WIND ASSISTED SHIP PROPULSION
DNA involvement, selected test cases and the future

Rainbow Warrior
2011
E-drive & sail

2021, G Dijkstra
CONTENTS

• INTRODUCTION DNA
• HISTORY
• SAILING SHIPS operational
• SAILING SHIPS under construction/ in design / studies
• DESIGN TOOLS
• TRANSITION AND BARRIERS
OCEAN RACING 1969-1980
SECOND LIFE 1972 O.S.T.A.R.
YACHT DESIGN 1975 ONWARDS
LAMINATED WOOD SHIP BUILDING IN INDONESIA
1982-1993
Student Thesis June 2003: Average 13% fuel reduction, for reductions >40% the soft sail route was developed.
2500 years in the past
SQUARE RIG

ILLUSTRATION
P. SCHENZLE

1870

2006

1960

FORE-AND-AFT RIG
RAINFOREST WARRIOR LIFE CYCLE ANALYSIS
MOTOR SAILOR OR MOTOR SHIP

ENVIRONMENTAL IMPACT FOR PRODUCTION, 30 YEARS USE, AND DISPOSAL
IN 1000 ECO-INDICATOR 99 POINTS

- 5% D. Max speed motoring main drive
- 5% C. Economic motoring electric drive
- 45% B. Sailing average
- 10% A. In harbour
- 10% Laid up - maintenance energy
- Production, maintenance, and recycling

SOURCE: TNO
Clipper STAD AMSTERDAM, 2000
GERMANY 1960
DYNARIG DEVELOPMENT  2000 AMSTERDAM
1960 HAMBURG

2003 TURKEY
MALTESE FALCON
2006

No issues with the rig
Full data set from Monitoring system
Rigs never removed & no plans to remove rigs
Sold to new owner 2009

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
Main control panel MALTESE FALCON
2000 ONWARDS
FIBRE OPTIC STRUCTURAL MONITORING, MagmaStructures
SAIL HANDLING MONITORING SOFTWARE, Caccini
BACK-UP SAIL HANDLING PANEL
MALTESE FALCON MAST ROTATION SYSTEM
BLACK PEARL 106m, 2018

Photo Tom Van Oossanen
46m AERORIG DWINGER
REFIT AND RIG DESIGN DNA 2002

Hoofdafmetingen:
Lengte = 46 m
Waterverplaatsing = 300 ton
Zeiloppervlak = 780 m²
Bemanning = 4 pers
ECOLUTION, AERORIG SCHOONER, a self sustained yacht, 2011
SOFT SAIL WING
MAST
DNA design 2012
Sea trials and load
Measuring
On a 30 ft hull,
For designing a
1000 m2 rig.
RAINBOW WARRIOR LAUNCHED 2011
2012-2016 150,000 NM SAILED
2018 MARIN, MEASUREMENTS ON A FREE SAILING MODEL OF A SAILING SHIP (or YACHT)
ECOLINER 8000 DWT WITH FLETTNER ROTORS OR DYNARIG
Related VPP DEVELOPMENT reported during this symposium separately by MARIN

DYNARIG TO WINDWARD, MOTORSAILING
FLETTNER ROTOR, DOWN WIND, MOTOR SAILING
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

DYKSTRA
NAVAL ARCHITECTS
SAIL CARGO, 2021
HIGHER SPEED, LESS CARGO
ECO CAR CARRIER 170m
Design study 2016

Main Particulars

- Lengte over alles: 170.0 m
- Lengte waterlijn: 170.0 m
- Breedte max: 25.2 m
- Breedte waterlijn: 25.0 m
- Diepgang max: 8.5 m
- Diepgang romp: 7.2 m
- Doorvaarthoogte: 70.8 m
- Volume: 17676 m³
- Displacement: 18118 ton
- Deadweight: 8580 ton
- Windweerstand opp.: 5061 m²
- Zeil oppervlak: 5000 m²
SEABRIDGE ONE  36M
Disaster relief and medical support vessel, in design
SEABRIDGE ONE  36M
Disaster relief and medical support vessel
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
ECOLINER RUDDER versus SKEG CFD CHECK

Baseline (Ecoliner)  
Eco2 (Simple skeg)
Polar Diagram – Sailing Performance

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

TRUE WIND DIRECTION

TWS 6 KTS

TWS 25 KTS
Thrust Prediction Program

- DNA in office software

Showing the required power for constant boat speed at different wind speeds
Polair diagram sail and selected thrust
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
WEATHER ROUTING BASED ON ISOCHRONES
SINGLE OBJECTIVE

- wind info grib files
- VPP
2000 onwards ROUTING FOR MOTOR SAILING
GRID CALCULATIONS, MULTIPLE OBJECTIVES
2012 MULTIPLE ENGINE SETTINGS
Weather Routing Program input of:

1. Weather information

2. Ship performance
Weather Routing Program selection of route
Weather Routing Program optimum routes calculated for a number of selected passage times
Weather Routing Program, optimum route sailing only
Weather Routing Program, optimum route for a selected passage time using sail and motor
11 KTS IS A GOOD BOAT SPEED FOR WASP
EXAMPLE CALCULATION FOR A 8000 DWT ECOLINER

Average over 20 years for all speeds
POWER RE-GENERATION ROUTE ANALYSIS 2021

Result for one departure date
Base sails

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<th>Distance (nm)</th>
<th>Average Boatspeed</th>
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1995 may 17th Auckland - Galapagos

Battery State of Charge

Total Energy consumption [kWh]

Average GC speed [kts]

Velocity over ground [kts]

1995 may 17th Auckland - Galapagos
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)
THE FUTURE IS IN MARKETS SUITABLE FOR WASP

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<th>Speed</th>
<th>Ship size in Deep-sea market</th>
<th>Effect rig on cargo handling</th>
<th>Effect on hull shape</th>
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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
Wind-Propeller Sails Proposed For Liners

Air blast from fan turns windmill mounted on model boat, in demonstration at English inventor’s exhibit. At right is artist’s conception of ocean liner using the wind-propeller sails.

THANK YOU FOR YOUR ATTENTION