WIND ASSISTED SHIP PROPULSION

DNA involvement, selected test cases and the future

2021, G Dijkstra

DYKSTRA
NAVAL ARCHITECTS

CONTENTS

- INTRODUCTION DNA
- HISTORY
- SAILING SHIPS operational
- SAILING SHIPS under construction/ in design / studies
- DESIGN TOOLS
- TRANSITION AND BARRIERS

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NAVAL ARCHITECTS

OCEAN RACING 1969-1980
SECOND LIFE 1972 O.S.T.A.R.

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YACHT DESIGN 1975 ONWARDS

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NAVAL ARCHITECTS

LAMINATED WOOD SHIP BUILDING IN INDONESIA 1982-1993

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NAVAL ARCHITECTS

Student Thesis June 2003: Average 13% fuel reduction, for reductions >40% the soft sail route was developed.

Stichting De Noordzee

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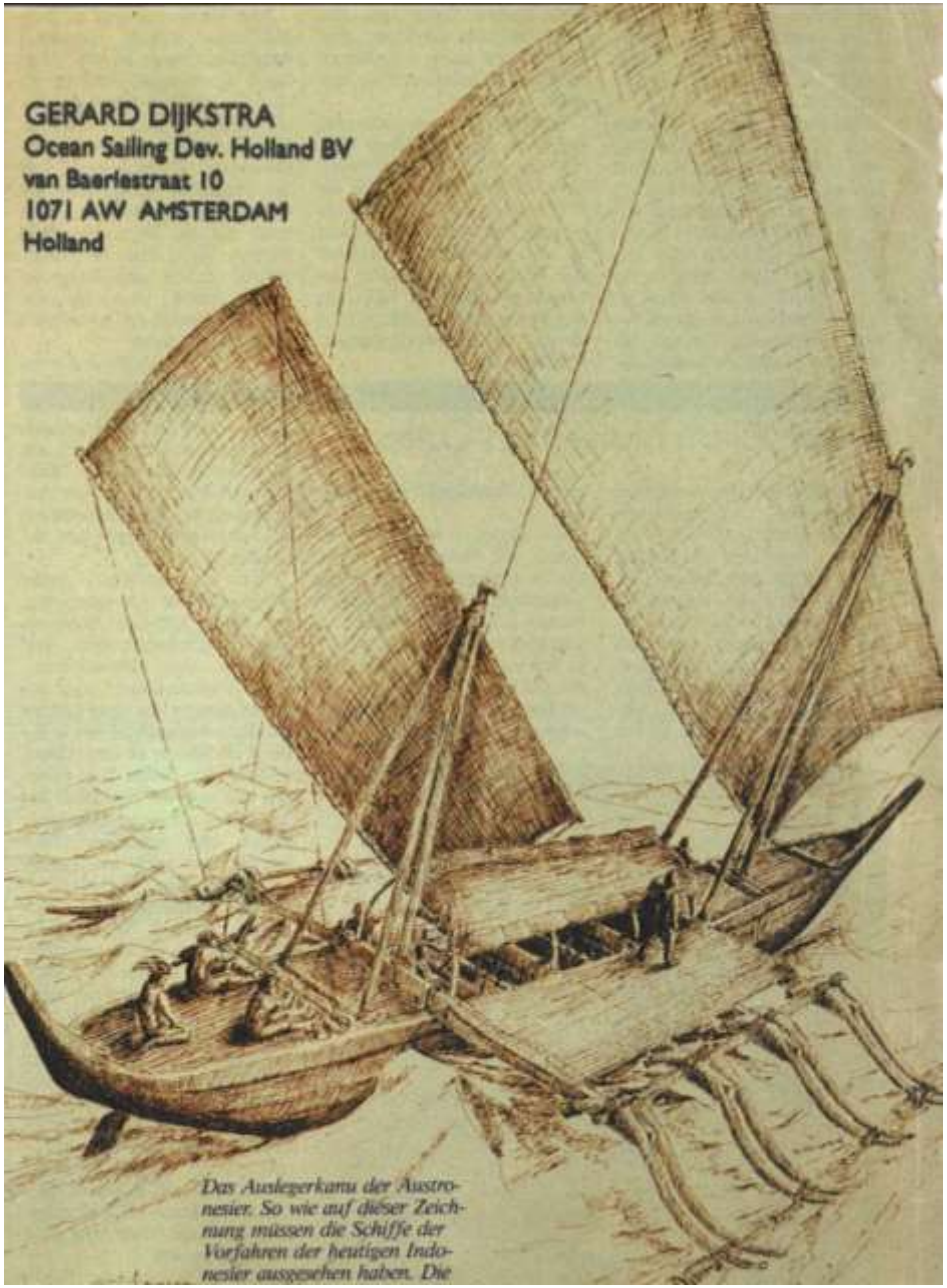
2500 years in the past



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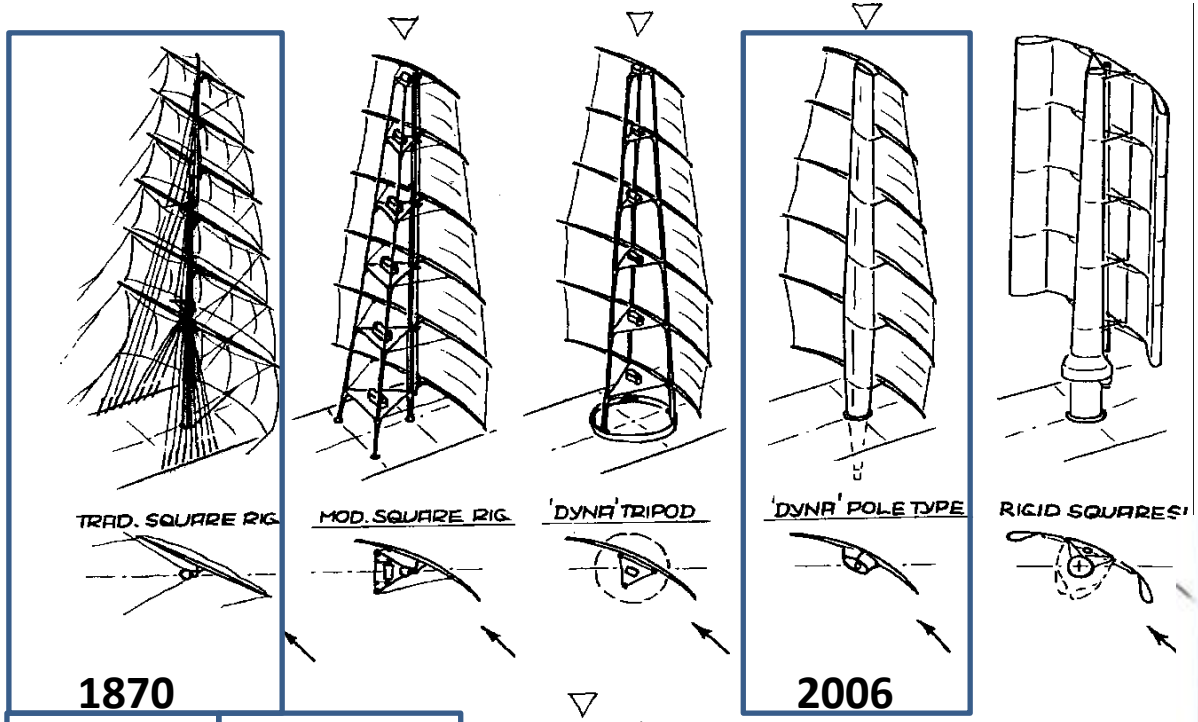
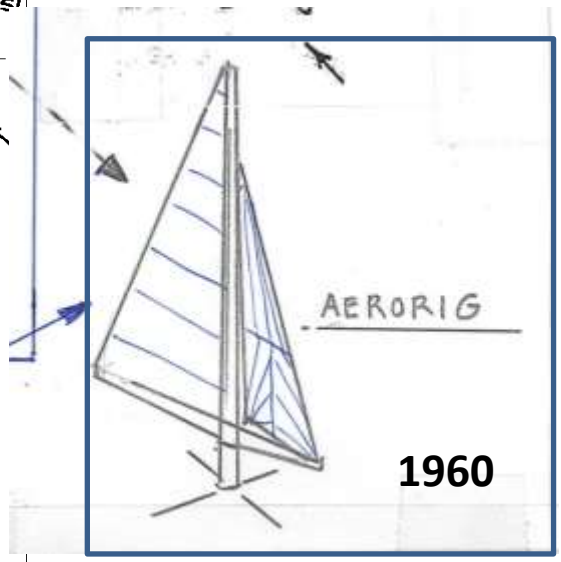
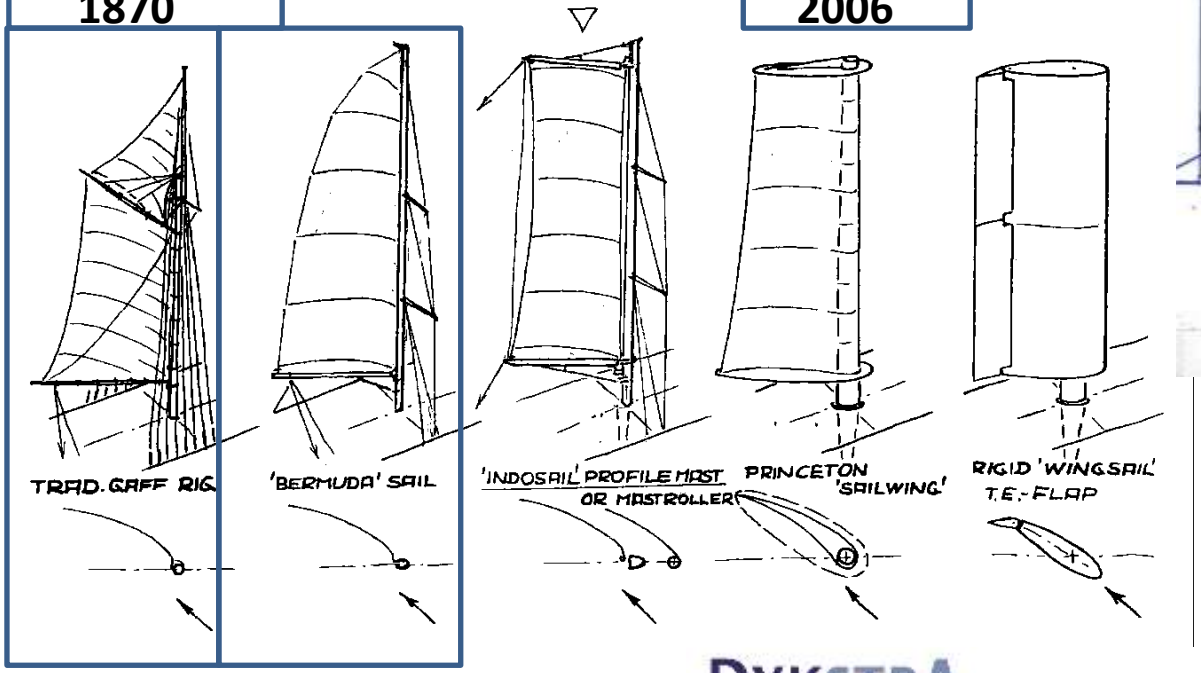
NAVAL ARCHITECTS

SQUARE RIG

ILLUSTRATION P.SCHENZLE







FORE-AND-AFT RIG

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NAVAL ARCHITECTS

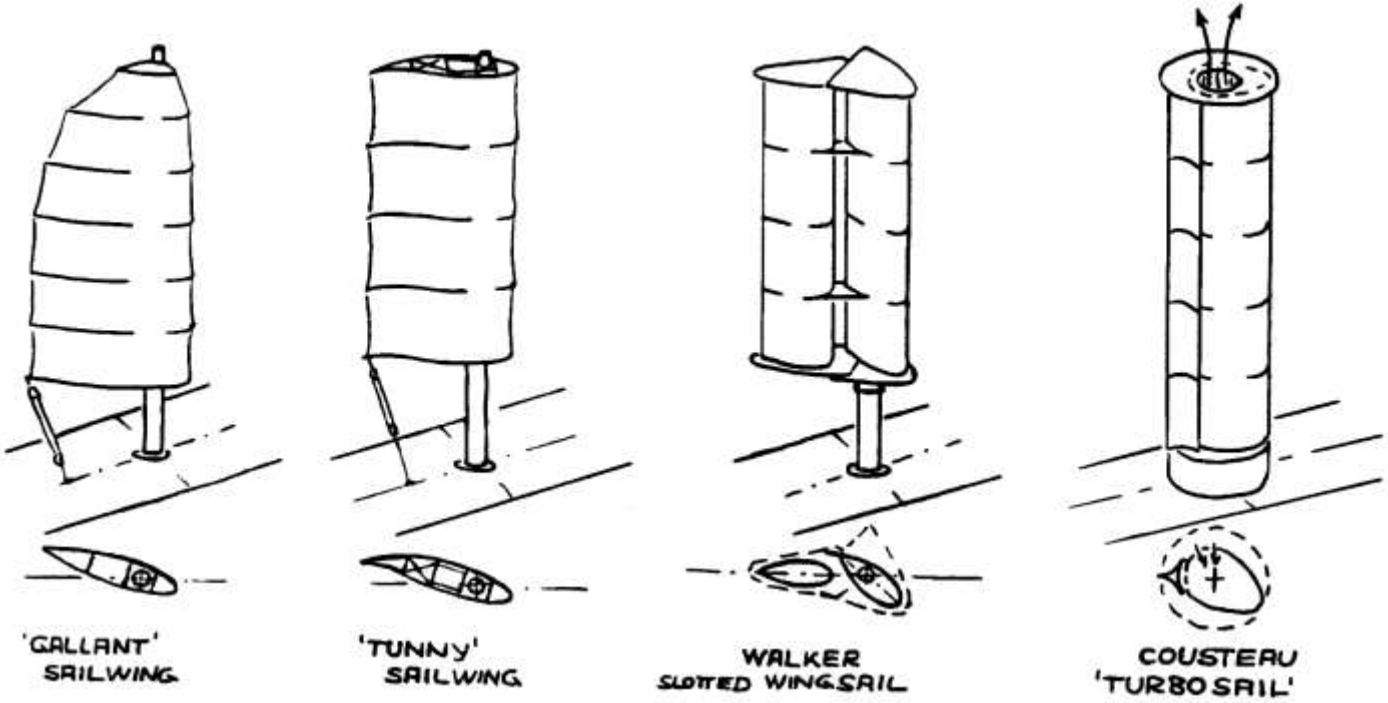
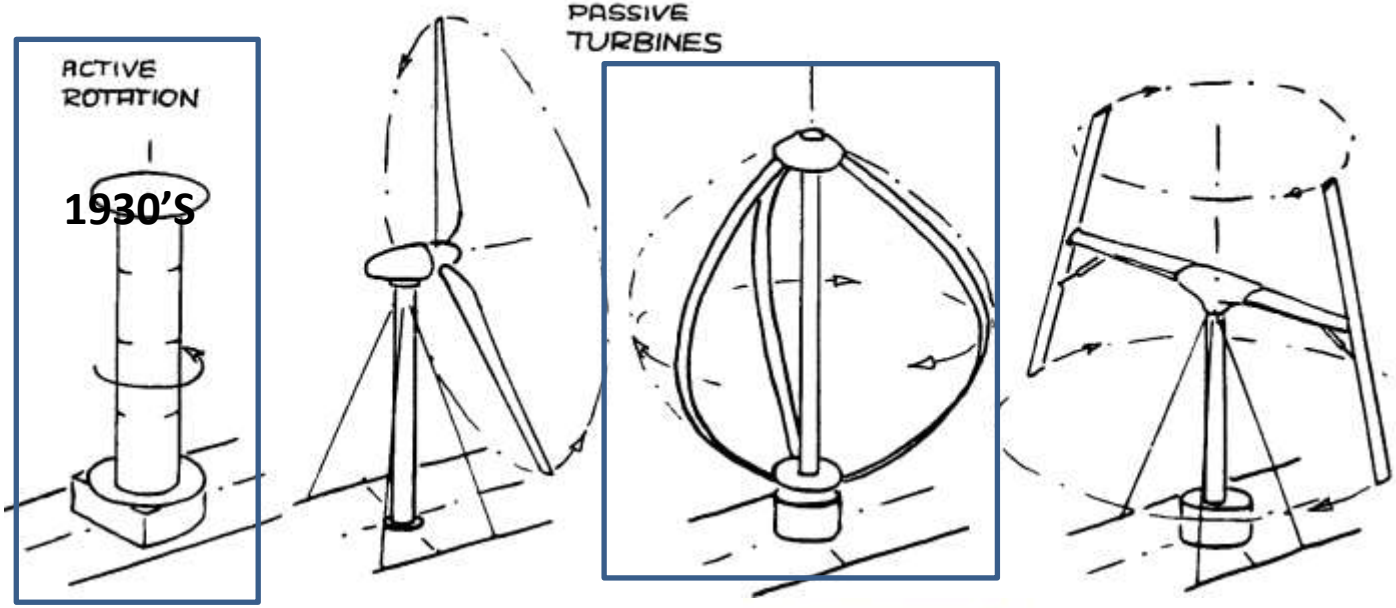


ILLUSTRATION P. SCHENZLE



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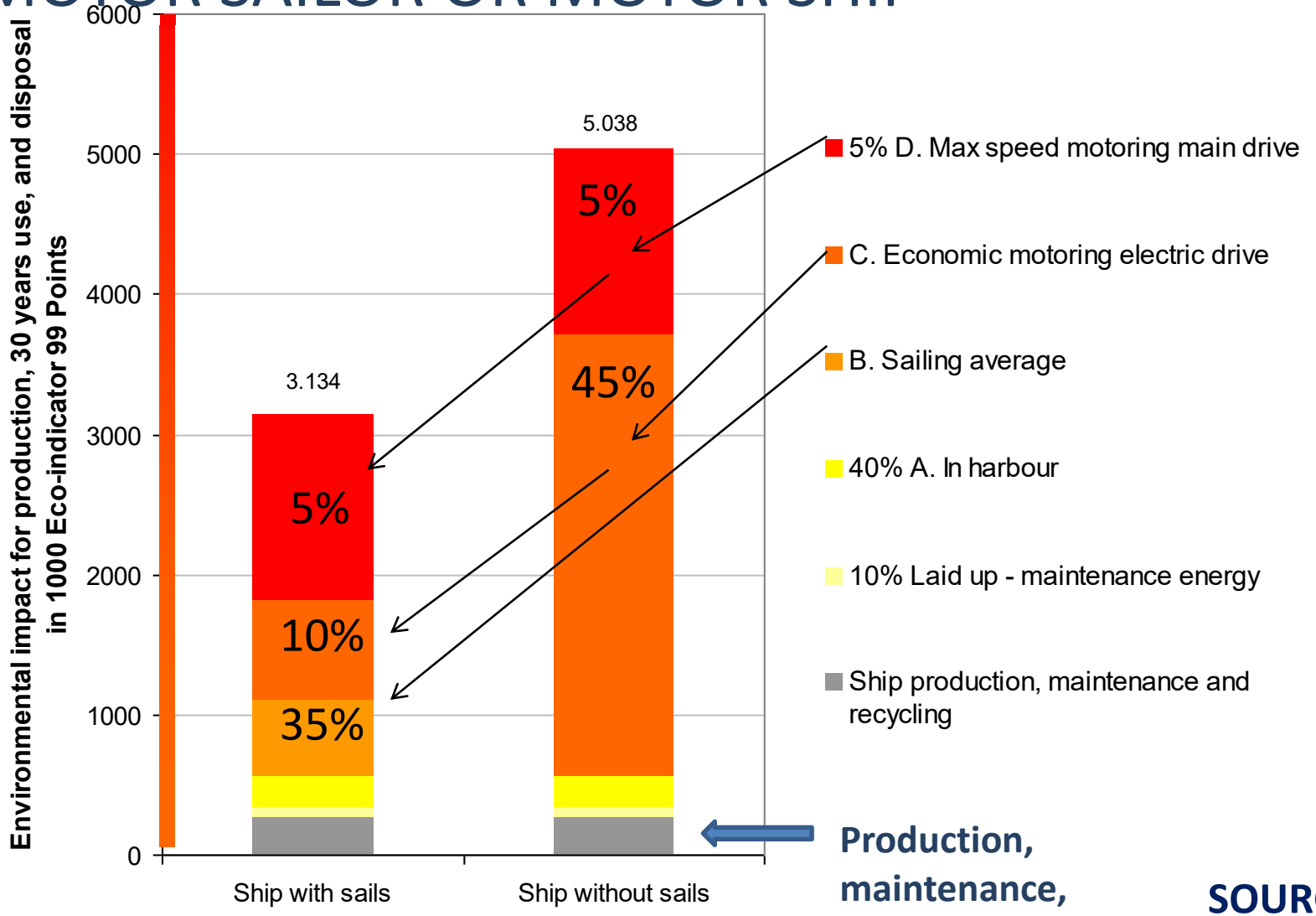
NAVAL ARCHITECTS

RAINBOW WARRIOR LIFE CYCLE ANALYSIS MOTOR SAILOR OR MOTOR SHIP



DYKSTRA NAVAL ARCHITECTS

SOURCE: TNO

Clipper STAD AMSTERDAM, 2000

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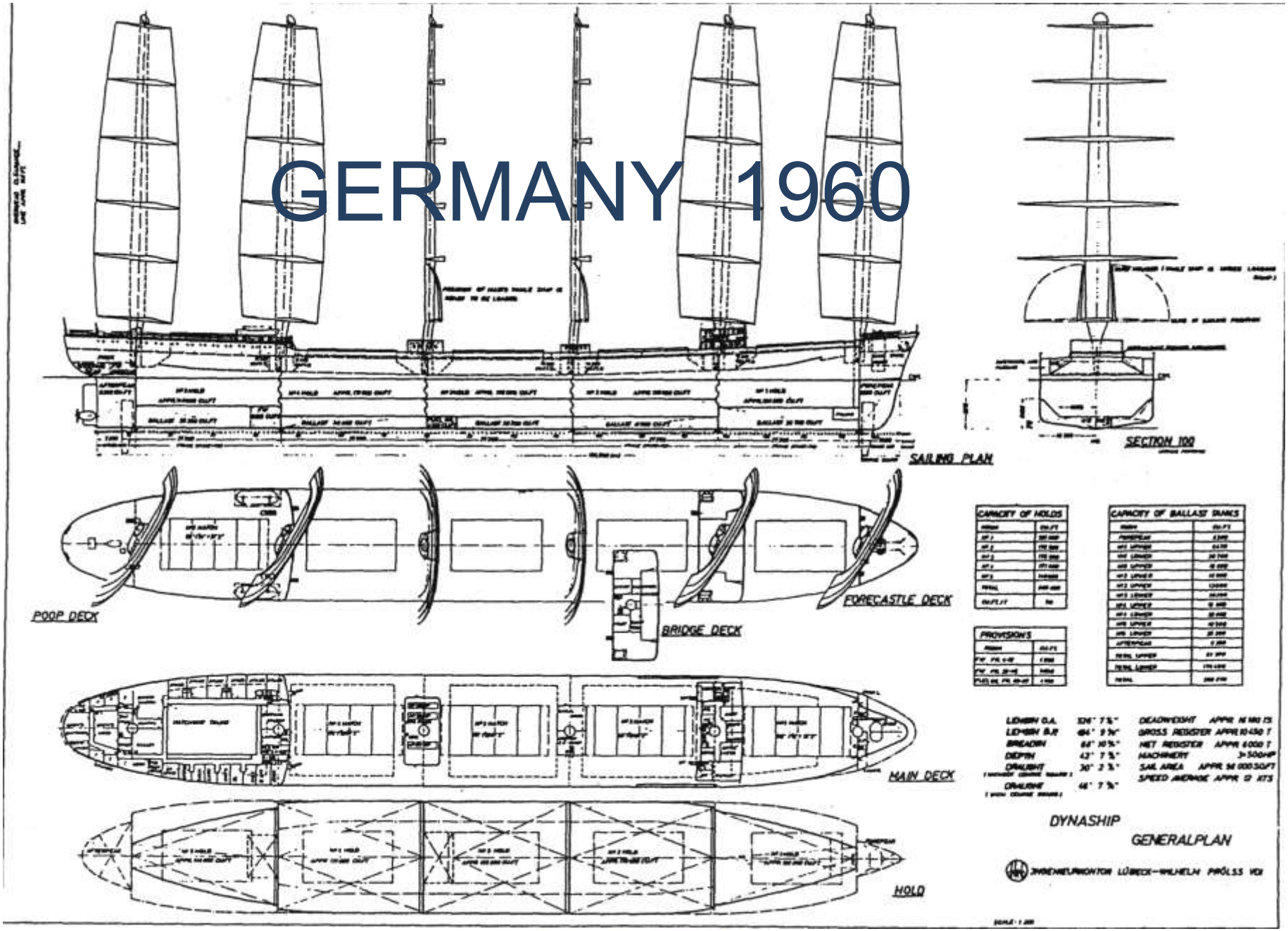
NAVAL ARCHITECTS

DYKSTRA
NAVAL ARCHITECTS

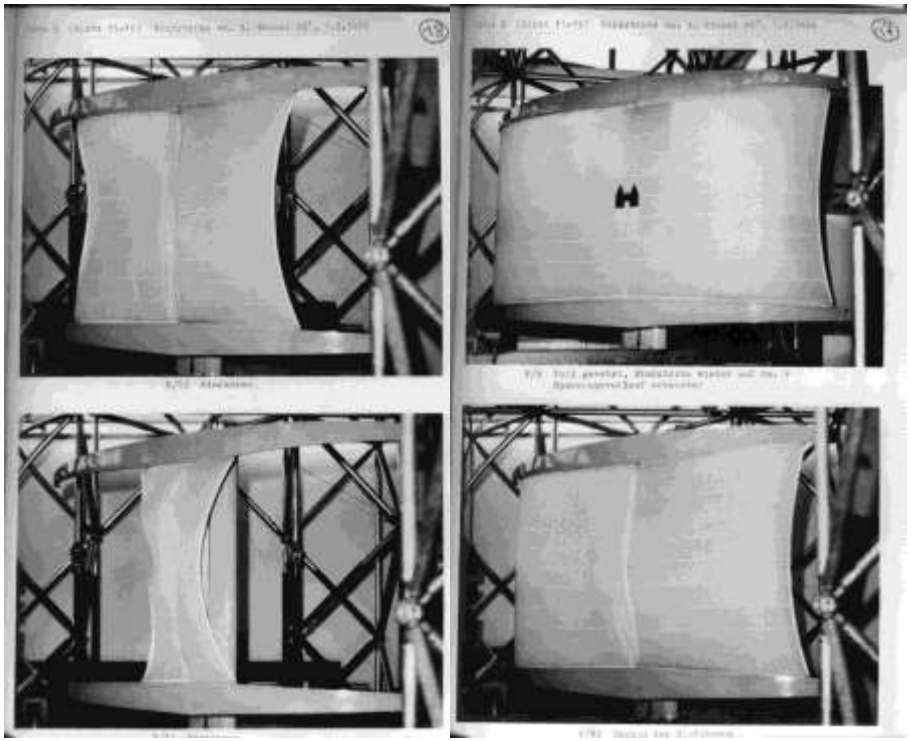
SHABAB OMAN 85m
2015

DYKSTRA
NAVAL ARCHITECTS



DYNARIG DEVELOPMENT 2000 AMSTERDAM

1960 HAMBURG



2003 TURKEY

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MALTESE FALCON 2006

Project commenced 2002

Launch 2006, To date (2011):

- 80,000 sea miles ,95% under sail
- 24 knots under sail
- several gales
- 3,000 sail sets
- winner Perini Navi Cup 2008, 2010 and many awards

No issues with the rig

Full data set from Monitoring system

Rigs never removed & no plans to remove rigs

Sold to new owner 2009

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Main control panel MALTESE FALCON

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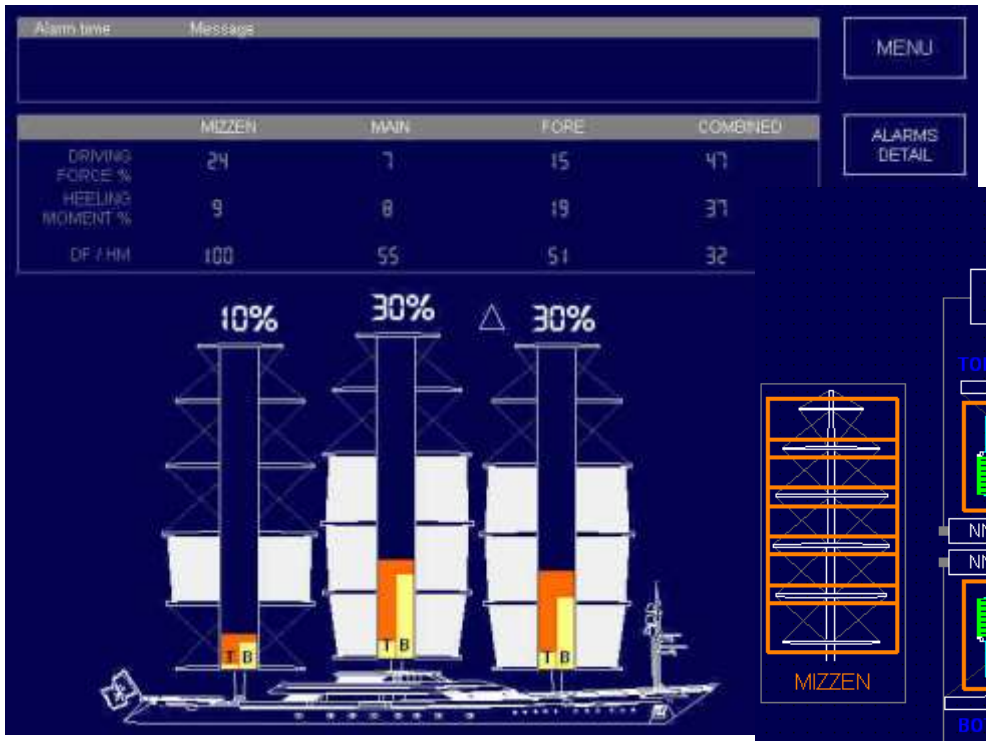
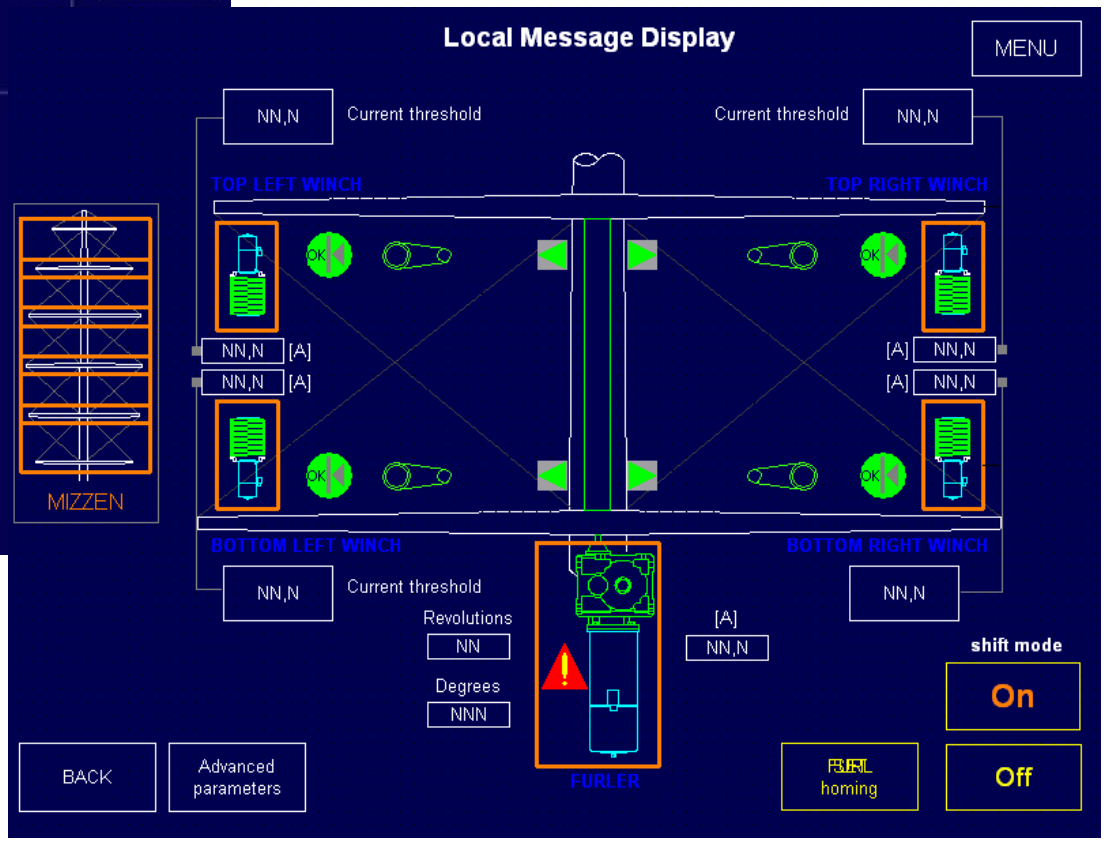
2000 ONWARDS
FIBRE OPTIC STRUCTURAL MONITORING, MagmaStructures
SAIL HANDLING MONITORING SOFTWARE, Caccini





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BACK-UP SAIL HANDLING PANEL

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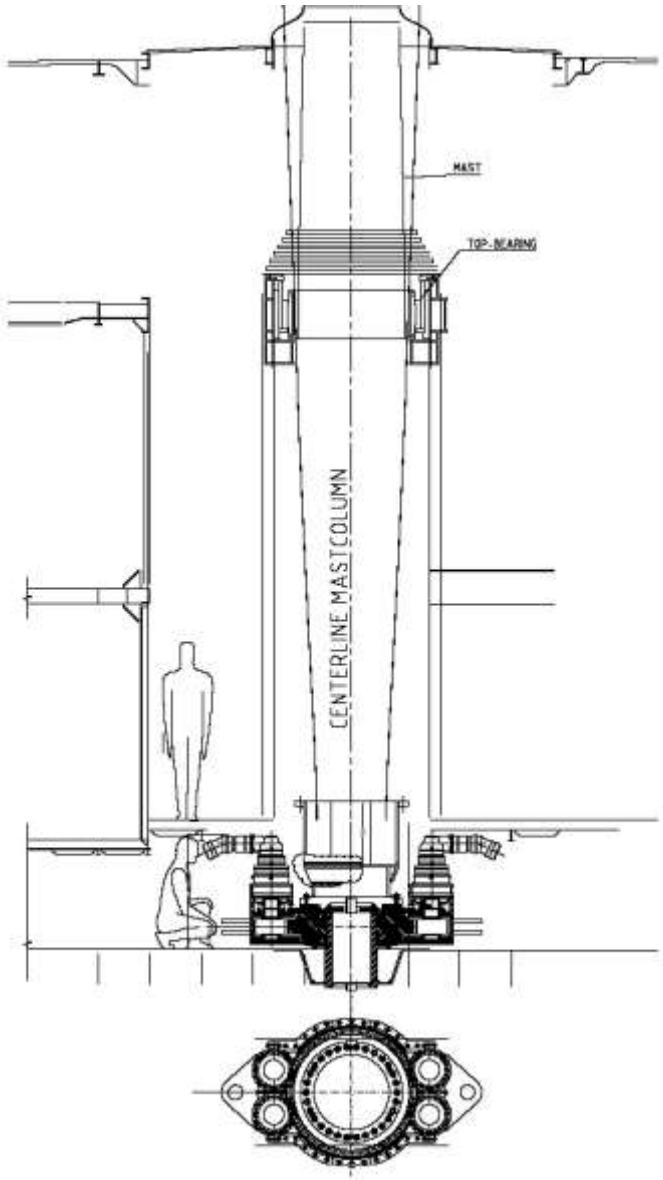
NAVAL ARCHITECTS

MALTESE FALCON MAST ROTATION SYSTEM



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BLACK PEARL 106m, 2018

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46m AERORIG DWINGER

REFIT AND RIG DESIGN DNA 2002

Hoofdafmetingen:

Lengte = 46 m

Waterverplaatsing = 300 ton

Zeiloppervlak = 780 m2

Bemanning = 4 pers

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ECOLUTION, AERORIG SCHOONER, a self sustained yacht, 2011

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SOFT SAIL WING MAST
DNA design 2012
Sea trials and load Measuring
On a 30 ft hull,
For designing a 1000 m2 rig.

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RAINBOW WARRIOR LAUNCHED 2011
2012-2016 150.000 NM SAILED

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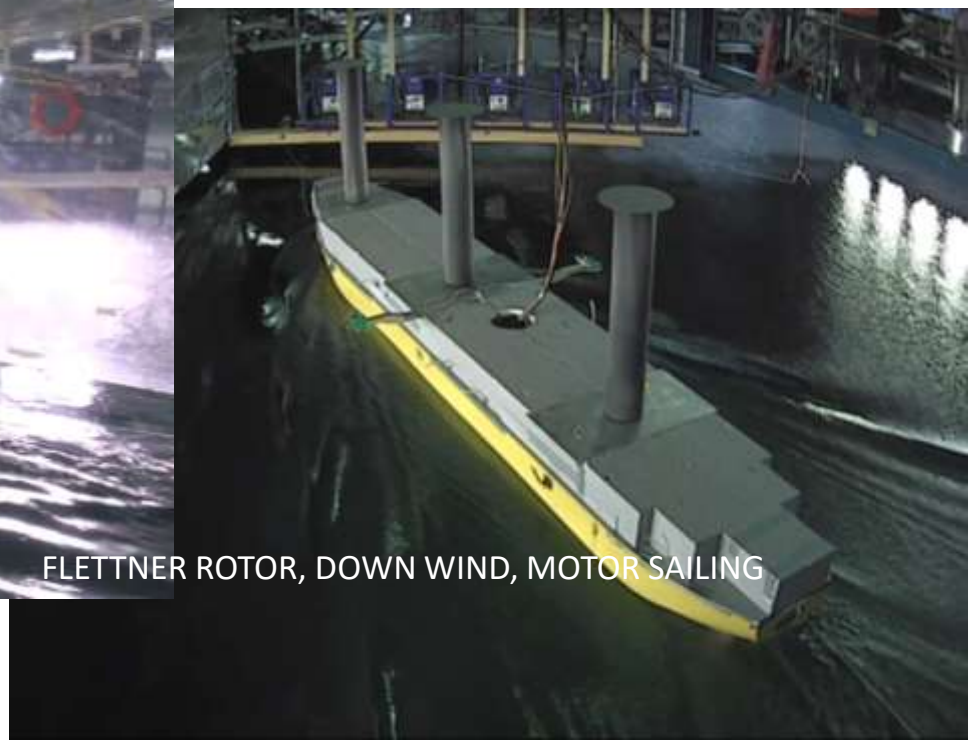
DYKSTRA
NAVAL ARCHITECTS

2018 MARIN, MEASUREMENTS ON A FREE SAILING MODEL OF A SAILING SHIP (or YACHT)

ECOLINER 8000 DWT WITH FLETTNER ROTORS OR DYNARIG

Related VPP DEVELOPOMENT reported during this symposium separately by MARIN

DYNARIG TO WINDWARD, MOTORSAILING



FLETTNER ROTOR, DOWN WIND, MOTOR SAILING

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DARIEUX ROTOR, KITE, ENERGY STORAGE, ENERGY GENERATION, ELECTRIC PROPULSION, RETRACTABLE OUTRIGGERS

STUDY DNA

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ECOLINER 8000 DWT, 2010

ECOLINER 2012

FAIR TRANSPORT

- LOA 138m
- B 18m
- T 6.5m
- DW 8200 T
- Multi purpose
- Containers 476

Preliminary Design trade wind Atlantic routes by DNA

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SAIL CARGO, 2021

HIGHER SPEED, LESS CARGO

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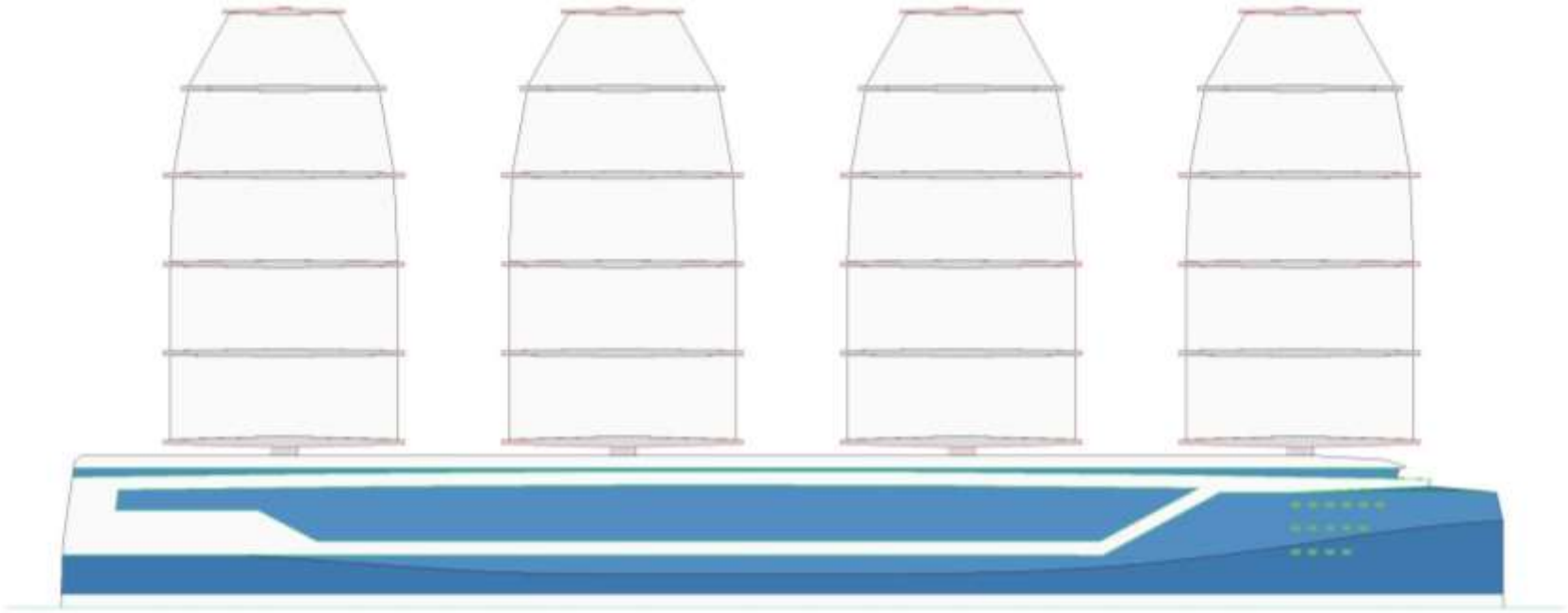
ECO CAR CARRIER 170m
Design study 2016



Main Particulars

Lengte over alles:	170.0	m	Doorvaarthoogte:	70.8	m
Lengte waterlijn:	170.0	m	Volume:	17676	m3
Breedte max:	25.2	m	Displacement:	18118	ton
Breedte waterlijn:	25.0	m	Deadweight:	8580	ton
Diepgang max:	8.5	m	Windweerstand opp.:	5061	m2
Diepgang romp:	7.2	m	Zeil oppervlak:	5000	m2

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SEABRIDGE ONE 36M
Disaster relief and medical support vessel, in design

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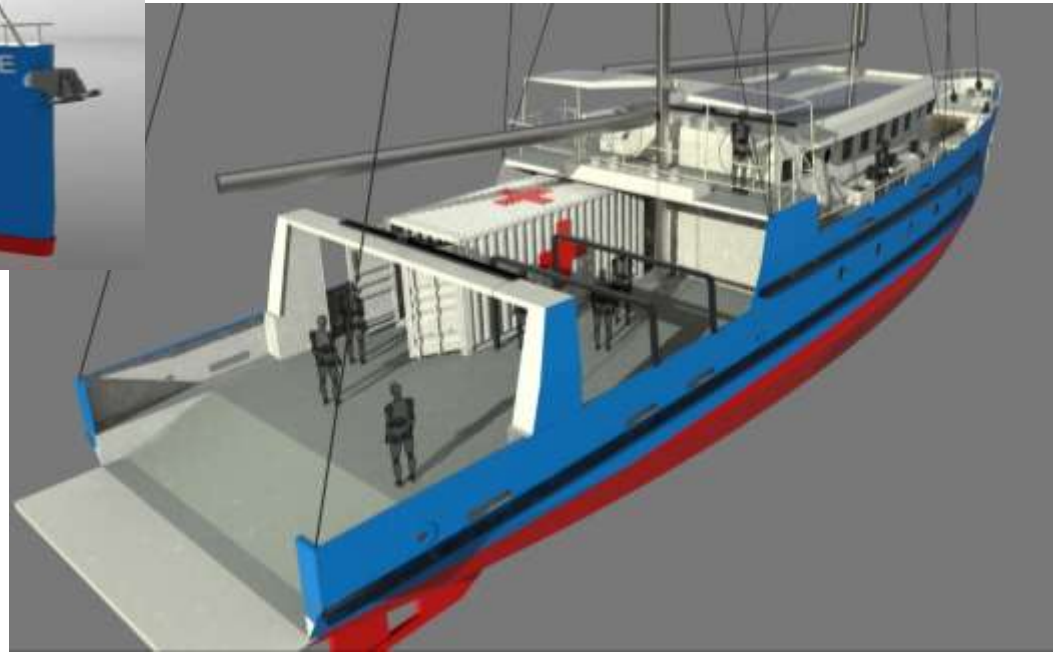
NAVAL ARCHITECTS

SEABRIDGE ONE 36M
Disaster relief and medical support vessel



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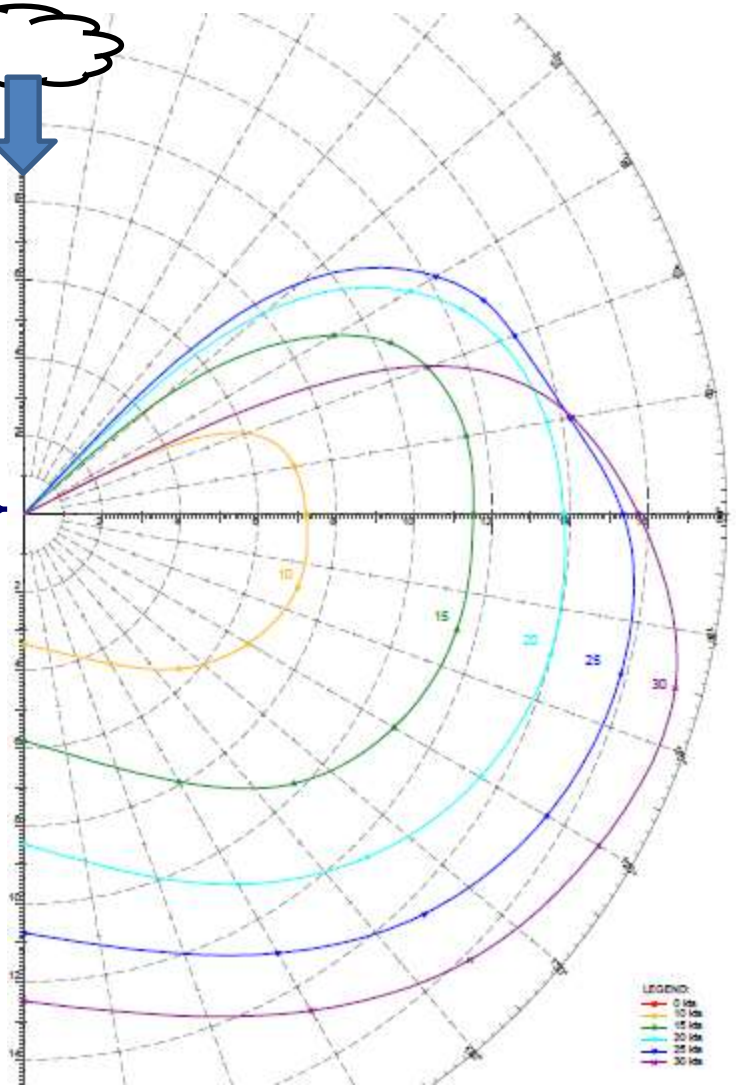
DESIGN TOOLS

DEVELOPED IN OFFICE

- VPP & TPP
- WASP WEATHER ROUTING
- ABOVE COMBINES TO FUEL SAVING CALCS., WHICH CAN BE LINKED TO AN ECONOMIC MODEL
- IN 2021 A MODULE TO INCLUDE REGENERATION OF ENERGY WHEN SAILING WAS ADDED

Performance calculations



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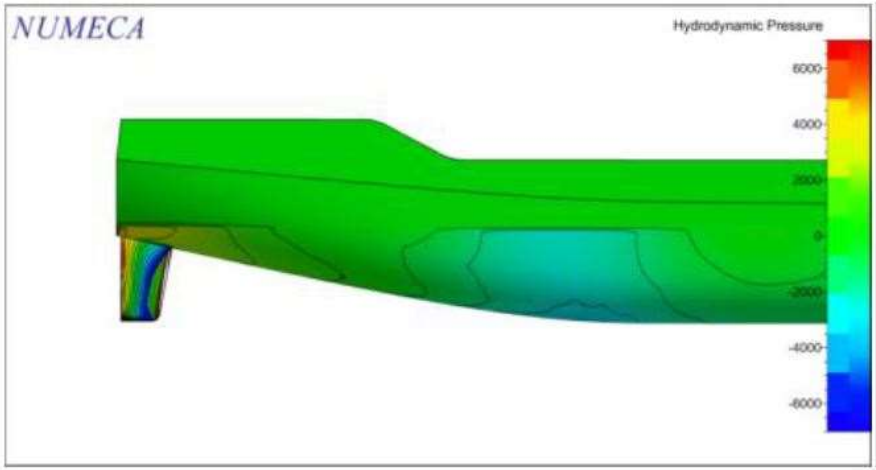
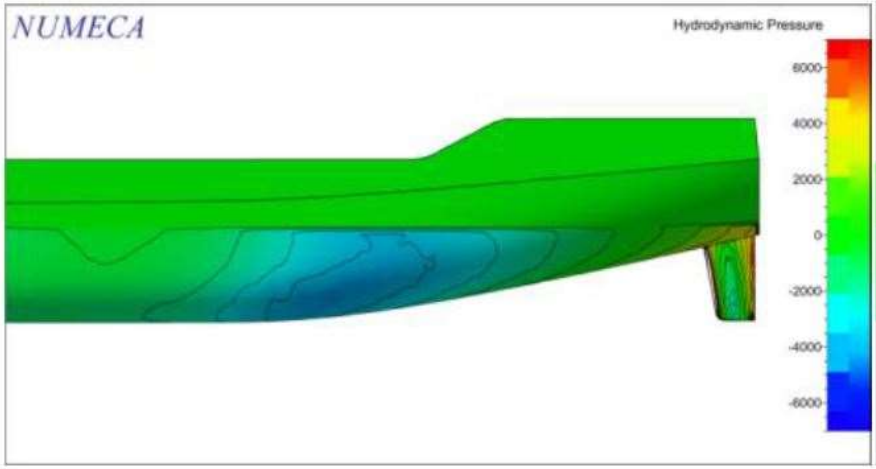
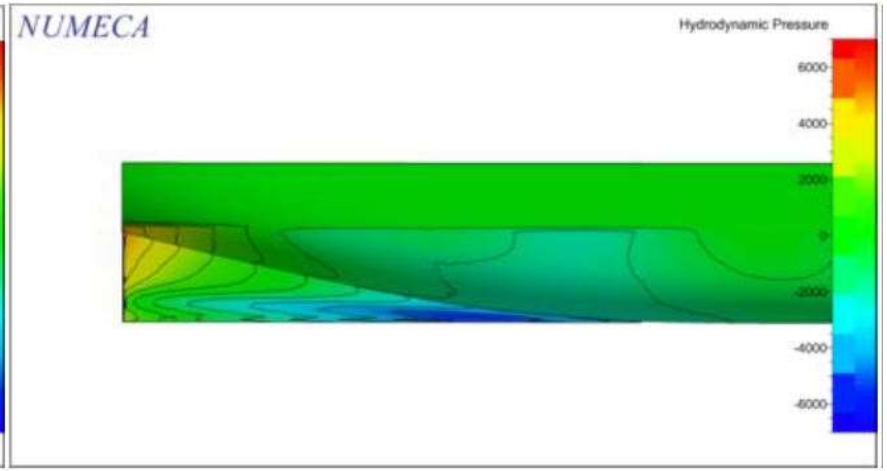
ECOLINER RUDDER versus SKEG CFD CHECK

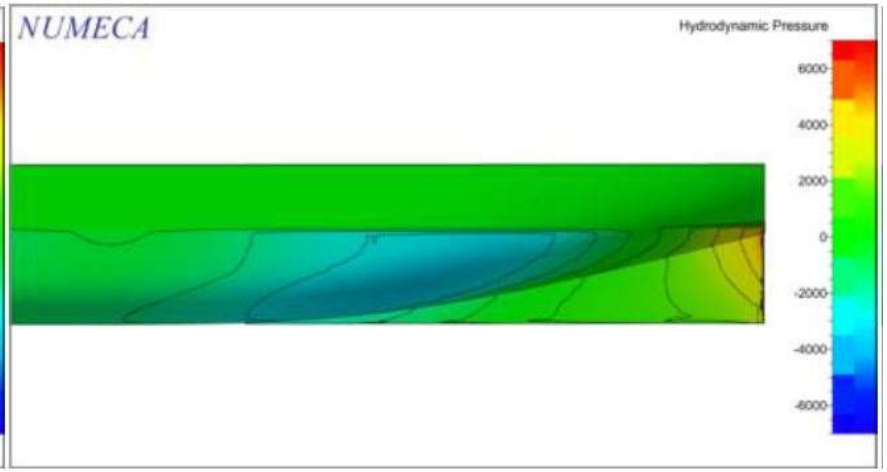
Baseline (Ecoliner)





Eco2 (Simple skeg)





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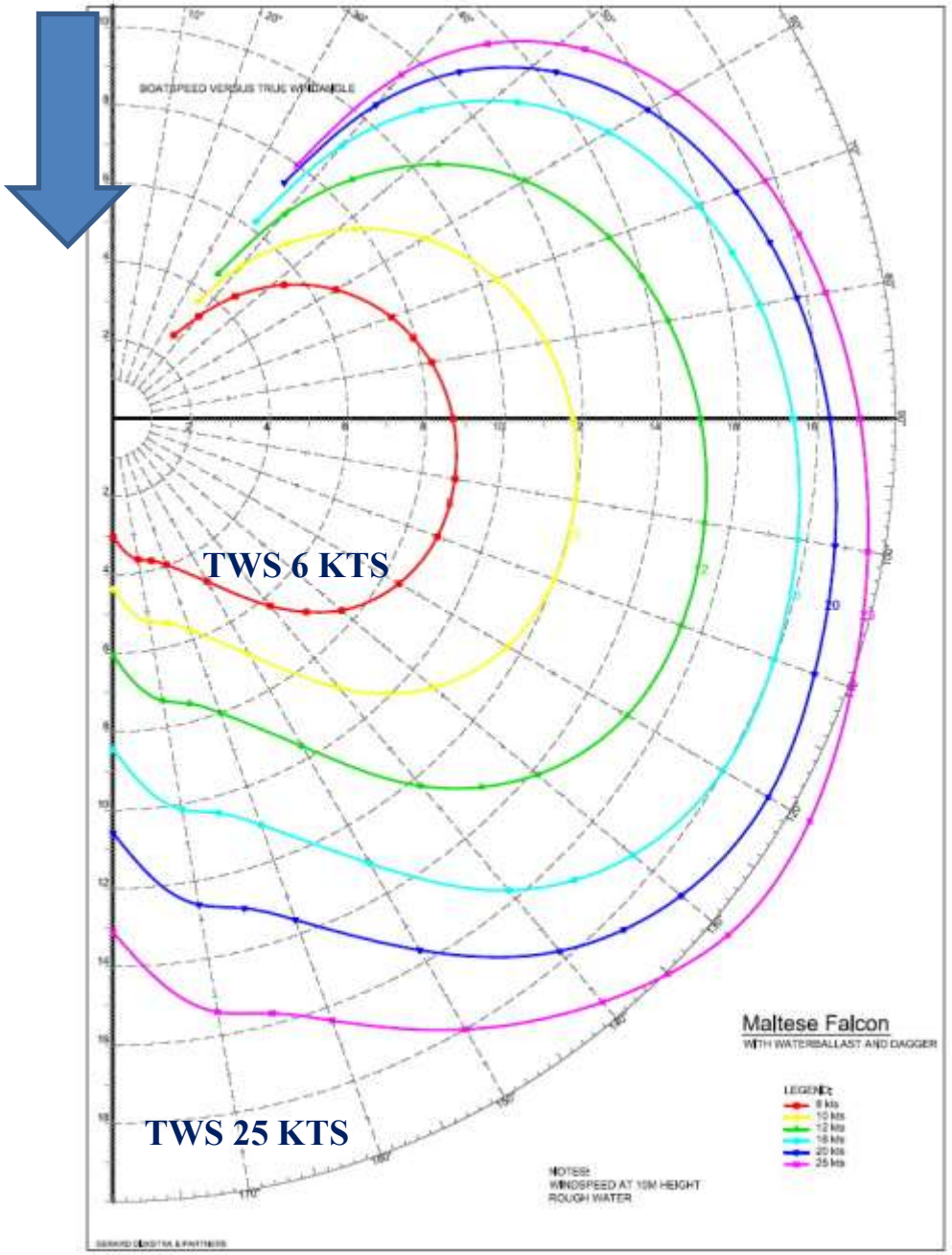
Polar Diagram – Sailing Performance

- DNA in office software or
- WIN DESIGN (WOLFSON UNIT) software



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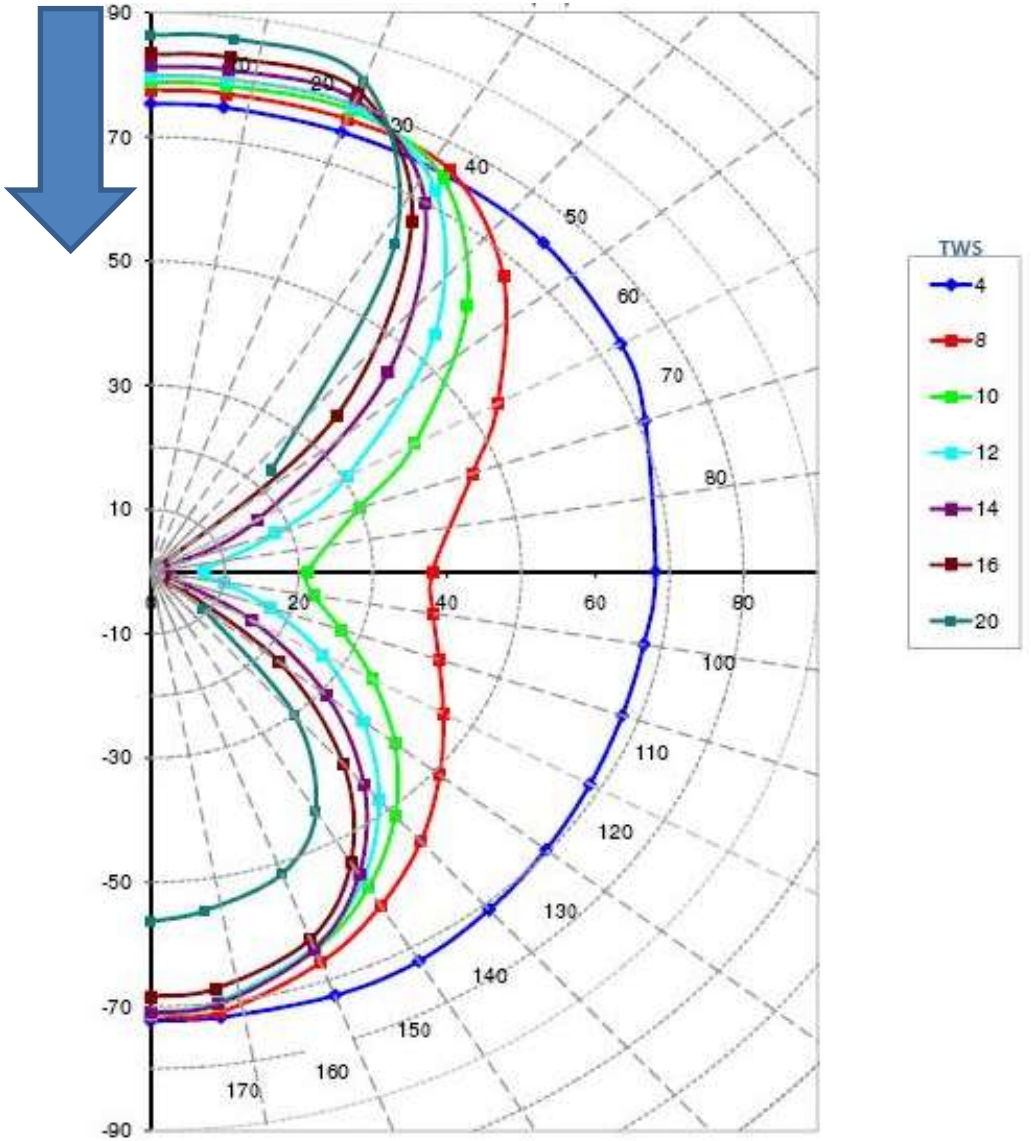
Thrust Prediction Program

- DNA in office software

Showing the required power for constant boat speed at different wind speeds



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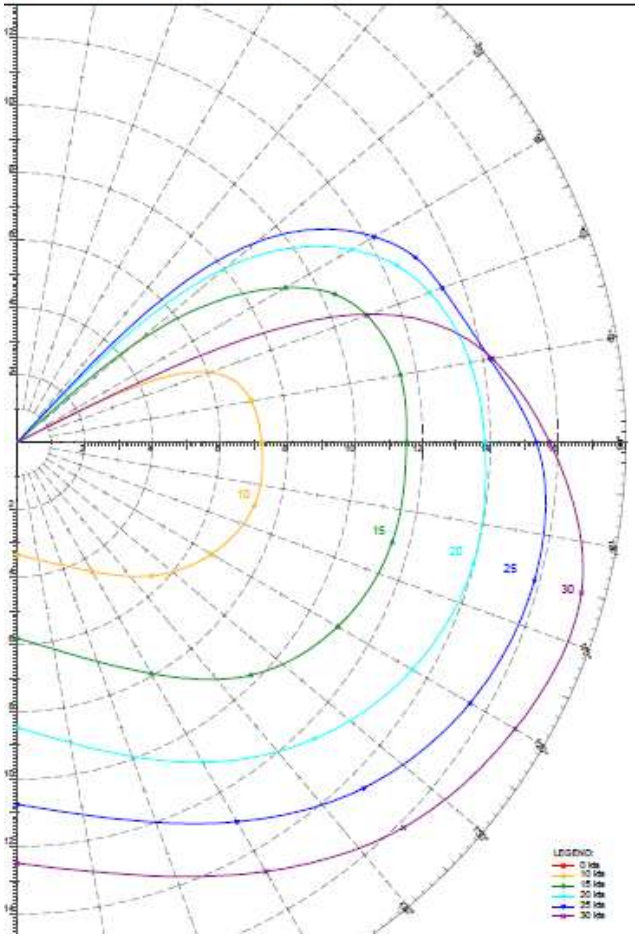
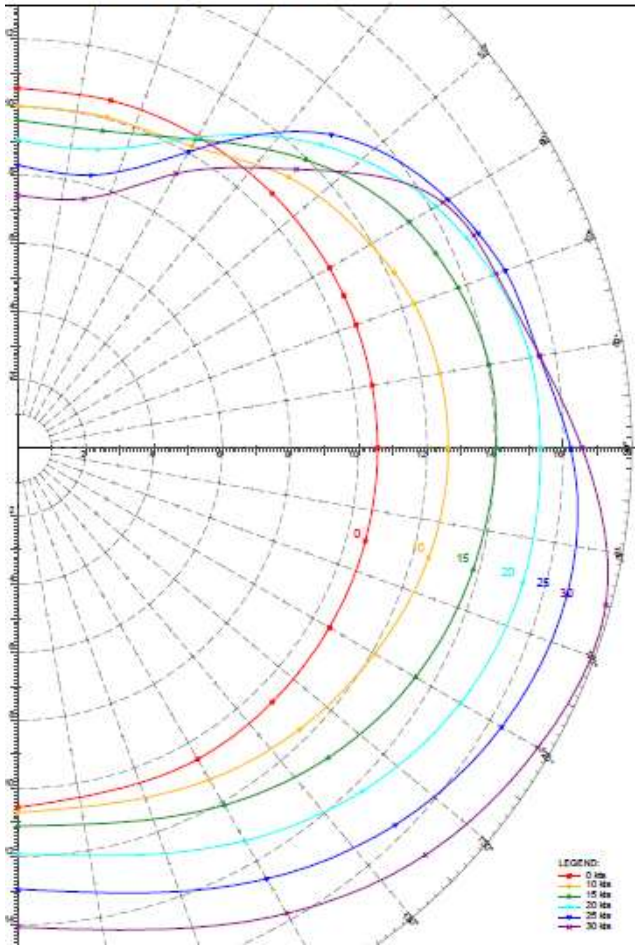
Polair diagram sail and selected thrust

Ecoliner - 0 kW



Ecoliner - 1500 kW



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WEATHER ROUTING DNA

- Existing weather routing programs:
  - Sail only
  - Sailing, minimum speed
  - Motor only
  - 2012: DNA motor sailing
  - New in 2021: DNA power re-generation

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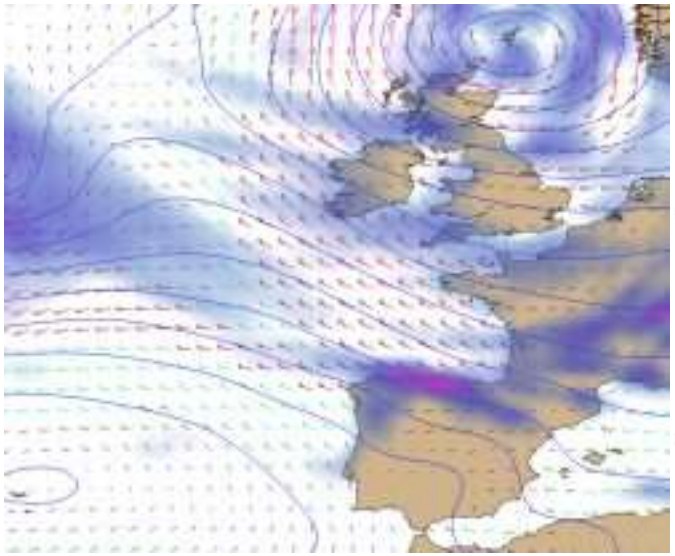
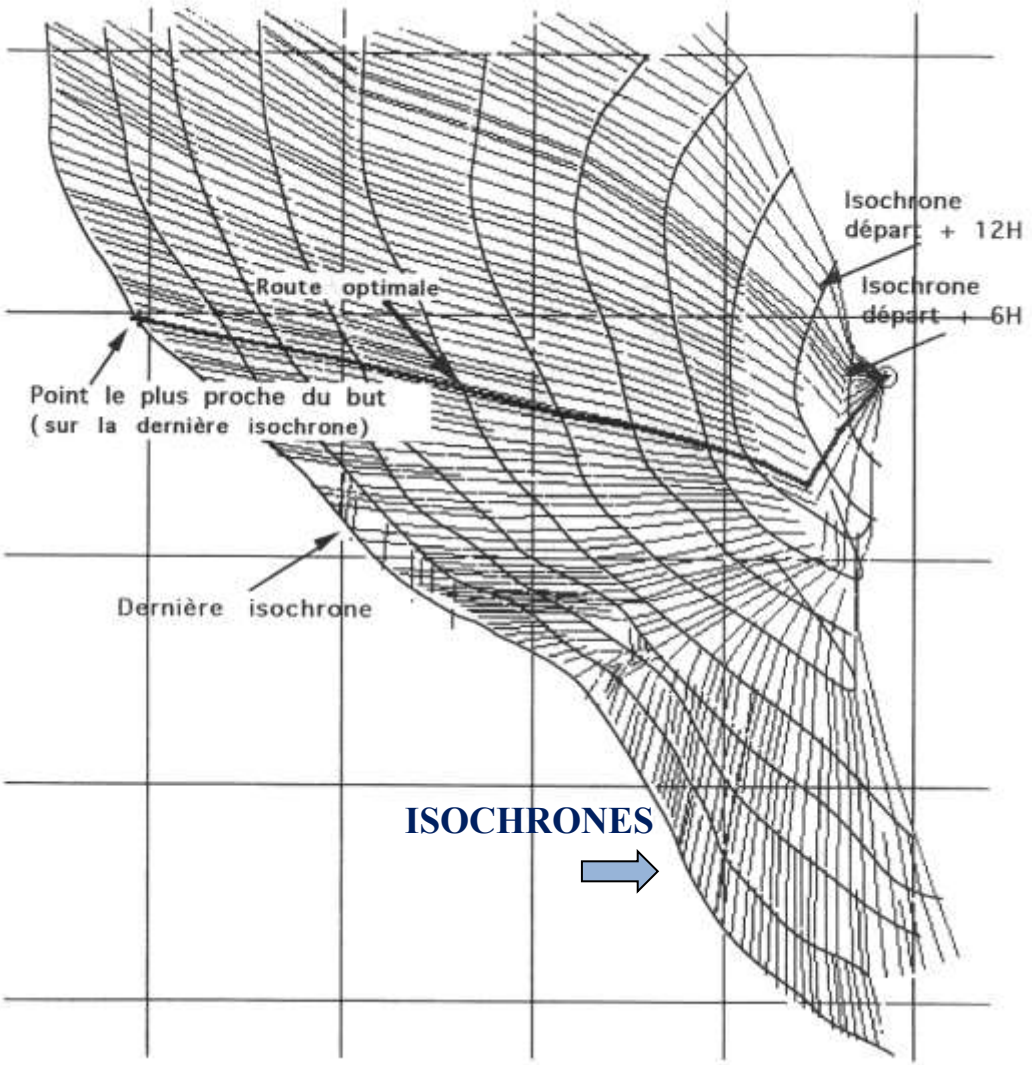
WEATHER ROUTING BASED ON ISOCHRONES
SINGLE OBJECTIVE

- wind info grib files
  - VPP





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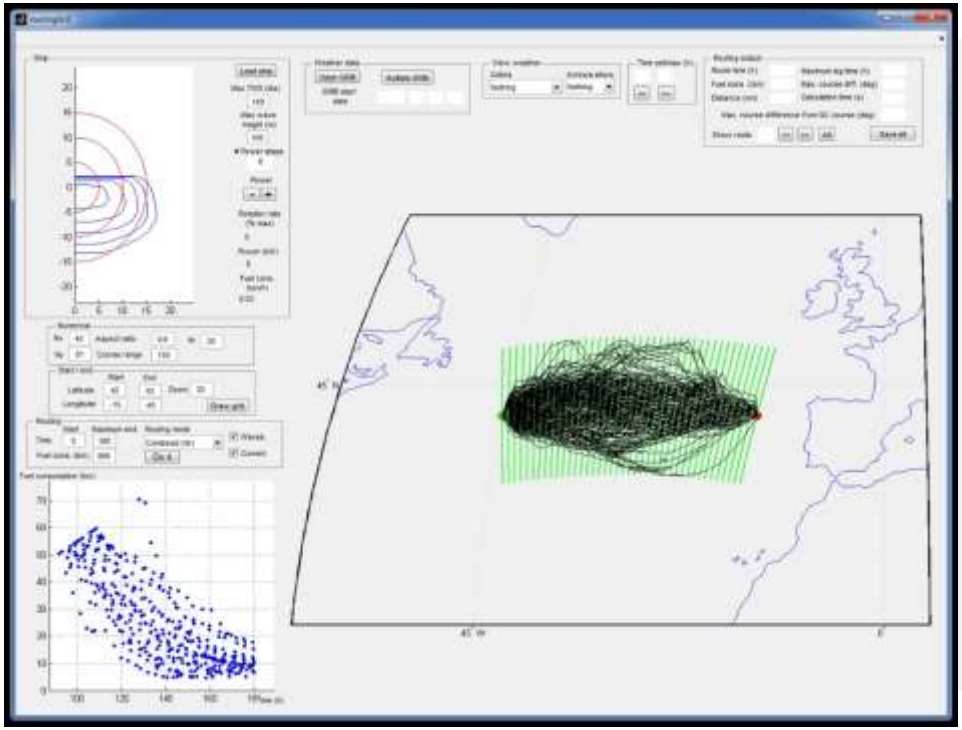
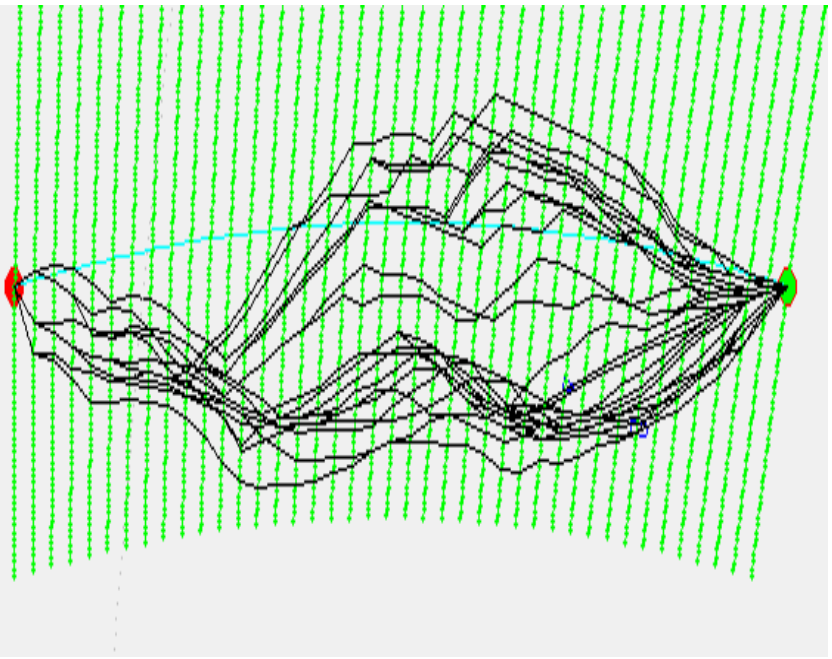
2000 onwards ROUTING FOR MOTOR SAILING
GRID CALCULATIONS, MULTIPLE OBJECTIVES
2012 MULTIPLE ENGINE SETTINGS





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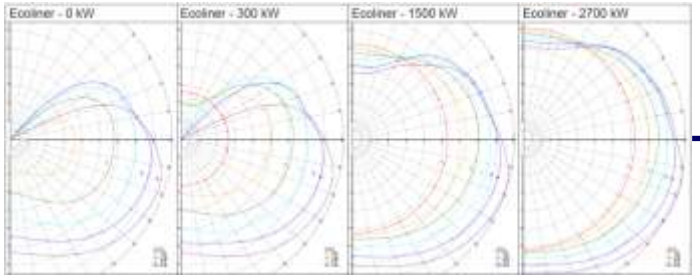
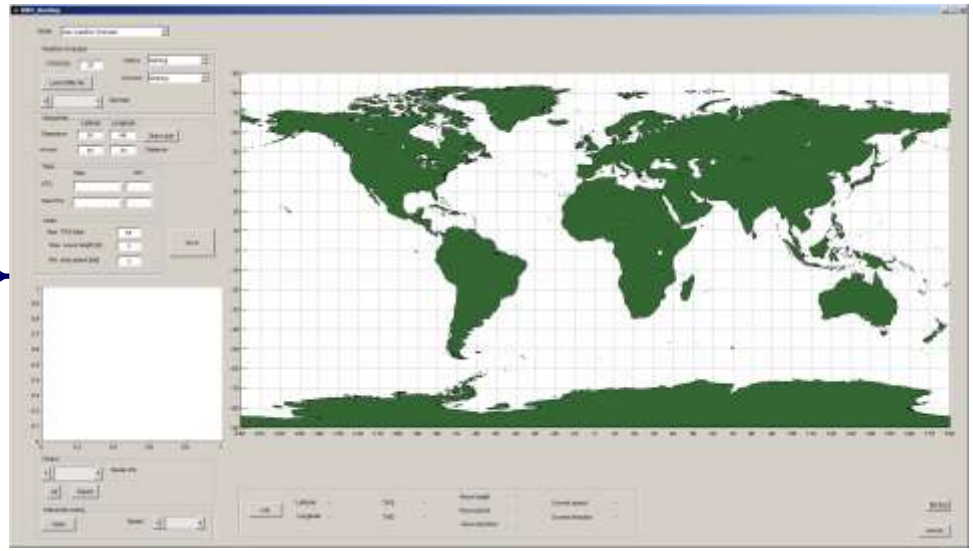
Weather Routing Program input of:

1. Weather information

2. Ship performance





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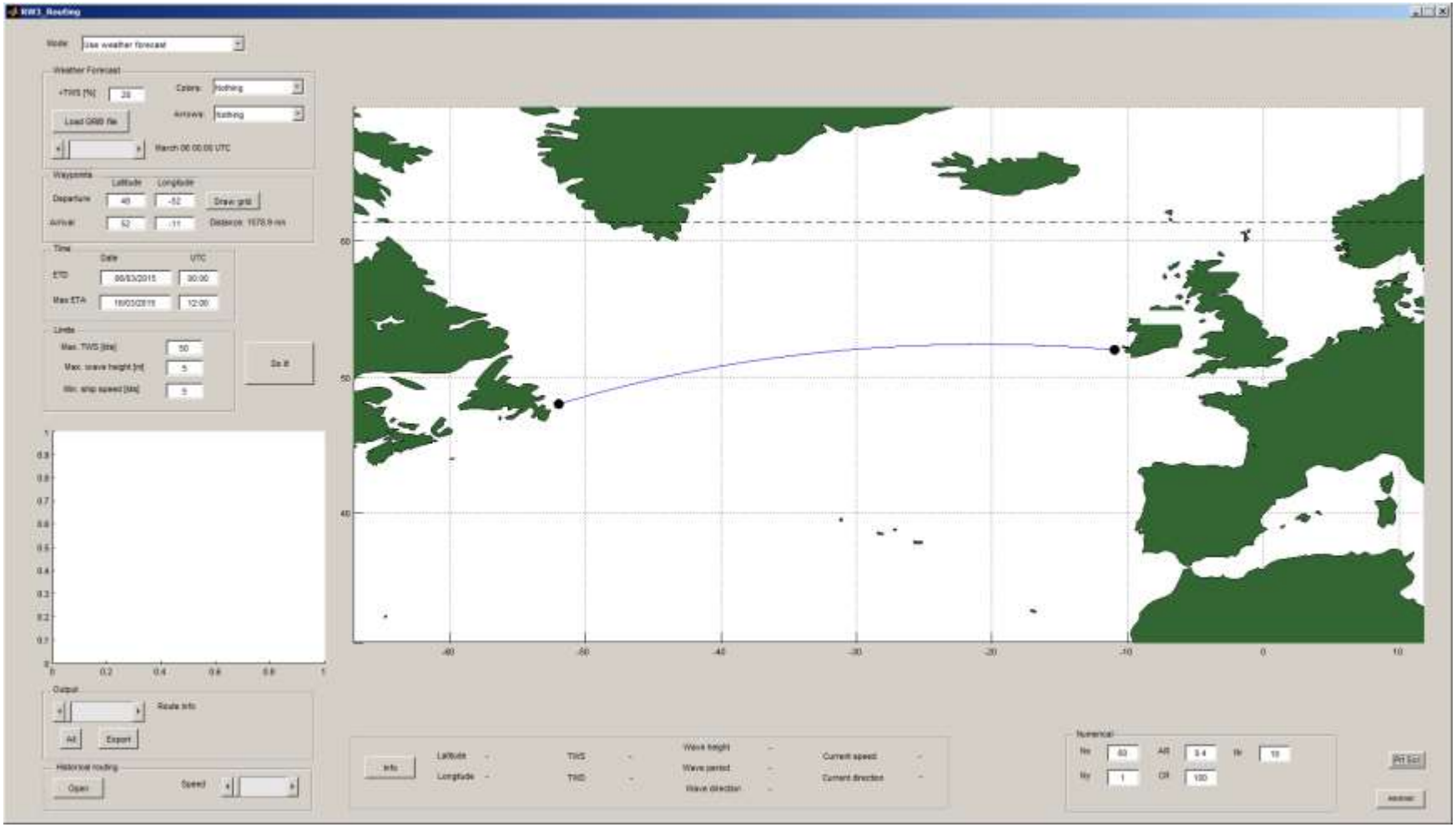
Weather Routing Program selection of route



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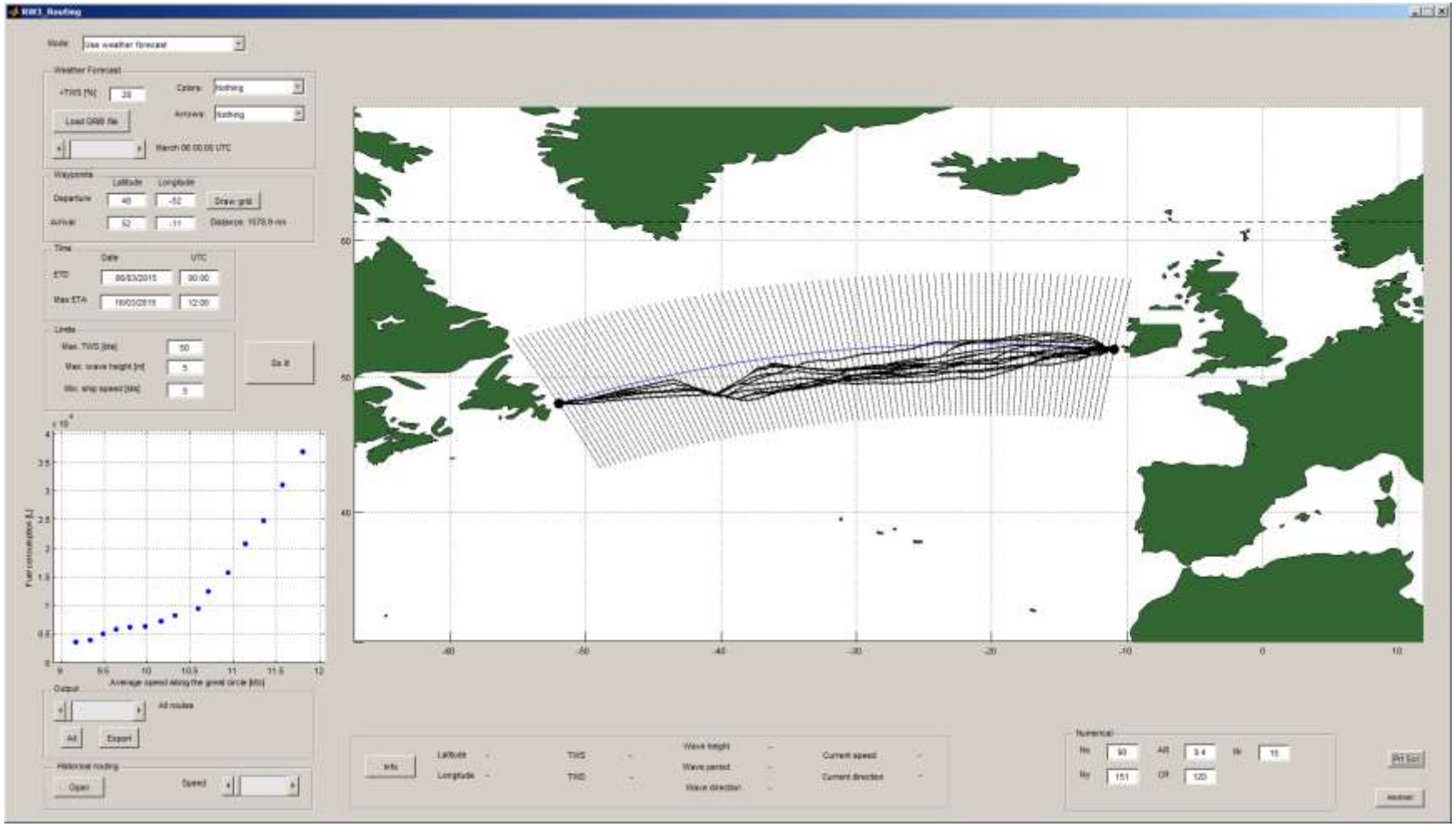
Weather Routing Program optimum routes calculated for a number of selected passage times



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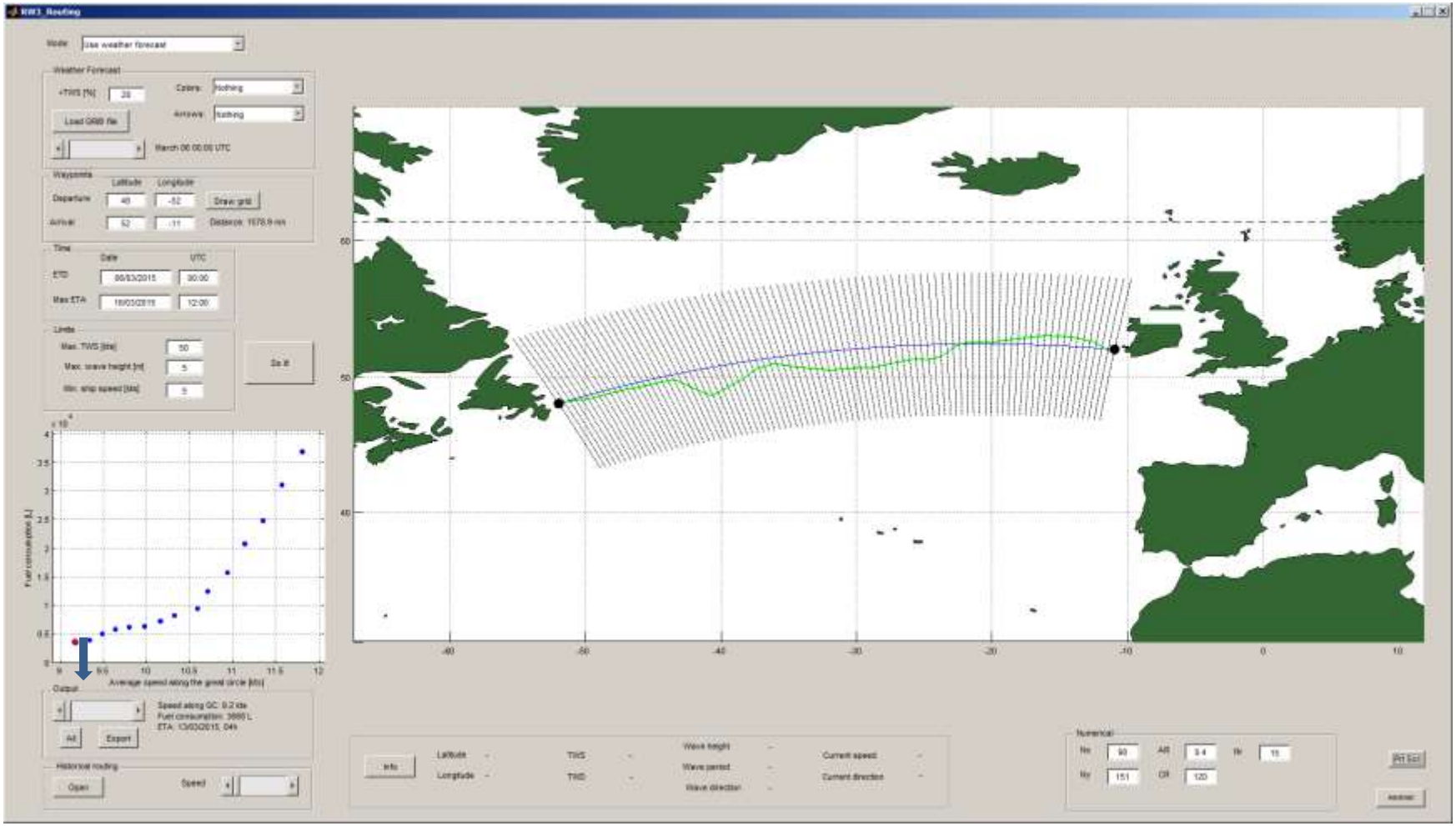
Weather Routing Program, optimum route sailing only



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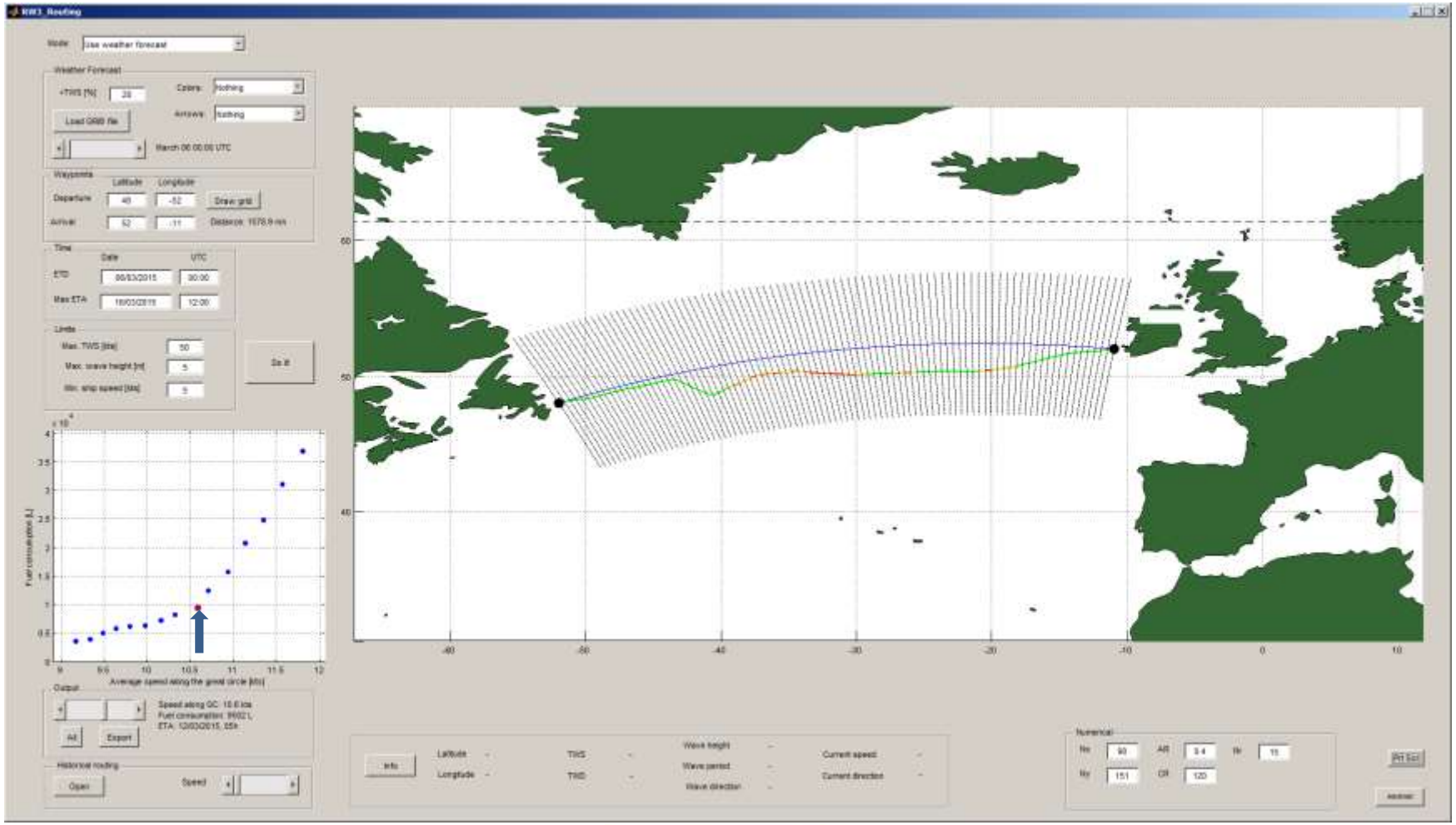
Weather Routing Program, optimum route for a selected passage time using sail and motor



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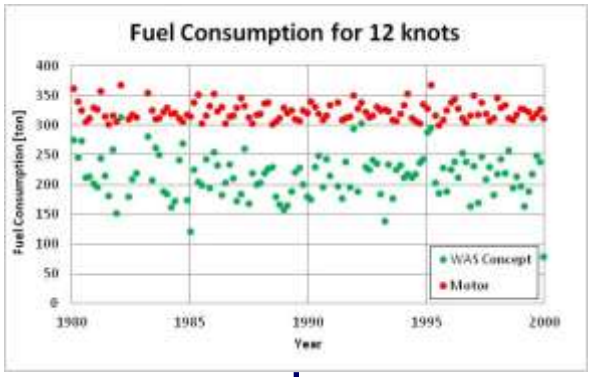
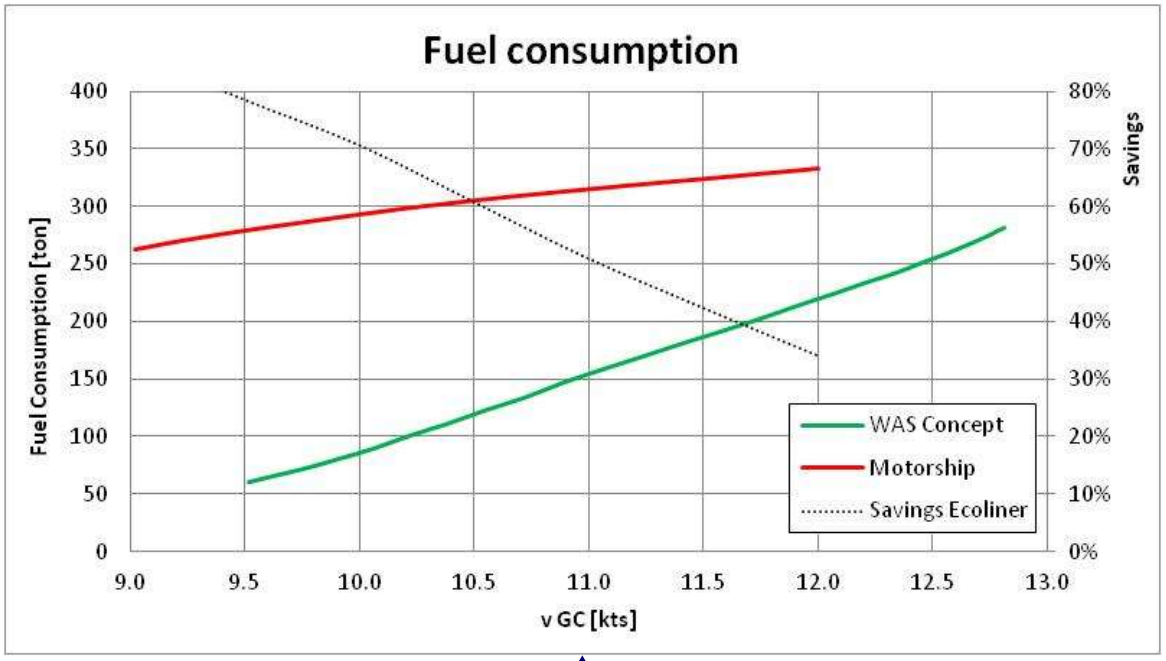
11 KTS IS A GOOD BOAT SPEED FOR WASP

EXAMPLE CALCULATION FOR A 8000 DWT ECOLINER





Average over 20 years for all speeds

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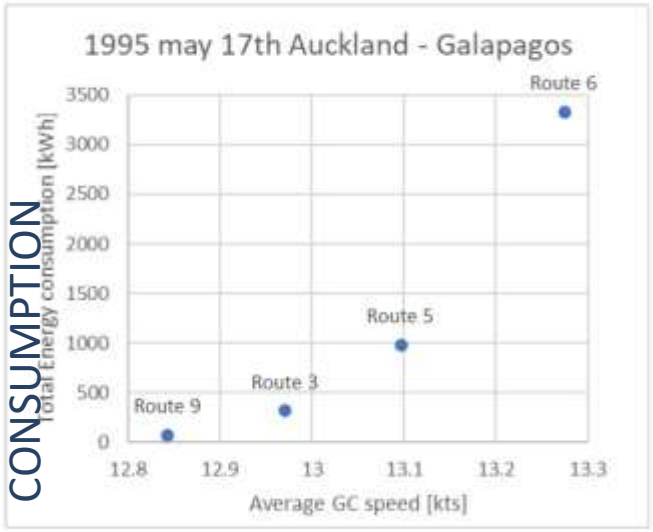
POWER RE-GENERATION ROUTE ANALYSIS 2021

Result for one departure date

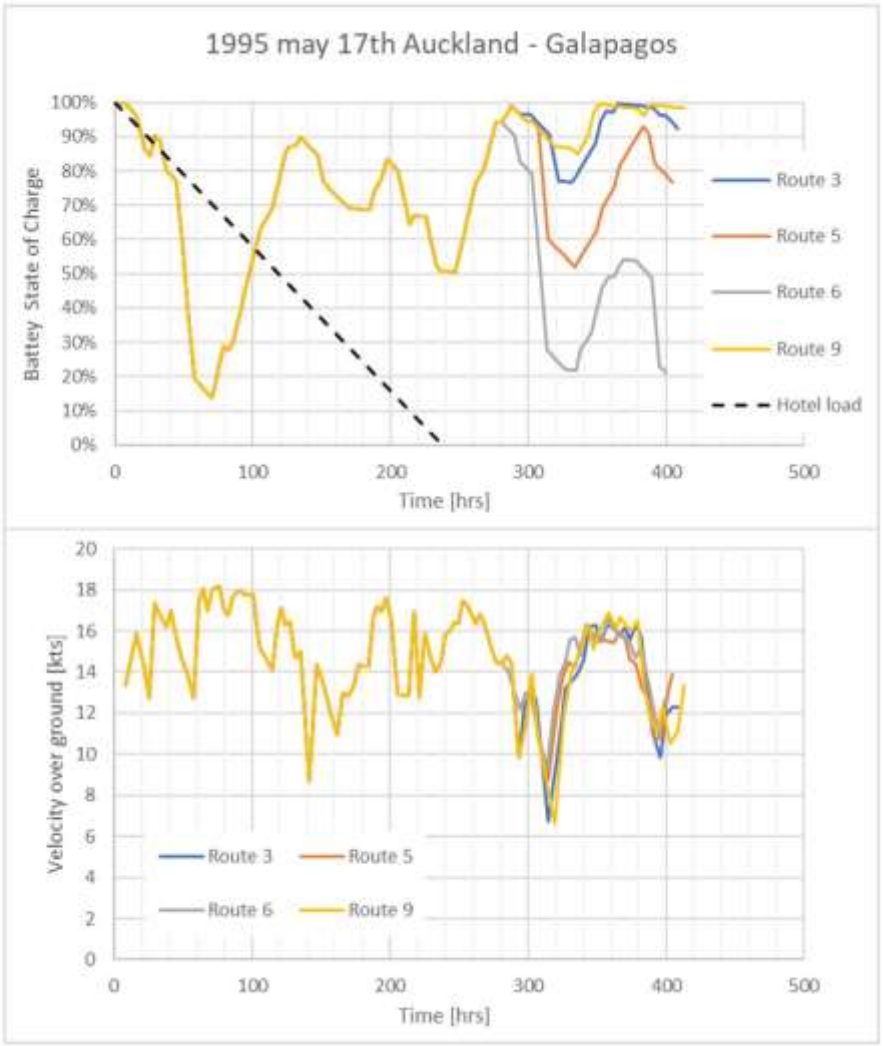
Base sails

Distance		TIME	
5300 nm		hrs	days
Average Boatspeed	9	589	24.5
	10	530	22.1
	11	482	20.1
	12	442	18.4
	13	408	17
	14	379	15.8
	15	353	14.7



ENERGY CONSUMPTION

AVERAGE SPEED



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TRANSITION AND BARRIERS

Why, after all those years, is there hardly any WASP ship operational.

1. CE STUDY 2019, GLOBAL :
   - TRUSTED INFORMATION ON THE WASP TECHNOLOGIES, BOTH CONSTRUCTION, COST AND PERFORMANCE CALCULATIONS
   - INCENTIVES FOR CO2 EMISSION, FUEL COST and others
   - ACCESS TO CAPITAL FOR DESIGNING, BUILDING AND TESTING OF DEMONSTRATORS

2. DNA SPECIFIC BARRIERS TODAY:
   - CONSTRUCTION COSTS COMMERCIAL DYNA RIG
   - CREW & MAINTENANCE REQUIREMENTS DYNA RIG & SOFT SAILS
   - DEMONSTRATOR(S) (LACK OF)

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NAVAL ARCHITECTS

THE FUTURE IS IN MARKETS SUITABLE FOR WASP

	Speed	Ship size in Deep-sea market	Effect rig on cargo handling	Effect on hull shape	Sustainable awareness	Liners	% of Max.
Importance	4	5	3	3	2	4	
Ro-Ro	3	5	5	4	4	5	100
Passenger	3	5	5	3	5	5	99
Chemical Tanker	4	4	5	3	4	4	91
Dry Bulk	5	3	4	3	3	3	80
Specialized Cargo	3	4	4	3	3	3	77
General Cargo	4	3	4	3	3	3	76
Project Cargo	4	3	4	3	3	3	76
Oil Tanker	5	1	5	3	3	2	68
LNG/LPG	1	3	5	2	4	3	65
Container	2	2	2	3	3	4	60
Refrigerated	1	2	2	3	3	4	55

Figure 24 Qualitative comparison of niche markets (Dunné, 2014)

A FINAL NOTE:

WASP ONLY WORKS OPTIMAL WHEN HULL DESIGN AND RIG DESIGN ARE MATCHED.

RETROFIT: SUITABLE FOR LIMITED CONTRIBUTION WASP SYSTEMS

WASP IS NOT A SOLUTION FOR ALL TRANSITIONS TO A GREENER SHIPPING, IT IS ONE OF THE POSSIBILITIES

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THANK YOU FOR YOUR ATTENTION

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