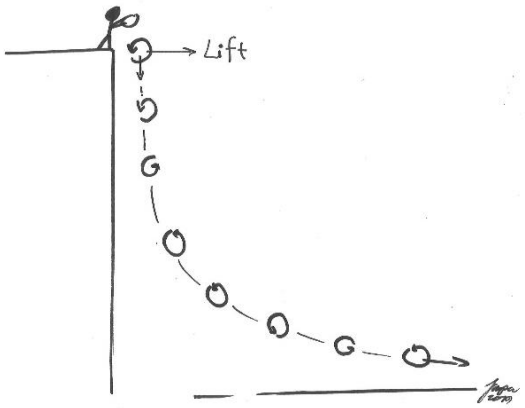
the fuel. What level of interest there is for each party to retrofit a vessel with auxiliary propulsion in that situation?

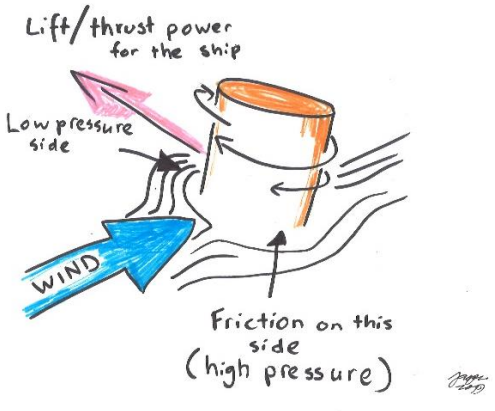
4.1.3 How does it work

I shortly clarify the principle of Rotor Sail just to make clear that there is no misunderstandings: there is a tall spinning cylinder, powered by electricity, which by its movement creates a thin air current around its surface while it rotates around its axis. While the cylinder rotates in a wind flow, it creates under pressure on the other side of the cylinder and over pressure on the other side, just like conventional sails. This creates a (forward) thrust power for the ship. The phenomenon is called “Magnus effect”, and it is exactly the same thing that you see when a rotating ball flies along a curve instead of a straight line, or why would you see a basketball curving heavily when dropped rotating from high altitude (see picture 04. You can also search “Magnus effect” on internet to see the principle in action).

The power needed to rotate the cylinder is very little compared to the power that is achieved from the use of it and the power for rotating can be get from the engines exhaust gas steam turbines, for example, as in Enercon’s *E-Ship 1* (Gerke, 2012).

The sail is useable in any wind conditions but not to dead ahead or stern, being most effective in the side winds. Compared to conventional sails, Rotor Sails need much less “sail area” to produce equivalent thrust power for the vessel, and it does not need any additional crew or training for handling. There is no safety hazard risk such as with conventional sails, i.e. sails jamming in rising winds. Rotor Sail can even be installed on a foldable basis, and it needs only little free deck space for installation.





Picture 04 – The Magnus Effect on a basketball that is dropped with a spin (the picture is not in a real scale) and the same effect producing thrust force for ships when applied to Flettner rotor on a side wind. *Photo credit: Jasper Armanto, 9.5.2019*

4.2 High altitude Towing Kite sail

SkySails Marine, part of the company group SkySails Group Gmbh, based in Germany, has developed and tested high altitude wind towing kites to reduce emissions and fuel costs for ships. The company was established 2001 for developing high altitude towing kite sails, so the idea of high-altitude sails is rather old-&-tested in this sense.

Skysails made their first commercial pilot installation of the system on a vessel *MV Michael A*, operated and owned by The Wessel Shipping Company in German, in 2007. The same company's vessel *MV Theseus* tested and apparently uses the system today (Skysails Marine). According to Konrad (and many other sources), m/v Beluga Skysails tested the Skysails system also in 2008 (Konrad, 2010). Today Skysails presents 3 installed systems on commercial ships, even though somewhat 10 years ago they targeted for 400 installed system on ships by 2013 (ship-technology). They have tested and used the system also on a super yacht (Skysails Yacht).

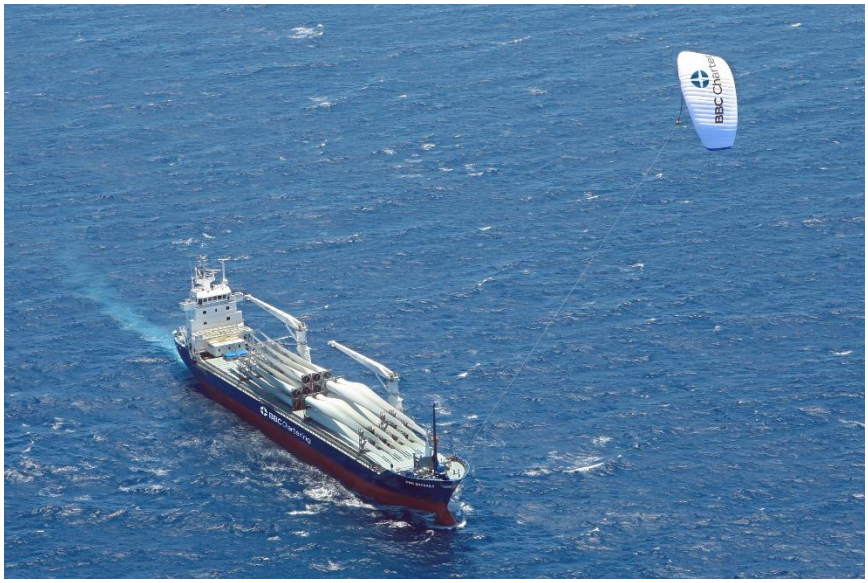
There apparently have been problems with the technology itself. The issue likely was that a minor thing with the sail – fast enough reaction to sudden changes in wind had major consequences. If the sail was by any reason mistakenly dropped to the sea, it easily destroys the complete, expensive sails and the use of it (personal communication, Riski, Tuomas, 30.3.2017, email). This would make the system unreliable and expensive, even though chances for dropping or destroying the sail were minimal. I tried to contact the company for an interview, but did not get any kind of contact or replies on my email in 2017. Later I found on Wikipedia that the company had economic difficulties during that time. Today, they responded my inquiry authorizing me to use their media photos for the work.

Skysails is not the only company that has developed highflying kite sails. At least one another company has developed kite sails in California, as early as in 1978, having successful sea trials on tugs or such vessels. Unfortunately, they were not able to bring the solution under commercial interest (Konrad, 2010). According to Riski, the

investment to the Skysails technology was about 40M EUR, meaning that if Skysails were not able to bring the technology into commercial interest at this point, it sounds that nobody else is going to do it either, not very soon at least.

How does it work?

Skysail's kite sail flies at the altitude high from 100 to 300 meters (picture 05). The sail area as tested has been about 160 square meters to 320 square meters. It takes 10 to 20 minutes to launch / recover the sail, and trained crew are needed to operate the sail. Once the sail flies, it forms a tilted figure 8 form in the sky by her movement. The Officer of the Watch can monitor the sail on a control panel, even though the system is much automatized. Stowing the sail takes only little space. While the sail is most efficient on dead downwind sailing, it can be used on the courses as much as 50 degrees upwind. Retrofitting on foredeck is possible with little installation devices. There is foldable recovery mast for the launching and recovery procedure. Depending on the route, Skysails estimated ships having 10 to 25% savings by using the system.



Picture 05 – Skysails' high-altitude towing Kite sail is old idea tested also on ships, on versatile success. *Photo credit /permitted by: © SkySails Group GmbH /19.3.2019*

4.3 Vindskip, “Aerofoil hull Sail”

Known as a “hull sail”, company Lade AS (Norway) has designed an aerofoil hybrid ship that uses her hull as a wing acting as an auxiliary wind propulsion - a Vindskip ship. This innovative concept is also member of IWSA, like other presented SC projects. The company was established 2010 to develop the project Vindskip. The company holds an international patent (2012) for using ship’s hull as an aerofoil. The company is now offering the licences under sale for ship owners and other interested parties for building an aerofoil ship (Lade AS).

The company estimates the ship having 60% savings on fuel and 80% savings on emissions (this design using LNG as her engine fuel). The ship would have dynamic weather routing data in the system updated every day, which would make weather routing easier. It would suggest on each waypoint the optimal course to steer according the forecasted and prevailing weather conditions and destination.

By the date now, there are no news about these kind of ships in building progress or in sailing. Designs like Vindskip (and others above) are a sign that designers, companies and developers are trying to find out a way to take benefit out of the wind and any other resources there might be available surrounded by us.

4.4 The Greenheart Project

The Greenheart Project, established in 2005, is a Japanese non-profit organization developing a small eco-coaster sailing hybrid ship. The target is to replace some old fuel-burning ships and ferries at the ocean archipelagos and coastal waters, yet the ships made for long-term ocean worth for multiple possible operation targets. “Millions of people worldwide are trapped in poverty, due in part to their inability to access the benefits of large-scale, modern global shipping, the superhighway of global trade. Whether from lack of capital, insufficient market size, poor location, or lack of deep-water ports, the seas that once represented infinite freedom and opportunity for coastal communities have increasingly become an isolating barrier”, Greenheart writes on their webpage (Greenheart).

The design is open source, available for everyone, which mean several customized designs may appear of the same ship type for different needs. The original design is beachable, her A-like standing rig is foldable and designed to act as a cargo crane while loading / discharging and the ship can hold up to 2 TEU containers and 18 passengers. The motivation of Greenheart Project, among creating sustainable shipping, is to improve standards of living, protect environment, connect coastal communities and preserve the cultural traditions of coastal communities.

Unfortunately, examining the webpages of The Greenheart Project I found out that the most recent activity and news are from June 2015. Their Facebook page have regular activity, but only sharing posts from other parties - no news of their own project. Most of my emails and contact requests got no replied, even though 2017 Chris Kozak who said he was from The Greenheart Project NPO, answered my inquiry for the general interview online at the Facebook Group called Sail Cargo Club. However, although the scheme today seems laid down for projects like this, projects like Greenheart holds something inspirational.

4.5 Tomorrows hybrid ships and rigging concepts

Getting back to “traditional, but renewed -looking” sailing ships, a few companies and organizations have developed and designed ships that use innovative, but comparable looking rigs to traditional square-sail rigs. Maybe the most known example is Dyna-Rig, which became familiar by a mega yacht *Maltese Falcon*.

4.5.1 Dynarig

Originally, DynaRig was idealised already at 1960s as potential fuel saving solution for large commercial vessels by Wilhelm Prölss. He was doing research on how different sail systems could be used on commercial ships, and found DynaRig being as much as twice that efficient than conventional rigs (Thomas, 2015). Prölss believed already that time that DynaRig could act as propulsion power for ships in the coming energy crisis. However, despite the idea got far in reviews and planning, no actual Dynarig was ever build that time.

In 2000 century a team of engineers and designers blew some fire for the idea and put the solution under test by building the rig for a new build super sailing yacht Maltese Falcon. Dykstra Naval architects designed and installed the “Falcon Rig” much like and based on the original Dynarig concept. Ever since the superyacht has proven the DynaRig being fantastic, easy handling and a safe solution for large yachts. The masts are free standing; rotating and one man through control panels can operate the sails.

A small number of companies have come up with plans for ships using the Dynarig or other rig concept for additional propulsion power (hybrid ships). One example of them is *Ecoliner*, a cargo windjammer, whose original designers (clients) I was unable to reach or confirm.

4.5.2 Hybrid designs sailing tomorrow?

At least Smart Green Shipping Alliance (Picture 01 at the Chapter 01) and Quadriga sustainable shipping project (Nextgeneration-cargo) have such ship design on the table. Gcaptain reported 2017 that Quadriga project intends to build the world’s largest sailing cargo vessel in the world, a car carrier of having capability to carry even up to 2,000 cars. The 170 meters long Quadriga would have four Dynarig-like masts, and Lloyd's Register has signed on it to ensure the compliance of the project (Gcaptain, 2017). That is a big step further, since one of the biggest challenges after the financial difficulties, according to many sailing cargo operators that I interviewed online, have exactly been registering issues and legal recognition of the new ship type.

Latest news on similar project comes from French automaker Renault. Schuler from Gcaptain reported in late November 2018, that the company has planned to construct two wind-propelled roro-type of hybrid vessels as early as next year – 2020. The vessels will be constructed in cooperation with a French sailing cargo shipping start-up Neoline (Schuler, 2018). Neoline is a start-up company founded in 2015, and they have a strong goal: become the world’s first ship owner specialized in sail cargo shipping. I do not know if this rigging system has a specific name yet – some kind of standing rigging and traditional sails it has anyway, developed by Neoline (picture 06).

Picture 06 – Neoline and Renault plans to build two 136-meters long vehicle carriers in 2020-2021. *Photo credit /permitted by: © Mauric, Vincent Seguin 19.3.2019 and © Neoline, Benedicte Enaux 18.3.2019*

Neoline's and Renault's plan is to construct two 136 meters long vehicle vessels as a pilot project. These ships would be fitted with 4,200 square meters of sail area, on a rigging concept developed by Neoline. Later they would continue with more wind-powered ships. The motivation on both sides lies clearly in reducing the environmental impact that shipping has.

Köhler said in the interview (personal communication, Dr Köhler, 25.2.2019), that the challenge in large scale of any type of rigged vessels are that they need to fit to the commercial standard ports. Even if cranes fit well in between (if rigging is not used as a crane), there is a bare risk of damaging the valuable rigging, which would become costly and make the rig unsafe and unusable. This would potentially make loading and discharging slower. Neoline's and Renaults vision of a roll-on/roll-off vessel would not have this problem, since the rigging does not prevent the loading ramp from standard type operation of loading or discharging cars and vehicles - a great deal for demonstrating sail hybrid vessels.

Another problem with these rig concepts is that they require very strong attachment points for the rigging on the deck. On a bulk or general cargo vessels, where cargo holds must be openable very close to the points where the extra deck strength and construction is needed, this becomes a slight problem for the construction and designing. (personal communication, Dr Köhler, 25.2.2019).

5 Traditional projects

In this Chapter, I present a few small projects that looks more like traditional sailing ships or vessels. They all carry cargo over the high seas with great enthusiasm and passion to sail cargo shipping. If the most visible target of large projects like hybrid ship designs is to reduce emissions and operational costs, these small projects carry rather a strong message of the fierce impacts of the global shipping infrastructure that goods in the large shipping terms. See Appendix 1 for list of projects that I have come through within the research.

5.1 Tres Hombres Shipping

Tres Hombres is a Netherlands based shipping company currently running two engineless cargo ships, *s/v Tres Hombres* and *s/v Nordlys*. The company was established 2007 by three captains, friends who "saw the beauty and power of great sailing ships that use only the wind as a means of propulsion". They decided to create the world's first "modern, emission free shipping company" (Treshombres).

Their ships Nordlys and Tres Hombres can carry up to 25 tons and 45 tons of general cargoes (see picture 07 for s/y Tres Hombres next page). Their very typical cargo they transport cross Atlantic or within coastal waters are cacao, chocolate, coffee, beans, rum, wine, beer, olive oil, honey, salted caramel and so on, but basically anything that can be loaded up to boxes or barrels can be shipped. They have shipped 10 years cargo "99% emission free" by today with the power of the wind, for the sake of illustrating that sailing cargo is yet possible in the modern world.

Their motivation in addition sustainable transport lies in a work for a peaceful and healthy planet. They spread alternatives and information, act as responsible players, seek that things are produced in an organic and fair way, locally under the "law of limited competition". One of the important aspects for *Tres Hombres Shipping* Company, like to many other similar companies is that the cargo they carry is equally fair trade, organic and sustainable produced.

Little fair-trade producers easily have also interest in shipping their items by the power of the wind, making their products 100% ecological from start to consumer (see for example the story by Allen, 2008). Making it niche, I found out in the questionnaires (Chapter 7.3) a story that one client (from similar company to Tres Hombres) would every time drive his car hundreds of miles to the coast where the ship discharged her cargo, just to buy their sail-labelled organic products, meaning all the emission-free effort for transporting lose the "real environmental value", but apparently the *beer never tasted so pure & good!*.

Captain Baerbel Beuse, master on general cargo ships and sailing ships clarified me about the challenges (questionnaire, 2017) that these small sail cargo pioneers may have: "A company like Fairtransport (Tres Hombres Shipping today, writers note) can only survive because there is a lot of enthusiasm, good will and voluntary work involved." The ship can take very limited amounts of cargo (Tres Hombres equivalents to one 20ft container), loading and discharging takes lot of time and people, which is uneconomic. "If you want to pay fair wages for all personnel involved, the prices for the transport will rocket to the sky", Beuse writes.

Picture 07 – Engineless cargo ship Tres Hombres. She is the "icon of the modern sailing cargo" movement. She has sailing cargo the past ten years only by sails. *Photo credit /permitted by: © TresHombresShipping, 20.3.2019*

5.2 Okeanos Foundation for The Sea

Okeanos Foundation for The Sea is inspiring wind-powered social entrepreneur company. They work at the Pacific Ocean to *"empower Pacific Island people to implement traditionally based sustainable sea transportation to ensure independence, cultural revival and ocean stewardship.*" All this they do with their 15 Vakas, ocean-going sailing canoes, and with 1 solar electric catamaran. While they take care of some transportation needs of passengers and cargoes at remote and distant islands at the Pacific, they also play a role at disaster areas bringing medicines, water, clothes and other urgent supply to islands that have suffered destruction from natural disasters.

Their two types of sailing canoes, Vaka Moana and Vaka Motu (picture 08) are both ocean going double hull sailing canoes. One vessel can carry 3 to 4 tons of cargo, 8 to 16 passengers and the vessels have also engine and water makers systems (essential at disaster areas especially), some of the engines compatible to run with coconut oil. Solar panels and batteries take care of the electrical needs and some of the vessels can be

propelled 4 knots also with the electrical batteries in case of wind and sun are both gone. They have carried cargo under their Vaka sailing canoes over a decade by today (Okeanos, 2019).

Picture 08 – Okeanos sailing cargo/passenger canoe Vaka Motu. *Photo Credit / permitted by: © Okeanos Foundation for the Sea / Tina Baumgartner 20.3.2019*

5.3 Ceiba / Sailcargo inc.

Sailcargo inc. is "freshly emerging freight company", which are here "to make a name in the sustainable transportation market." Inspired by Tres Hombres Shipping, Sailcargo inc. is currently building their first ship, *S/V Ceiba* at a jungle dockyard at the coast of Costa Rica. They estimate to start sea trials for this new build vessel at 2021 (see picture 09 for rendered image of the upcoming ship). As a notice to former Finnish boat builders, the design of *Ceiba* is based on the Finnish three masted square-topsail rigged schooner vessel **Ingrid** (sailcargo).

The company's focus is not only environmental; they are developing an innovative, assertive business model. Their homeport and dock yard being in west coast of Costa Rica is a cognizant choice: the emission free freight vessel Ceiba fits perfectly to Costa Rica's country-wide carbon neutrality plan: Costa Rica aims to be total country-wide carbon neutral by the same year than the vessel is planned to launch. Furthermore, Costa Rica's Pacific Coast offers a good location along the many routes from North to South America and Pacific Islands, and is reachable close to even the Caribbean Sea. Sailcargo inc. has "created" a route, The Pacific Exchange Line (*the PAX Line*), just

designed especially for their newly-coming vessel (Sailcargo). Sailcargo inc. seems to have a strong, emerging, innovative yet sustainable business building around the idea of sailing cargo. Ceiba will be able to load 250 tons of cargo (equal to nine TEUs) and she will be fitted with an electric engine. All energy needed for the engine (auxiliary propulsion) are planned 100% renewably sourced (sailcargo). The company estimates that at the end of the building 250 people have worked on the ship.

Picture 09 – s/v Ceiba will be ready-to-go in 2021 built at the jungle coast of Costa Rica. The rendered image of the coming vessel is a design by DVS Marine Design. *Photo credits /permitted by: DVS Marine Design /Pepijn van Schaik 21.03.2019*

5.4 Brigantes, Timbercoast and Grayhound Lugger Sailing

"*A step back to move forward*", is written on the front page of Brigantes homepages. Sometimes this saying is true: Brigantes is a project of reconstructing 1911 built old sail freighter (former names *Meta* and *Onice*) back to sail shape and sail cargo between Mediterranean Sea and Caribbean. The vessel was originally built in Germany, and during her life she has seen a lot of changes, survived world wars and removal of her rigging transforming her to a motor vessel only, now being reformed back to sailing vessel and continue the past task of sailing vessels: to sail cargo.

In 2016 an enthusiastic group found her foreboding, bad-looking hull, but after a close inspection by a naval engineer, they figured out she was worth of saving and making a

living cargo ship. That fitted perfectly to their plans of joining the newly emerging sailing cargo movement (Brigantes).

Brigantes is about 30 meters long and will be capable of carrying approx. 220 tons of cargo (see picture 10 for the reconstruction of the ship). Like many other sail cargo ships (likewise former mentioned *Ceiba*), she will have self-produced electricity for auxiliary electric engines to use when wind is not available. The company estimated that the vessel would be launched May 2019 and go for Maiden Voyage 2020 (yet they are posting online pictures of the last ongoing hull frame work). Her sister ship *Eye of the Wind* is one of the most known sailing vessels in the world and *"look much like Brigantes will as she will be ready"* (Brigantes).

"The luxury of today's *'efficiency'* in modern maritime transport is unfortunately achieved only by allowing significant environmental degradation. Marine fuels (heavy oils) are extremely toxic. On land, they are considered hazardous waste and would require expensive and complicated disposal treatment", Brigantes writes on their webpages as a motivation to move into cleaner propulsions (Brigantes).

Furthermore, Brigantes, likewise brotherhood SC companies Timbercoast, Greyhound Lugger Sailing, Towt (Trans-Oceanic Wind Transport) and others are not only moving cargo from place to another: they do also sell and label their products (products they are shipping), forwarding them to suppliers and raising the imago of sail shipped products. They, for example, arrange product tasting events on board where everybody may participate and buy their wine.

Timbercoast with their reconstructed vessel Avontuur, and a family business Greyhound Lugger Sailing with their traditionally own-build vessel Grayhound Lugger, have both been sailing cargo nearly if not completely since the last decade. These vessels are quite similar in size than what Brigantes and Tres Hombres are. While family-based Grayhound Lugger Sailing sails much at the English Channel and European waters (Grayhoundluggersailing), Avontuur has scheduled across Atlantic voyages between Europe and Caribbean (Timbercoast). Shipmates (paying crew /trainees) are a common way to increase the income of the vessel among many of these small sail cargo shippers. Luxury cargo with luxury vessels, I would say! See more details on these projects at the Appendix 1.

Picture 10 – This is how Brigantes, an inspirational, yet fine and hard-working sailing cargo project have started (the vessel in the front). They have scheduled to launch the reconstructed vessel at the end of May, 2019, while Maiden Voyage scheduled for 2020. *Photo Credits /permitted by: Courtesy of Brigantes, / Daniel Kravina, 21.03.2019*

5.5 Hawila Project

Hawila Project is a non-profit organization based in Copenhagen, Denmark. The organization was founded 2014 after a group of friends found a disrepaired vessel *Hawila* being left on Copenhagen harbour. The owner donated this useless and costly vessel to the newly created organization. Maybe he saw the potential of the young group to "*trade, education and culture under sail*"? (Hawila Project).

I met the founders of the Hawila Project by coincidence at the Viapor's dockyard at Sveaborg (Suomenlinna, Suomenlinnan telakka), Helsinki in Finland 2015. They had come to Finland to learn and consult about refitting of their over 80-years old Hawila, since the vessel was very similar to the ones in the Sveaborg dockyard: traditional, old, culture heritage, former Baltic trader and similar new builds. I had great discussions with them about the idea of sail cargo; one thing that made me keen into sailing cargo projects. The truth is, if I did not have a boat to reconstruct and live my own (and the Sea Captain Maritime school still on the way), I would likely have joined a project like this.

After a few years of refitting Hawila and sea trials, the ship went on her maiden voyage 2017. They offer placements for enthusiastic people who are eager to learn and experience the culture on the ship. In 2018, Hawila sailed to Estonia for European Ecovillage Conference where they hosted workshops and offered the ship for accommodation. This year, 2019, they are rounding at the Baltic and North Sea (around Kattegat region) hosting a circus collective *Acting For Climate*, which will present a circus show on board spreading a word about Climate Change (Hawila Project).

The main vision of Hawila Project, as written on their webpages, is to bridge coastal communities, serve as educational platform, spread information about the issues of globalization and the challenge of current food system, and to transport local products by sail. Volunteers power the organization, and even though they yet have not carried much of physical cargo (as far as I know), they talk about it and support the idea fully (for example, Hawila Project is one of the founders of Sailing Cargo Alliance). They carry culture and ideas that has a valuable message for the global human community: we must change the way we live and exhibit culture. Human being and his civilization culture are spoiling our liveable hoods, environment and ourselves (Hawila Project).

Picture 11 – s/v Hawila – Trade, education, Culture. *Hawila Project (2017), Samuel Faucherre, 08.05.2019*

5.6 Sailing vessel KWAI

Sailing vessel Kwai has operated with her current area at the Pacific Ocean since 2006. Kwai is old, 43-meters long, 179 tons carrying German build sailing vessel. She requires min. 8 crew whereas she can accommodate 11. Her current operation area is from Hawaii to Cook Islands and islands of Kiribati (i.e. the Christmas Island). They make about 3-4 round-trips per year, depending on the destinations of the trips. One

turn-round trip from Honolulu to Cook Islands and back is usually 6 to 7 weeks, while round trip to Kiribati 4+ months (svkwai).

Kwai seems to have the longest practical experience in the "modern sail cargo fleet" of those vessels I have presented. They describe their motivation as follows: "the main goal of this project is voyaging on the high seas. The present service is a packet vessel between Hawaii and the Cook Islands, which offers excellent year round sailing across the trade winds in both directions. Adventure travellers and the crew immerse themselves in life at the sea, sharing the opportunity to learn seamanship, navigation, rigging and ship and small boat handling. A round trip schedule of two to three months will allow for half of the time at sea and half of the time in port or at anchor. The ocean passages are memorable, but so are relaxed stops at very remote islands." (svkwai).

"A powerful sailing ship, driven in part by the free energy of the wind, dependent only on nature and the resources she carries aboard is not only a work of art and beauty; she is a proven, economical vehicle of transportation where fuel is expensive and often scarce. Our sails are our subsidy, while the ship rides the waves in the timeless tradition of her pedigree." (svkwai).

"For centuries these islands were supplied by infrequent ships arriving to sell their cargoes to the local inhabitants. Even in these modern times, many of the small islands on our route are still not supplied on a regular basis. With approval and support from the local governments and island councils, we provide a comprehensive service. We deliver ordered cargoes from the least expensive sources in Hawaii, and charge a purchasing fee and freight on all goods. Within the Line and Cook Islands we carry local cargoes outbound from Christmas Island or Rarotonga and return with copra, frozen fish, and other island products and carry up to 60 passengers on deck under a big awning tent." (svkwai).

6 SC agents and other projects

This chapter presents a few SC agents and their missions. Such projects are Trans-Oceanic Wind Transport (TOWT) Company; International Wind-shipping Alliance (IWSA); Sailing Cargo Alliance (SCA); DUAL Ports Project; Charity and other SC Projects.

6.1 TOWT

TOWT (Trans-Oceanic Wind Transport) is a French company started in 2014 (Towt). Their mission is to bring the sail propulsion for the future, and for this aim they work on several ways: they for instance connect sailing cargo ships and cargo delivers that are enthusiastic to deliver their products under sail. The company has created an ANEMOS label for products that they prompt for SC shippers. Their labelling creates positive, fine, elegant and desirable image of sail shipped products. For example, through your ANEMOS code one can trace the product's history and origin, maybe even stories behind the products travel.

On yearly basis TOWT have cooperated with more or less with 3 to 5 small scale sailing cargo ships like Grayhound Luggers and Avontuur for example. TOWT have established five different "sailing cargo routes", delivered 400 tons of products by 48000 sailed miles and estimated to save 185 tons of CO2. Furthermore, they are conducting a research for constructing a new type of working tall ship - much like the other small hybrid sail cargo ships (Towt).

New Dawn Trader is another SC agent providing Sail Shipped products. They have their own label as well and they work together with the Sail Cargo Alliance (SCA). They have filled cargo holds for i.e. Tres Hombres and Avontuur (Timbercoast) and regularly organize SC festivals and products prompt events (newdawntraders).

6.2 IWSA

International Windship Association (IWSA) is an international, non-profit association "to promote the use of wind propulsion in commercial shipping to reduce fuel consumption and decrease climate change related emissions" (IWSA).

IWSA has nearly 60 members and over 50 supporters, all of them providing the future for sailing cargo ships. IWSA hosts a research centre webpage providing studies on sail cargo ships and on the use of wind propulsion. IWSA organize and attends to maritime conferences & events, evaluates and estimates the market potentiality for sail/hybrid

ships and offers technology & design consultation. Overall, IWSA is a large organization providing information and bringing together all parties in the development of wind ship sector shaping “industry and government attitudes and policies.” Among three other agents, Tuomas Riski from Norsepower is sitting in the Executive Committee of IWSA (IWSA).

6.3 Dual Ports Project

Dual Ports Project is a North Sea region’s development project started in 2015, currently continuing until 2021. The main objective is in promoting “resource efficiency and stimulate the adoption of new products, services and processes to reduce the environmental footprint of regions around the North Sea” (Dualports). One of their aims is to decarbonise regional entrepreneurial ports while they have several ongoing projects to reach their many aims. Two of their 15 individual pilot projects are directly Sail Cargo related where they target to promote sail cargo shipping. The project SAIL develops a wind cargo platform, and the project SAIL CARGO TESTING demonstrates operation of a sail cargo vessel combining wind and hydrogen. There are seven organizations collaborating Dual Ports within these projects, one of them Port of Oostende as a key node for sail cargo ships and others as Fair Winds Trust and Celtic Cruises offering knowledge and expertise on sustainable shipping. Dual Ports have received 3.4 mills of euro support from EU funds.

The idea of the SAIL project is to create sail cargo hubs in small ports and harbours which gives local businesses access to ethically transported goods around the North Sea region. The aim is to make ethical equation with a zero-emission low-impact cargo ship. Here sails seem just the best available, existing solution (combined with zero-emission fuels as hydrogen) for demonstrating zero-emission ship. “My interest is how to bring new, sustainable technologies and ways of doing things in transportation, including ships”, Dr Köhler says, a naval architect designer and specialist in sustainable innovation in shipping, currently working for the project (personal communication, 25.2.2019). Köhler is working at the moment, among all, for building up a cost accounting tool for assessment of costs and prices for SC ships and their operations. Finding cargoes and ports for SC ships helps the shippers to create Sail Cargo business models, which is one of the targets of Dual Ports.

Dual Ports Sail Cargo testing project highlights on their webpage that “although transporting goods by sail can reduce both carbon and costs, there are currently no SC concrete projects which are achieving this.” Köhler explains that this is because they once tried to contact Sailing Cargo Alliance people, but having little success with them at the end. “SCA people turned out that time, unfortunately, to be too much unorganized in a way that they could not provide exact data and calculations of their business cases, cargoes, ships maintenance /refit costs and others in time”, Köhler says. This made the cooperation difficult for Dual Ports, since they needed some real estimations on things. Köhler confirmed me that now they have two Excel-calculation sheets from two different sources, and currently they are supporting financially at least one refit of an old sail cargo vessel (personal communication, 25.2.2019).

This vessel, *s/v Lo Entropy*, intends to start a sail cargo business at the North Sea region, which goes well along with the targets of Dual Ports Project: “to get some sail cargo ships at the North Sea”. From scrap metal self-made vessel, Lo Entropy has been sailing cargo and doing chartering business at different regions of the world more than a decade before, as chartering in Africa, but low price of oil made the business “hard times to survive” that time. Now the vessel will be modified transforming the diesel engine to run by hydrogen and updating cargo spaces and passenger quarters. Lo Entropy originally was designed to carry 50 tons of cargo and was built by its current owners (Loentropy).

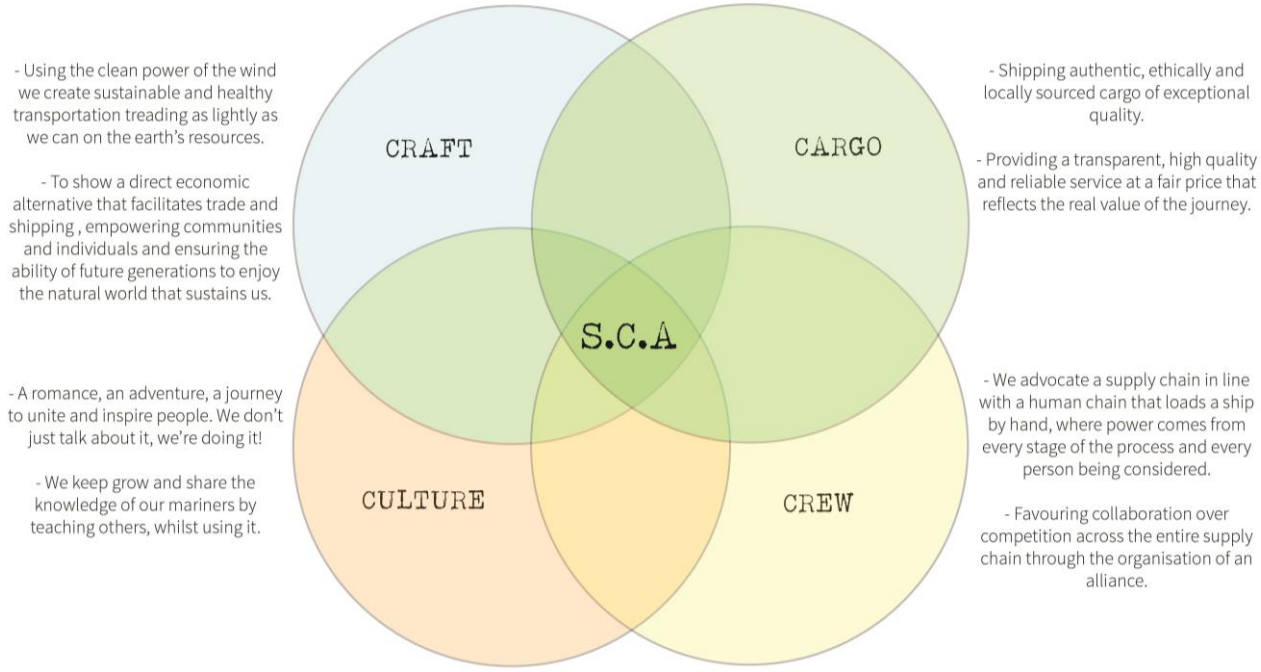
Picture 12 – Lo Entropy – Working with the wind. This vessel is part of Dual Ports Project to creating a sail cargo network at the North Sea, and her engine will be

modified and test to run by hydrogen. *Photo Credit /permitted by: Geoff Boerne, 15.04.2019*

6.4 Sail Cargo Alliance (SCA)

Sail Cargo Alliance (SCA) is "an alliance of organizations who share a passion for sail-shipped cargo, working together with shared ethics to create a healthy transport culture that promotes the preservation of the environment for the future generations" (SCA). SCA recognizes four core ideas they are working for: cargo, craft (sailing ships), culture and crew (community) (see picture 13).

Sailing Cargo Alliance appreciates cargo that is ethically and locally sources of exceptional quality. Their ships facilitate a direct economic alternative for trade, empowering communities and individuals ensuring future generations to enjoy the natural world that sustains. Crew means everybody from farmer to sailor and to vendor, and where "power comes from every stage of the progress and every people being involved". Transparent, high quality and reliable service with fair prices that reflects the real value of the journey are their core values. 15 separate, individual organizations in all form the Sail Cargo Alliance (as represented on their webpage 1.4.2019), including agents as Tres Hombres Shipping, Towt, Timbercoast, New Dawn Traders, Grayhound Luggers Sailing, Brigantes, Hawila and many others. Sail Cargo Alliance was formed around 2017 (referring to the starting date of their Facebook page).



Picture 13 – Values of Sail Cargo Alliance. *Photo Credit / Permitted by: Sail Cargo Alliance, Alexandra Geldenhuys, 24.04.2019*

6.5 Charity Vessels, sailing boats and others

There are an uncounted number of other minor scale SC projects around the world. I was not able to count or list each single one since reliable information was many times difficult to reach, i.e. I did not find webpages of projects I had heard of or there was lack of information. In addition, since I kept searching information I found continuously more and more projects to check out (until the last day of writing the thesis). Due the limits of the research, there was always something new happening on the field that eventually it become impossible to list any further projects. Here is just some examples of the many other sail cargo projects that there are.

Let us start from the historic vessel *Vega*, a charity vessel sailing at Indonesian waters. She is 120 years old sailing vessel and has been carrying donated supply cargo from 15 to 20 tons, such as tools, educational materials and medical supplies to remote locations at the Indonesian and Pacific waters (sailvega). They say "we are not out to change the world. All we want to do, in our own small way, is to help others in a manner that makes a real difference." All her crew is volunteer.

Sea Mercy operates another charity sailing vessel, *s /v Sea Bridge One* (seamercy). Aegean Sailing Cargo Project then again sets their third season on demonstrating sailboat cargo trade at the Mediterranean Sea, more closely at the Aegean archipelago between somewhat 18 Greek islands (sailmed). They are a project formed by Sail Transport Network and Sail Med.

Schooner Apollonia on her side trades local goods at the Hudson River with a schooner Apollonia (schoonerapollonia). Sailing barque Belem has shipped wine for a French wine company, because of a demand from the cargo owner (Allen, 2008). Vermont Sail Freight Project might be sailing something at the U.S., alike The Salish Sea Trading Cooperative at Seattle and Dragonfly Sail Transport Co at Michigan, according to Sailingdogs (sailindog). Did you know that *Falls of Clyde* is the oldest remaining sail-driven oil tanker vessel? Now she is struggling to keep up her life (Hannan, 2018). Elegant schooner Ruth (schoonerruth) and the Sail Trade Company at the east coast of U.S. have a story to tell about sail cargo as well (sailtrade). Number of small-scale SC ship designs are out there waiting for enthusiastic builders and operators, such as El Nino clipper, GoSailCargo's electric clipper designs (3 different sizes from 33 feet to 100 feet) and Schormanns Maritime 2-masted schooner designs capable of carrying even up to 24 TEU (IWSA). A Finnish boat designer Ville Linden has also designed a sustainable cargo schooner for sustainable trading initiatives as his bachelor thesis work at the Southampton Solent University, much reminding the case of Ceiba. Voyage Vert is something to look up for inspirational sail passenger vessels reforming the way passengers to travel over oceans (voyagevert). Yet I heard about a sailing cargo initiative project in Africa recently on a Facebook post.

Overall, there are many small-scale projects and bigger plans idealising the return of sailing cargo ships and changing the world into better trade form. Nearly invariably, all of them value emissions free, clean, and sustainable means of transporting, social aspects and environment as intrinsic value. Fair trade or organic produced cargo is important value for many traders as well.

7 Questionnaire outcomes

Another aim of the research was to find out motivations beyond the people working on the field, and threats and challenges their projects have met.

7.1 Motivations - Why sail cargo?

Ultimately, the future of sailing cargo would lead to the question "Why by sail?" Where wind propulsion is an alternative to clean fuels and propulsion methods, I got these kind of answers in the questionnaire replies through the Facebook group Sailing Cargo Club 2017:

- It is environmental friendly, good to promote niche cargoes like fair trade products.
- less environmental impact, cultural heritage, blue jobs
- overall cost (becomes cheaper), once cost of external fuels are included (assuming fuel prices remain high / increase)
- save fuel and money
- existing, well proven technology
- predictable of costs since wind isn't subject to the vagaries of the market
- pollution free or minimal, ethically responsible
- to reduce CO2 emissions (plus the fact that oil is not going to be any cheaper in the future)
- Publicity (to spread information and build momentum for clean shipping), at this point the (initiative) projects are too small to have a real impact on the environment, especially when our clientele drives their SUV an hour to buy an over-prized bottle of rum.
- Long term, Global emissions reduction.
- The market need to ship products (raw materials and finished products) 4 times around the world even CO2 free does not make sense any other context than monetary
- free, non-polluting and unlimited energy available
- Build a community looking for greener future
- Sustainable way of transporting stuff

- The great image of sailing ships sailing again

In addition, personal motivations to work with SC project was asked. There came reasons as

- enthusiasm
- I believe it must be done
- I want to help build a sustainable future and believe there's a potential for huge technology to transfer from yachting to shipping
- Why not - an adventure brought me here
- Something I am passionate about and want to do my bit in invoking change in the way of (general) thinking
- Because traditional vessels are close to my heart
- Reach emission reduction needs of ship transport
- I believe in the most of the ideologies the movement represents. Of course reducing emissions, but also diversifying the power control over shipping worldwide. The monopoly over international shipping is getting increasingly narrower. Unfortunately, a lot of environmental minded legislation demands ship design and operational changes that only the largest companies can achieve.
- Be actor of an environmental change, inspire others do the same, all this while sailing
- Reduce Co2 emissions dramatically in shipping.
- Climate change is the most important issue facing the planet. Divesting from fossil fuels and switching to 100% renewable energy is an important goal in reducing our impact to the environment

TOWT presents four main motivations to ship by sail: reduction in the use of fossil fuels, preservation of the climate change, a new transparent transport sector and reintroduce the use of working sailing vessel. They continue presenting their own Smart Sailing Cargo Ship: "(The Sailing Cargo vessel is) an alternative to the very polluting conventional cargo ships that is reliant, inexpensive, profitable and commercially viable in an eco-responsible and carbon-free approach."

IWSA underlines their mission as promote wind propulsion (in commercial shipping) to reduce fuel consumption and decrease climate change related emissions. SGSA pops

out the IMO 2050 commitment. They say, “This means that new ships operating today, which have a typical 30-year lifetime, must work in a zero-emission world”. SCA is then again created around shared passion for SC shipping, working for healthy transport culture and preserving environment for the future generations (SCA).

7.2 Threats & Challenges

How about what threats there are to sail cargo? These types of answers I got:

- limited space of cargo
- it takes lot of time and people for loading and unloading
- uneconomic, if you want to pay fair wages for all personnel involved the prices for the transport will rocket they sky
- “A company like Fairtransport can only survive because there is a lot of enthusiasm, good will and voluntary work involved”.
- ignorance
- split incentive of current charter model
- lack of motivation if the regulatory doesn’t force action
- impact of climate change can be dangerous (changing long term wind patterns, extreme weathers)
- not competitive against efficiency of containerised ships
- maritime industry itself
- Currently, shareholder’s greed in oil industry and societies addiction to crude oil slows down alternative energy innovations.
- In the future, capability to invent new technologies to power the ships is the limitation
- governments seeking economic growth above all else
- indifference to most markets as where their products come from and reluctance of most people to make a change until its painfully too late
- slow legislation makes changes more difficult
- Climate change could modify drastically the ancestral wind patterns
- relying only to the wind is unreliable
- too tight schedules and high running speed needed

- I worked as a Captain on one SC cargo vessel (name hidden), where the idea of ecology went a bit too much over safety limits. I like the idea of Green things as well, but none should sail in the middle of night without radar ending up in the middle of a windmill farm just if using radar is not considered as a green act. The ideology is good but how to reveal them in the action safely and rationally? There are lot of volunteers which is nice and good (the community is very good) but maybe only the Captain and 1st Officer being paid. The level of professionalism must vitally increase among all crew.

These type of challenges SC projects have had:

- find of experienced and professional, licenced people (both in cargo and sail) still willing to live with zero comfort earning peanuts without any kind of social security
- money, industrial acceptance
- huge lack of culture at the Mediterranean area
- Way too many answers to put here but getting IACS classification society and Flag State authorities into one line
- negative views saying sail was replaced due progress and capitalism favouring oil fired ships
- lack of interest
- Financial ones, i.e. not enough people strongly believing in sail propulsion
- Safety concerns (I know many skilled captains and shipbuilders in Europe and North America who like the idea of the movement and would support it fully, if it were not for grave safety concerns. The Maritime industry is a dangerous one, even on the big ships, but the smaller ships currently plying the Eco Freight market are essentially toys compared to the industry standard volumes and power. The sailing ships are being run far less safe than the current industry practices (in western regulated zones at least), and they are not playing the big boys game yet. If sail transport is to be taken seriously, it must adhere fully to IMO, MARPOL, SOLAS, etc. Currently knowing first hand it does not even come to close, and the minimum skill levels I see in the “real” Marine industry are not heard of in the Eco Freight companies.

- The initial cost to build a ship

- Problematic legislation when needed to register an old vessel as commercial cargo. Second challenge is money…

7.3 Comparing fuels and sail propulsion

What makes sail propulsion superior compared to other propulsion powers? (LNG, nuclear ships, solar / wave propulsion etc).

At the time of making the questions I was unaware of hydrogen, fuel cells, ammonium and other potential new fuels there might be, which why I presented as an example only those in brackets above. These kind of answers I got:

- It is clean, silent and peaceful. The ratio (wind speed, "input power" compared to ship speed, "received power") is better than with any motor.
- It's historically proven it worked for centuries
- LNG is fossil fuel. Nuclear - cost, public acceptance, scale. Solar - puts marine in competition with land use (manufacturing capacity) but will work well with wind. Wave - only small scale of proof so far. Bio oil - take competition with food production (land).
- Difficult to answer. There are cargoes that might be very difficult to be sailed. Reefer for example, where do you get the energy? Other cargoes are perfect for sail transport
- It is using only what nature has given us from mother earth
- If EU target path were taken as a reference, the 2050 target for shipping sector would range -78% to -94% compared to 2005 emissions
- It's completely free of emissions and there's almost infinite amount of energy available
- They are the cleanest technology we could implement universally tomorrow without great advancements in technology, relative low cost design, construction and operation. They harness an abundant source of energy and turn it directly into useful kinetic energy
- Free, non-polluting and unlimited energy available

How about what makes those other propulsion powers superior compared to sail propulsion?

- less people to operate
- more fast, timing easier to manage
- LNG and biofuels are easily understood by the industry and fits the current infrastructure and trading patterns
- time table
- ease of use, reliability
- higher energy content and ability to store energy in form of fuels
- Most other forms can be implemented safer than sail technology. Sails are able to harness huge amounts of energy, and the misuse of sails is common and easy to do. Though even large electric Engines, if they were completely CO2 free, and the energy supplying them was renewable and limitless (hypothetical), the electric fields created and high frequency /supersonic / vibrations, would still have an impact on the crew and the marine life / environment.

7.4 Shipping Future in general

How do you in general see shipping future to be?

- More automatized. If you want to use wind energy, you need to have automatized rigging fitting into standard terminals and build vessels minimum the size of the Flying-P-Liners
- challenging yet brilliant
- difficult to say
- Nothing like it is now. Different ownership structure, autonomous vessels
- I hope a better shipping will occur. The crisis in container shipping since 2007, offshore shipping for some years now, will hopefully lead to a better future.
- It is heading greener but at very slow pace
- Very grim if we do not cut our consumption levels radically
- Someone with enough money (VW, Maersk, etc.) will snap their fingers and overnight the industry will change. Its will be brought about thanks to the educating and publicizing of companies like Fair Transport and Timbercoast, but the grass roots movement will not be consulted, or acknowledged . I do not mean for this to sound bitter, but someone will beat us to the punch, the industry will completely reform in half a decade, and the practice for tennis balls to

circumnavigate the globe 5 times in their production will continue. Any change is welcome in my eyes!

- Difficult to say but personally I am very worried about short term policy, e.g. fossil fuel (diesel) will be replace with another fossil fuel like LNG

8 What factors determines the future of wind ships?

One question of the thesis was to find out answers to questions like "shall sail /hybrid ships become common, and potentially by when?" and "What factors determine if sail propulsion on ships will become common in the near future (10...30 years)?" In the previous Chapters (as in Chapter 4.1 and 4.5) I bypassed the question already a bit. Here I continue where I left.

According to Dr Köhler (personal communication, 25.02.2019), new models of ships (sailing hybrid vessels) *might* become common in the next 20 to 30 years, if

1) There are strong and measurable demands put in the game for emission levels. This can happen through policies or customer demands,

2) The technologies need to be demonstrated to be feasible and reliable. This could take 10 years as in minimum, where the technological development will take 5 years at least bringing a few new ships to sail, increasing eventually to 10 to 20 ships fleet, and

3) The propulsion must be competitive to alternative propulsions and fuels. This one is "the easiest to achieve with sail propulsion, *but very necessity*", Köhler says (personal communication, 25.02.2019).

Köhler also pops out the very fact that new build hybrid ships like *Ecoliner* are not yet commercially tested or demonstrated (although potential riggings as Dynarig have been used a few years in super yachts). New types of vessels are always much more costly to build than "standard" common type of vessels and it will be a risk investment. This takes brave and confident investors who should strongly believe in the technology and the ideology, Köhler adds.

As I discussed in the Chapter 4.5., feasibility to the port infrastructure may become a problem: rigging may be vulnerable (i.e. port cranes work close to them or in severe

weather) and needs extra strength and structure whereas the mast and other fittings are on the deck. The latter limits designing and retrofitting to only certain type or purposes of vessels. These things, among possible many others, has to be "solved" and demonstrated working before hybrid ships come common (personal communication, Köhler, 25.04.2019).

Gavin Allwright from IWSA clarifies the competitive situation. According to Kinthaert (Kinthaert, 2017) Mr. Allwright talked in the Green Ship Technology event 2017 saying: "ultimately there are two main things that will convince the industry of the viability of the wind – first is 3rd party verification of the technologies available (…). Secondly, the need for demonstrator vessels, testing the wind power systems in real conditions and all sectors of the shipping industry. Once we see these vessels more prevalent, then we will see the commercial interest pick up."

Diane Gilpin estimates (Kinthaert, 2017) that there are about 15.000 ships suitable for retrofitting auxiliary sails. This estimation is "the easiest ships" sailing in windy enough conditions, including small and larger ships and ship types of dry bulkers, tankers and general cargo vessels with enough free deck space. Smaller ships exactly benefit from the sails relatively more than larger vessels, Gilpin says. "There are definitely ship types we won't ever expect to see using wind – containers who use the deck space; ships operating in, say, Mediterranean where winds are not great – there would be insufficient payback", Gilpin clarifies. Also, this estimation is a very broad number – technical suitability does not mean commercial desire or political interest.

Allwright continues that a recent EU commissioned report by CE Delft estimated the maximum market potential for bulk carriers, tankers and container vessels are up to around 3,700 to 10,700 installed systems by 2030, including both retrofits and new builds, depending on the fuel price. This would equate CO2 savings around 3,5 Mt to 7.5 Mt in 2030 and the wind propulsion sector would bring 6.500 to 8.000 direct and 8.500 to 10.000 indirect jobs, Allwright describes (Kinthaert, 2017). Allwright reveals that the question is, in the end, not why but "*how* do we get there?"

Mr. Riski says that he sees in the auxiliary wind good market capability, auxiliary wind propulsion becoming slowly but probably even a megatrend. He says that ships will always need some sort of fuel from shore: "That's a fact. There are no admissible technologies available (maybe nuclear power being the only one) to produce on-board propulsion for sustaining service speed. The price of fuel won't become cheap very

soon either (bio-oils being even 6 times more expensive compared to conventional fuels), so there will be a strong demand on saving every piece of coins, where auxiliary wind propulsion brings welcoming relief on savings, yet auxiliary wind solutions can be fully automatized and safe to use", Riski summaries (personal communication, 28.3.2017).

Christian Smith, a low carbon shipping emission researcher from University College London says that we could move away from using heavy fuels today. "All of the technology needed to create zero emission ship exist in some form. The problem is that the commercial drive to develop these technologies is not yet here. Without clear regulations with strict deadlines or very high oil prices, the companies do not have much interest", he says (Smith, 2017).

9 Conclusions

In this work, I aimed to find answers to several questions about sail cargo projects and sail propulsion aspects in the future. I talked directly by interviews and indirectly by emailing and using Google Form with numerous experts on the field, including interviews with Tuomas Riski (CEO, Rotor Sails) and Dr J. Köhler, specialist in sustainable innovation of shipping from Dual Ports project, added with a list of online sources and webpages of projects.

9.1 The aim and my proceed

I wanted to find answers to questions like: Shall sailing ships become common? Potentially by when? What motivations there are within SC projects? What threats and/or challenges there are to sail cargo? I also wanted to present SC projects as an example of the Sail Cargo movement and familiarizing myself, and the reader to the many SC projects.

This target in mind, I am very satisfied with this study progress. I successfully gathered information as intended and learned lot of no only about SC projects and ships, but also ideas about how to bring new thoughts into public and how certain things work in a

large scale. Example of this is how major new technologies, i.e. development of new propulsion forms takes a long time before hitting commercial interest.

The work included also lot of communication in different many ways. In the end, I had to close my study for new contacts and interview possibilities with experts just to finalize and enclose this work. I am very surprised about all the positive feedback and inquiries I have had from SC people all around the world from presented projects. This if something is a sign to me that I have really got deep in my study.

I have dreamed about an alternative seafarer life, using sails as the mean of propulsion. While it is hard to tell why I am passionate about sailing, it is easy to say why I am urgently fanatic connive sustainable culture. I have learned that while there are crucial things needed to transport, there are huge amounts of waste and unethical things produced and transported as well. We are overwhelmed of material and waste, and still producing more.

I have learned also that it is possible to make living by sailing ethical cargo and that "cargo" which gives you living can be something immaterial too: culture, art, research or even a school. This might be challenging way of life, but it is possible. This study offers a good overview to Sail Cargo projects of today and tomorrow, for those who are interested in the topic and willing to work with such projects.

9.2 Outcomes

While it is obvious quite that SC ships will not overturn the world very soon, here is the main points of the research:

- Safety and lack of comfort limits the growth /success of SC projects. These issues exist, not within all, but within some initiative projects. If SC initiatives are to be taken seriously by "The Big Trade Community", it's maybe good idea to re-check that your project intends to follow and increase these aspects on board and other actions.
- SC initiative projects are mostly companies, but some of them lack well-organized /financed organization behind the scenes. Making money is not easy, and the projects exist mainly because of passion and volunteering, even though there are strong and forceful thoughts about shipping. Fair trade and organic

goods are valued and sought. The message is good, but how to bring the waken spirit into big scenes and increase the momentum of the little sailing ships?

- Development of large-scale technical processes, like sailing hybrid ships, needs a lot of momentum and years to become commercially interest. It takes easily 10 years (as some sort of minimum) to get from the drawing board to actual built-vessel. As an example, the idea of Flettner Sail (Rotor Sail) was here already at 1920s, but only now the idea is really in commercial use. Major part of such innovates never come to this point or they come after generations changed.
- According to occasional news, we can expect a few new built hybrid vessels sailing here in the next two-three years or so. Rotor Sail by Norsepower, Neoline car carriers, IWSA and Smart Green Shipping Alliance's plans are something worth of to follow for latest news.
- These vessels would be the first demonstrations of hybrid vessels, but it could easily take 30 years before seeing these ships really getting common (10-20 ships) even if the ships provide themselves fully capable.
- Effective auxiliary wind propulsion could become common and financially viable solution in reducing costs and emissions if fuel prices stay high /increase and no superior competitive fuel/ propulsion are not find. The question is not why (to use sails/reduce emissions) but *how*?
- Engines will be needed in many various places like cars, planes, military and certain type of seagoing vessels. Sails could be used where applicable as additional propulsion for saving fuel, money and emissions. People will eventually find a way to get rid of engines' bad effects, just how is the question.
- Whether there will be large commercial interest into sail shipping, it depends on much on the fuel price, the regulations and available, feasible and demonstrated technologies. Customer demands may fasten the urgency.
- Even though the technology used for shipping were 100% pure, the current number of amount, quality and flow direction that are shipped, would still sustain destruction of the environment and the global society. There must be deeper awareness spread to make a change.

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Appendix 1. List of SC Projects*

* There are uncounted number of SC related projects, initiatives and start-up companies developing wind propulsion systems. Only within IWSA there are over 100 partners, which many of them working on the field somehow. This list here is not to be a "Full & All" list of each existing project there might be, since there are so many, but a reference list to those projects I have gained valuable information for the thesis.

This list may be used as a reference for further studies or to find out more information on SC projects.

Traditional and small projects

Source	Since	NAME	VESSEL	Built	Capacity	Material	Length	Area	Maiden Voyage	Crew + Ship mates /trainees	Additional Info	
www.treshombres.eu	2007	Tres Hombres Shipping / Dutch	Nordlys	1873	25 ton	Wood	32	Worldwide/ European	NA	5+4	Engineless	Former Fairtransport Co. 99% Emission free
		-"-	Tres Hombres	NA	45 ton	Wood	NA	Worldwide / Atlantic	2009	7+8	engineless	
Timbercoast.com/en	2013	Timbercoast / Germany	Avontuur	1920	114 dwt	Steel	43.5	Worldwide / Atlantic	2017	6+10	RINA Class	
Sailcargo.org	2016	Sail Cargo Inc. / Costa Rica	Ceiba	2021	250 ton	Wood	45	Worldwide /Pacific Line	2021	NA	Three masted schooner	Initiative "jungle dockyard": new trees plant on each one that has been cut off. Electrical engines
Hawilaproject.org	2014	Hawila Project / Denmark	Hawila	1935	NA	Wood	24	North Sea & Baltic	2017	4+12	organization	Culture, education and trade
Grayhoundluggersailing.co.uk	2010	Grayhound Lugger Sailing /British	Grayhound Lugger	2012	50 ton	Wood	32	Worldwide / Europe	2012	5+8	Family business	Built by using traditional methods by the family
Brigantes.eu	2016	Brigantes /	Brigantes	1911	NA	Steel	30	Worldwide / Atlantic	2020	NA		In reconstruction now at Sicily, Italy Electrical engines
Sailtrade.co/about	NA	Sail Trade / USA	"Tom Colvin Schooner"	NA	80ton	Steel	NA	US east coast / NA	NA	NA		"Sail trade Movement"
Okeanos-foundation.org	2012	Okeanos Foundation / German	Vaka Moana	NA	4 ton	Wood	22	Polynesia		4+16		Coconut oil engines Drawings from James Cook (1770)
		-"-	Vaka Motu	NA	3 ton	Wood	14.8	Polynesia		4+8		
Svkwai.com	2006	KWAI / Honolulu	Kwai	NA	80ton	steel	43	Pacific	2006	8 (-11)		
Lo-entropy.weebly.com	1993	Lo Entropy / North Sea	Lo Entropy	1993	50 ton	Steel	NA	Worldwide/ North Sea, Baltic	NA	4		Cooperation with Dual Ports, in reconstruction now. Engine will be modified and test to run with hydrogen

Gosailcargo.com	NA	Go Sail Cargo	Electric Clippers									Electric clipper designs
Sailmed.org	NA	Sail Med /Mediterranean						Mediterranean /Aegean Sea				Initiative Sail cargo boat
SOURCE: Facebook @sailcargoafrica	NA	Sail Cargo Africa	NA									Potentially coming Sailing Cargo initiative at Africa "half profit, half ethical benefit"
Hannah, Martin (thenational, 2018)	NA	Falls Of Clyde	NA									The last sail cargo tanker
Projetcarina.wordpress.com	NA	Carina, Musique & Theatre	NA									
Bessie-ellen.com	NA	Bessie Ellen	NA									
Schoonerruth.com	NA	Schooner Ruth	NA									
Seamercy.org	NA	Sea Bridge /Sea Mercy Support Vessel	NA					South Pacific				Charity Vessel
Sailvega.com	1892	Historic vessel VEGA	NA					West Pacific / Polynesian				Charity Vessel
Voyagevert.org	NA	Voyage Vert	NA									Ethical travel, sail transport alternative to i.e. air flights
Schoonerapollonia.com	NA	Schooner Apollonia	NA									
Vermontsailfreightproject.wordpress.com	2012	Vermont Sail Freight Project	NA									Disbanded in 2015
NA	NA	De Gallant	NA									
NA	NA	Salish Sea Cooperative	NA									

Typical cargoes: rum, coffee, chocolates, cocoa, peanuts, creamed caramels, tea, boxed cargoes /goods, trainees /shipmates, rice, wine, beer

SC Agents, Associations and related

Towt.eu	France	TOWT	Trans-Oceanic Wind Transport	Connection for freight and SC ships
Fairwindstradingcompany.org		Fair Winds Trading Company		Working many parts of the field, i.e. Currently in cooperation with Dual Ports Project
Wind-ship.org		IWSA	International Windship Association	Promoting Wind propulsion technologies. Hosts researches of wind propulsion technologies. Attends maritime conferences and organizes them. Evaluate wind propulsion market and assist and offer consultation. Over 60 members (companies/associations) and over 50 supporters.
Dualports.eu		DUAL PORTS PROJECT		Project received funds from Eu, Part of the target is to develop Sail Cargo network at the North Sea and demonstrate the use of SC ships.

				Support SC projects. Work within other sustainable fields also related, i.e. develop sustainable ports and energy solutions.
Sailingdog.org		Sail Dogs		
Sailtransportnetwork.org		Sail Transport Network		
Nsrsail.eu		SAIL		Project developing hybrid ships at North Sea region
Newdawntraders.com		New Dawn Traders		SC agent and trader. “Buy less, buy better, buy local, by SAIL.”

Hybrid-, Auxiliary and other innovative projects.

Skysails.info	Germany	Skysails Group GmbH	1-3 ships, R&D mainly	2001	MV Beluga (2008)	Towing Kite Sail
Norsepower.com	Finland	Norsepower	3 ships by end of 2018	2012	MV Estraden (2014) Viking Line (2017) Maersk Tanker (2019)	Flettner Rotor / Rotor Sail
NA		Enercon	1 ship		E-Ship 1 (2010)	Flettner Rotor
NA	Italy	Seagate Sail				
Smartgreenshippingalliance.com		B9 Shipping / Smart Green Shipping Alliance		Wing Sails (retrofitted feasibility study ongoing). Possible 2021 sea trials. New build hybrid vessel design since 2012. FAST -brand, rigging technologies.		
Propelwind.com	France	Propelwind				
Neoline.eu/en		Neoline		Cooperation with Renault to build 2 hybrid car carriers in 2020-2021		
Wind-ship.org/utwindchallenger	Japan	Wind Challenger				
Greenheartproject.org	Japan	Greenheart Project		2005	Small eco coaster hybrid vessel, connect coastal communities	
Windwingtech.com		Wind+Wing Technologies			Initiative Wing Sails, “high tech sail could one day power ferry boats”	
Ladeas.no/about.html	Norway	Vindskip / LADE AS			The “HULL SAIL” Ship	
Nextgeneration-cargo.com		Next Generation Cargo (NGC)	Vessel “Quadriga”		“The world’s largest” hybrid vessel design for car carrier or sea food growing	
NA		Schormanns Maritime				
NA		EL Nino Clipper				
https://www.ship-technology.com/projects/peace-boats-ecoship/		Peace Boat Ecoship			Japanese innovation sustainable passenger ferry using some sort of sail-looking things	