# Measuring, Monitoring and Reducing CO2

December 18th 2013

# Programma

| | | |
|---|---|---|
| 13.30 – 13.55 | Opening | David Anink |
| 13.55 – 14.20 | $CO_2$ emissions from shipping | Eelco Leemans |
| 14.20 – 14.45 | EEDI for small ships | Guus van der Bles |
| 14.45 – 15.10 | Real Efficient Ships | Peter van Terwisga |
| 15.10 – 15.35 | MRV EU debate | Henk-Erik Sierink |
| 15.35 – 16.00 | Break | |
| 16.00 – 16.25 | How to manage your fleet efficiently | Arne Hubregtse |
| 16.25 – 16.50 | Options for monitoring emissions | Jasper Faber |
| 16.50 – 17.15 | $CO_2$ reduction a ship owners vision | Peter Hinchliffe |
| 17.15 – 17.45 | Discussion | |
| 17.45 | Drinks | |

# Stichting De Noordzee

## Climate Change and shipping

Platform Schone Scheepvaart 18 december 2013

Eelco Leemans

The North Sea Foundation

# North Sea Foundation
## *Stichting De Noordzee*

**Our mission:**
*Striving towards sustainable use of the North Sea*

- Environmental organisation since 1980
- 17 staff
- Board of 6 members

*Solution driven* approach
Constructive dialogue with sectors and other stakeholders

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# Programmes and areas of interest

- MPA´s
- Sustainable fisheries (VISwijzer, Award 2010)
- Clean Shipping (Sustainable Shipping Award 2010)
- MyBeach clean up campaign
- Microplastics


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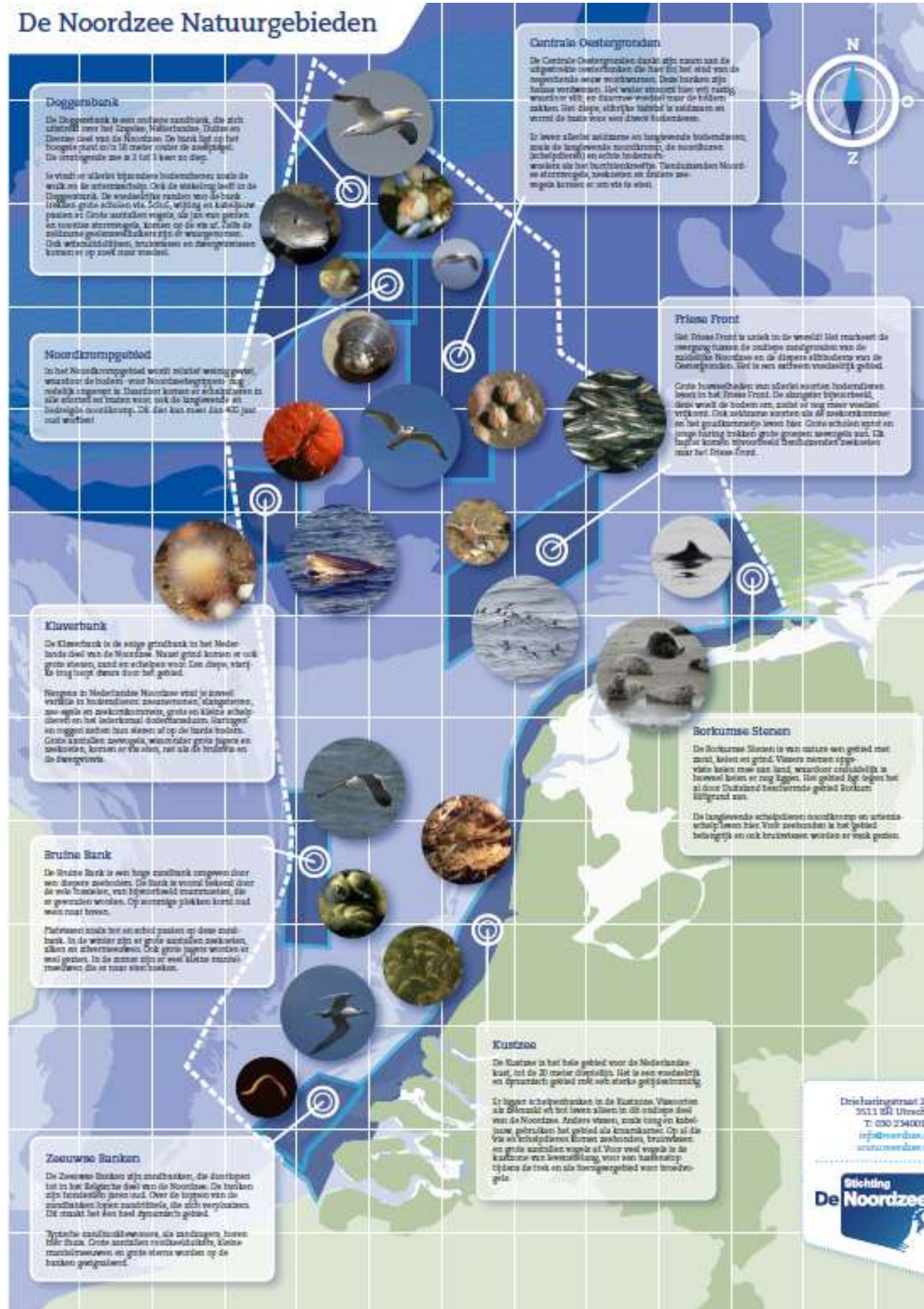
- Marine Protected Areas

# Programme Clean Shipping – NSF's international work

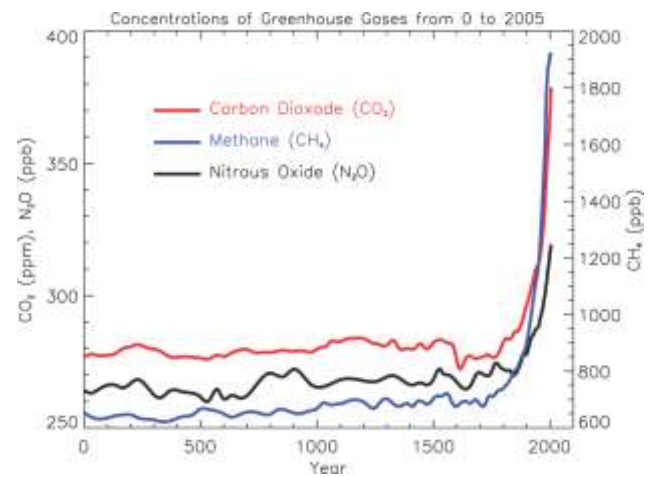
8 International environmental NGO's teaming up in the Clean Shipping Coalition (CSC)

**http://cleanshipping.org/**

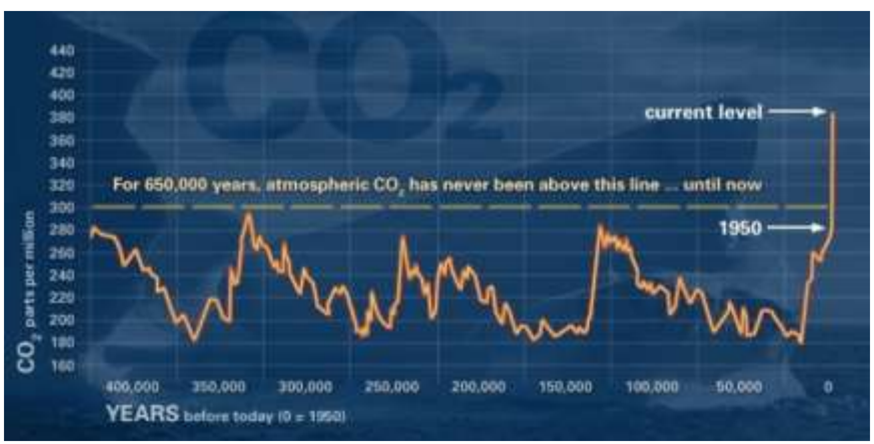
# The problem of Climate Change and the necessity to act

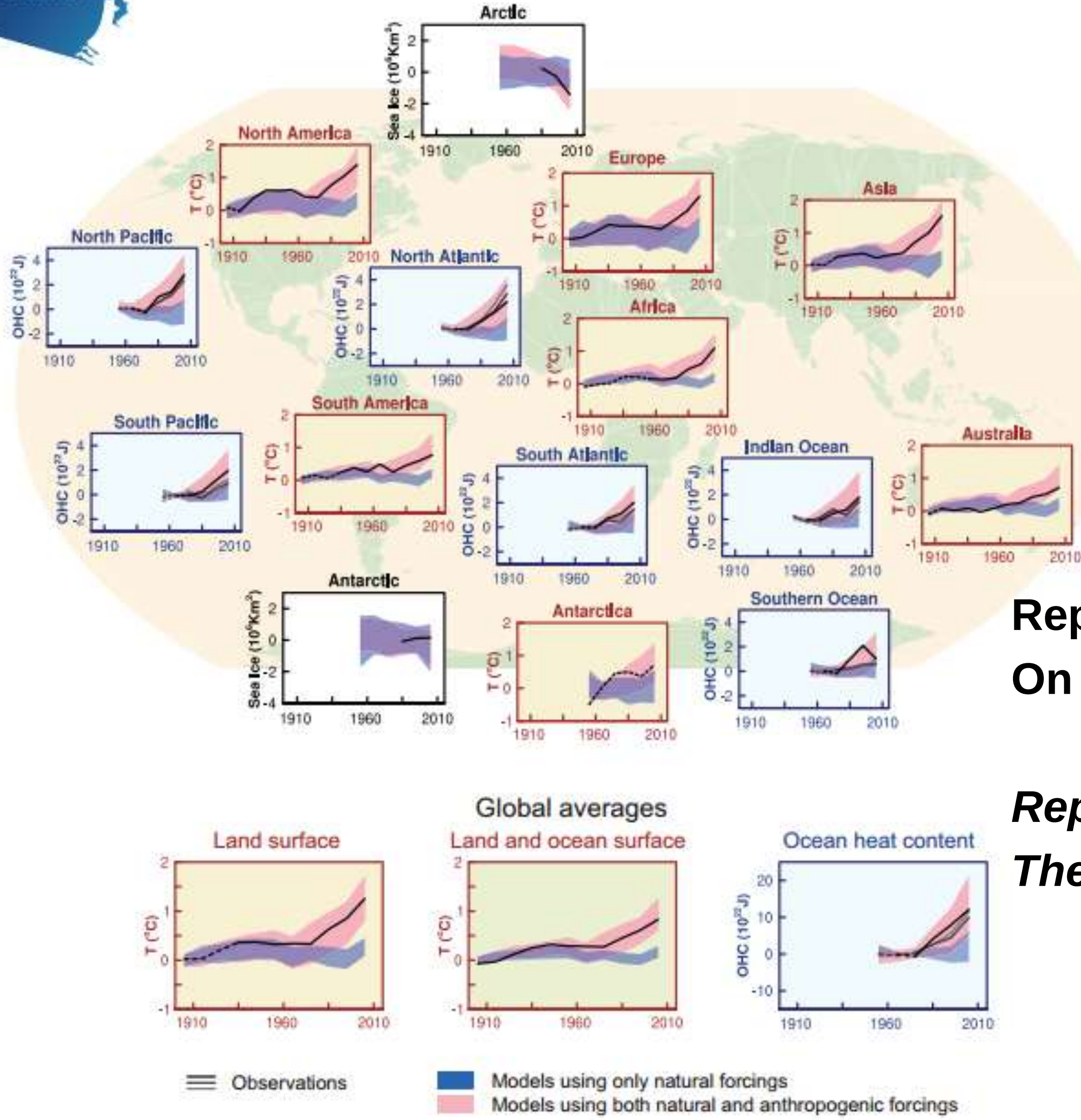
- Long scientific and political debate has concluded…
- The climate is changing

- **humans enhance the natural GHG effect**





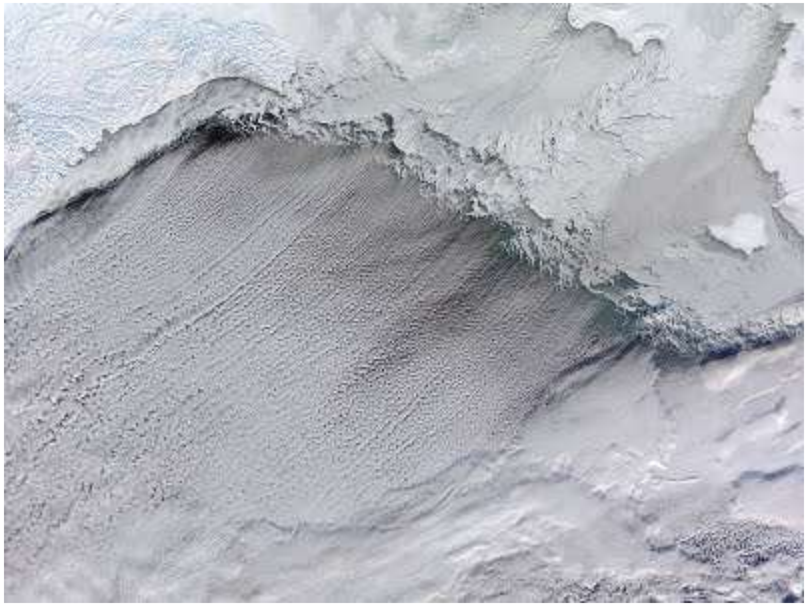



**Report Intergovernmental Panel On Climate Change (IPCC)**

***Report Climate Change 2013 The Physical Science Basis***

# Additional to $CO_2$: Black Carbon



Caused by incomplete combustion of fuel

Lowers albedo, increases melting of ice

Shipping 2 % of global emissions
But impact many times higher
Emissions are close to area of impact

Causes further climate change  (chain reaction)

# Consequences for the marine environment

*Increased CO2 storage in oceans:*

**Ocean acidification**

- Negative impacts shell-forming organisms

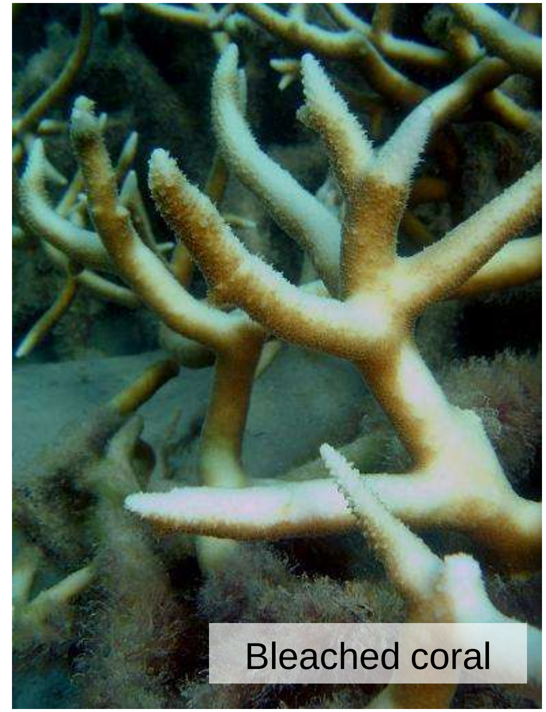
*Increased sea water temperatures:*

**Coral bleaching**

- corals release their algae
- deadly if prolonged

**Phytoplankton declines**

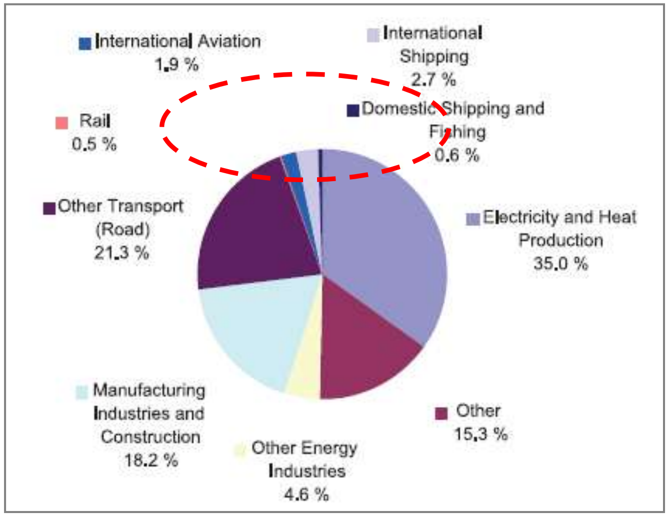
**Lower nutrient supply**




**Time for action!**

# The role of shipping and the maritime industry

shipping emits 2.7% of human-based $CO_2$ by burning of fossil fuels. (2nd GHG study 2009)




- 2,7 % is about 870 million tons
- A relatively low contribution ~ 90 % of all world trade → shipping
- However, attention also on shipping, because:
  - these emissions comparable to those of a major national economy (ICS 2009)
  - international shipping produces more $CO_2$ than all air transport

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In principle, shipping has a *favourable starting position*
-‘economies of scale’
(long distances, larger ships)
- efficient engines

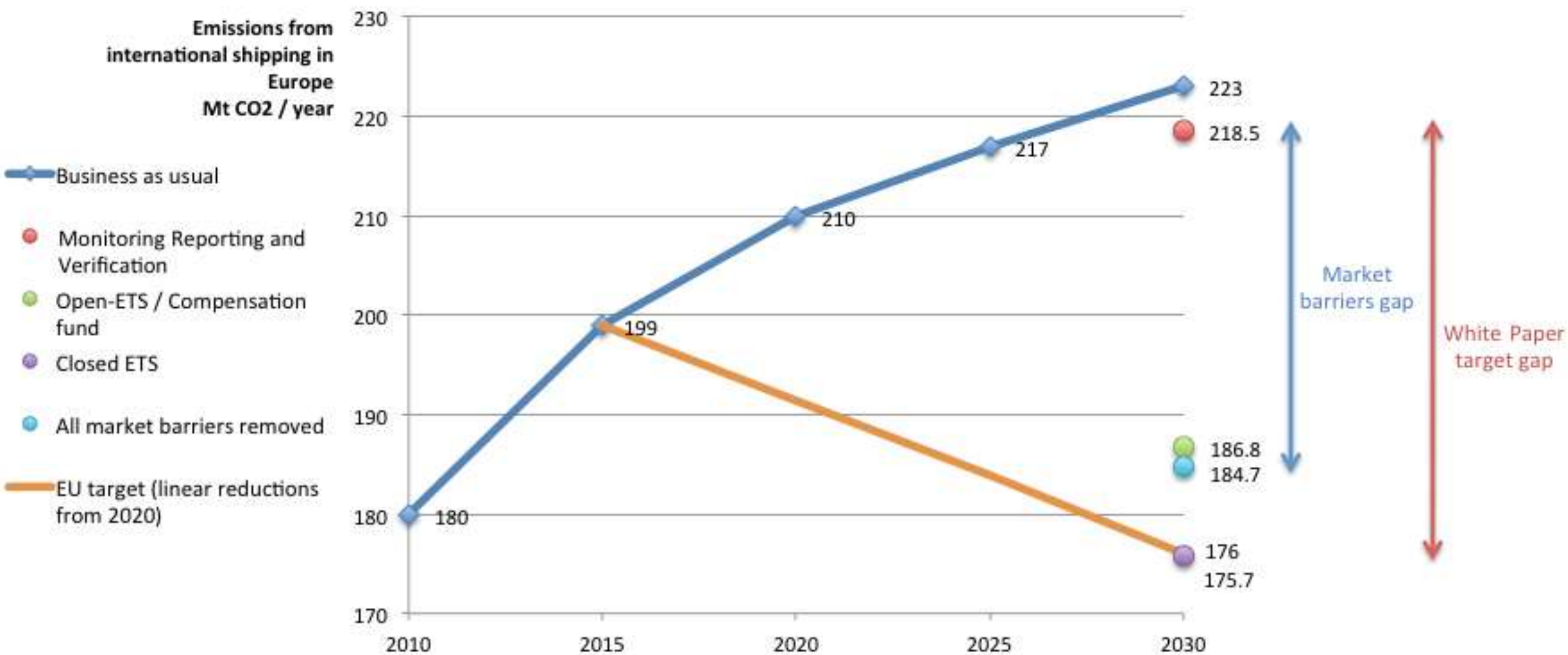
**However:**
$CO_2$ emissions will most likely be four times higher by 2050

… ongoing globalization and increased speed of shipping

# Policy Measures IMO/ EU

## The European “phased approach” has to be complemented by a clear pathway towards effective emissions reductions

**Emissions from maritime transport: trends and projections of different policy options to 2030**




Source: impact assessment of MRV by the European Comission 2013

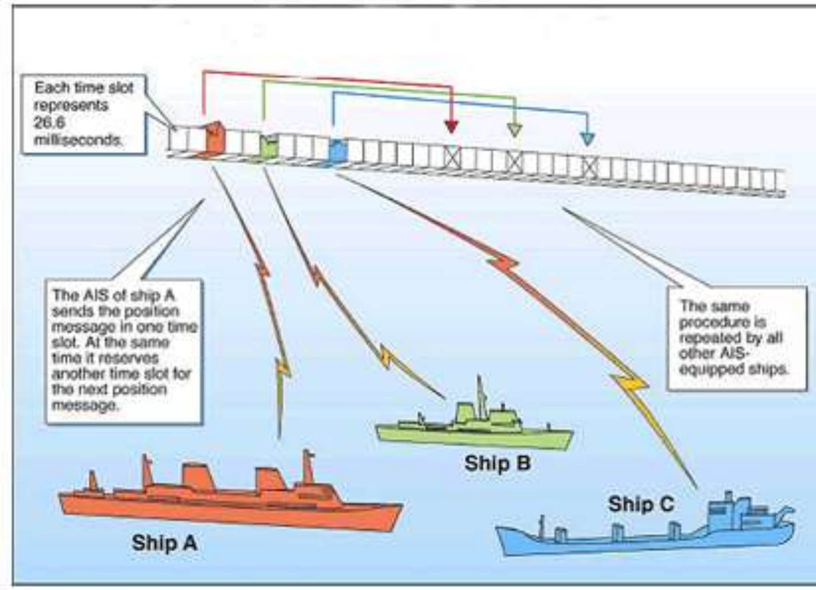
Approaches for Monitoring, Reporting And Verification (MRV)

- BDN: sensitive for fraud

- Learn from experiences Clean Shipping Index

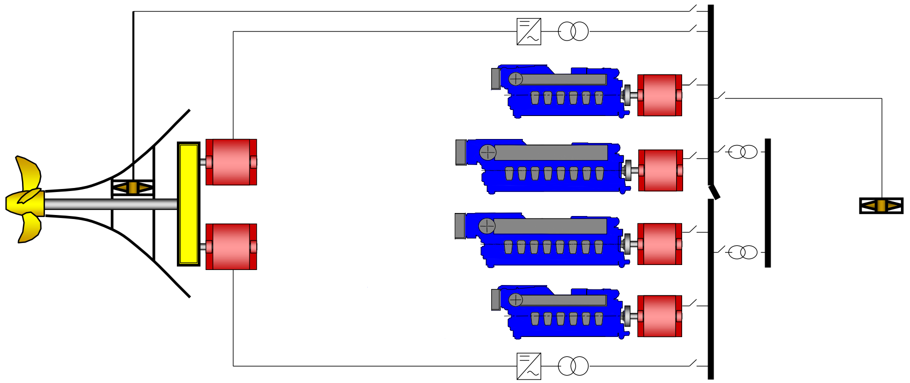
- AIS and real time emission measurement is technically feasible

- Will increase transparancy and reduce administrative and cost Burden for the industry



# Potential of technical and operational measures

Emission reduction potential
Of technical and operational
measures
(Wärtsilä ao)



- Ship design measures – depending on ship type – up to 15 % (for example air lubrication)
- Alternative fuel (ie LNG): around 10 %
- Propulsion method several to10-20 %
  (ie wind assisted propulsion)
- Other ship engines: up to 20 % (diesel-electric)
- Operational and maintenance: up to **23 %**
  (speed reduction, weather routeing)

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# Future Outlook

*EU Interreg SAIL Project*

Developing 1st generation modern wind assisted propulsion ships is a matter of time

sail

Sail into a sustainable future

*EcoLiner*: use of Dynarig sails, limited use of MDO driven auxiliary engines

Dry bulk might be viable first option

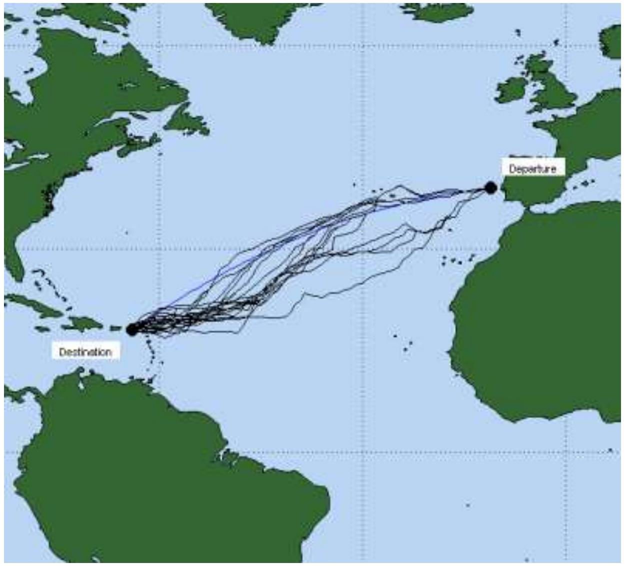
## Japanese and German consortiums are seriously working to commercialise wind driven trade routes within years

Mitsui O.S.K. Lines (MOL), Nippon Yusen (NYK), Kawasaki Kisen (K Line) and Oshima Shipbuilding + Tokyo University developing a 80,000 gt vessel that can be driven by wind, conventional fuel or a combination of both.

Sails made of aluminium and fibre-reinforced plastic and computer controlled to find the best trim.

Ship can also use intermediate fuel oil (IFO) but in winds of at least 12 metres p/s  possible to operate under sail power alone.


Wind assisted propulsion depending on trade routes + type of cargo





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# Seminar $CO_2$

# EEDI for small ships

## *Minimum power requirements*

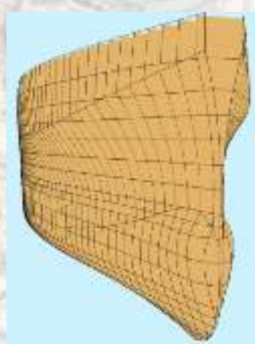
*By: Guus van der Bles MSc*

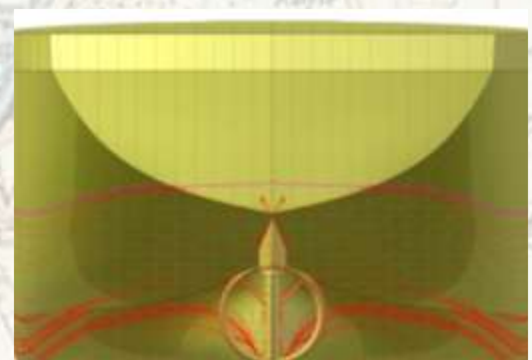
# *Program*

1. Introduction
2. EEDI for Small Ships:
    1. IMO-theory
    2. Small ships corrections
3. eCONOlogy optimisation: ConoDuctTail, Lady Anna
4. Minimum Power Requirm.
5. Conclusions/discussion

# *Introduction*

– Guus van der Bles: Dir. Conoship + ass.Prof. TU Delft
– Drive: to apply innovations in ships
– Focus  R&D:  Economy  & Ecology : ‘eCONOlogy’
  - **Saving fuel and emissions by hull + thrusters**
  - **ConoSeaBow & ConoDuctTail with CFD**
  - Windpropulsion units TurboSail
  - LNG for propulsion





# *Intro Conoship*

– 60 year Design office in Groningen
– Specialist innovative designs for Short Sea Shipping : all types 30 to 130 m Length
– abt. 2000 ships of our design sailing : “World Market Leader” in ‘coasters’
– Focus  to apply practical innovations, oa LNG, Open Top, Dredgers



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# *Fastest Project-cargo vessel: < 3000 GT, <3000 kW, >18 kn*

# *Small Project-cargo vessel < 3000 GT, OpenTop , Max m2*


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# 4500 m3 Trailing Suction Hopper Dredger


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# *Pilot Station Vessel: Polaris*



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# LNG tanker Pioneer Knutsen: which is Conoship Design ?

# EEDI-Champion: mv Lady Anna
# eCONOlogy optimisation:
# 3700 tdw, 749 kW, 10,8 kn
# EEDI of 60% of allowable

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# 2. EEDI for Small Ships: part 1: IMO theory(1)

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}**\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

Looks theoretical and complex:

- To be calculated in design
- To be measured at trails

‘Attained EEDI’ below max value of ‘Required EEDI’


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# EEDI part 1: IMO theory(2)

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$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}**\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

- $P_{ME}$ = 0.75 * ($MCR_{ME}$ – $P_{PTO}$) => enginepower = kW
  = at $P_{ME}$ will Vref be determined => speed = kn.
- $C_{FME}$ = Conversion factor : gram $CO_2$ -emissie per gram fuel (high for HFO, low for LNG)
- SFC = Specific Fuel Consumption from testbed gr/kW.hour
- $P_{AE}$ = "Normal maximum sea load" ~ 5% MCR

⇒ Above the line: gr CO2/hour ( Numerator)

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# EEDI part 1: IMO theory (3)

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}**\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

- $CO_2$ emissions for electrical power, PTI
- Reductions for innovative electrical energy efficient technologies

⇒ Above the line: gr CO2/hour
( Numerator)

# EEDI part 1: IMO theory(4)

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}{*}\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}{**}\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

Capacity = deadweight at summer draught

$V_{ref}$ = Speed at summer draught at $P_{ME}$, = 75% MCR, corrected for PTO

= Trail speed (no wind/waves)

⇒ Below the line: ton x miles/hour (denominator = transport capacity)

⇒ EEDI : gr $CO_2$ / ton x miles

# EEDI part 2: Corrections

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}**\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

Correction factors:

- $f_j$ = power correction factor for iceclass $f_j \leq 1$
- $f_i$ = Deadweight correction factor, f.e for icebelt construction $f_i \geq 1$
- $f_w$= correction factor for slowing down in heavy seaways
- $f_c$ = Correction factor for tankers;

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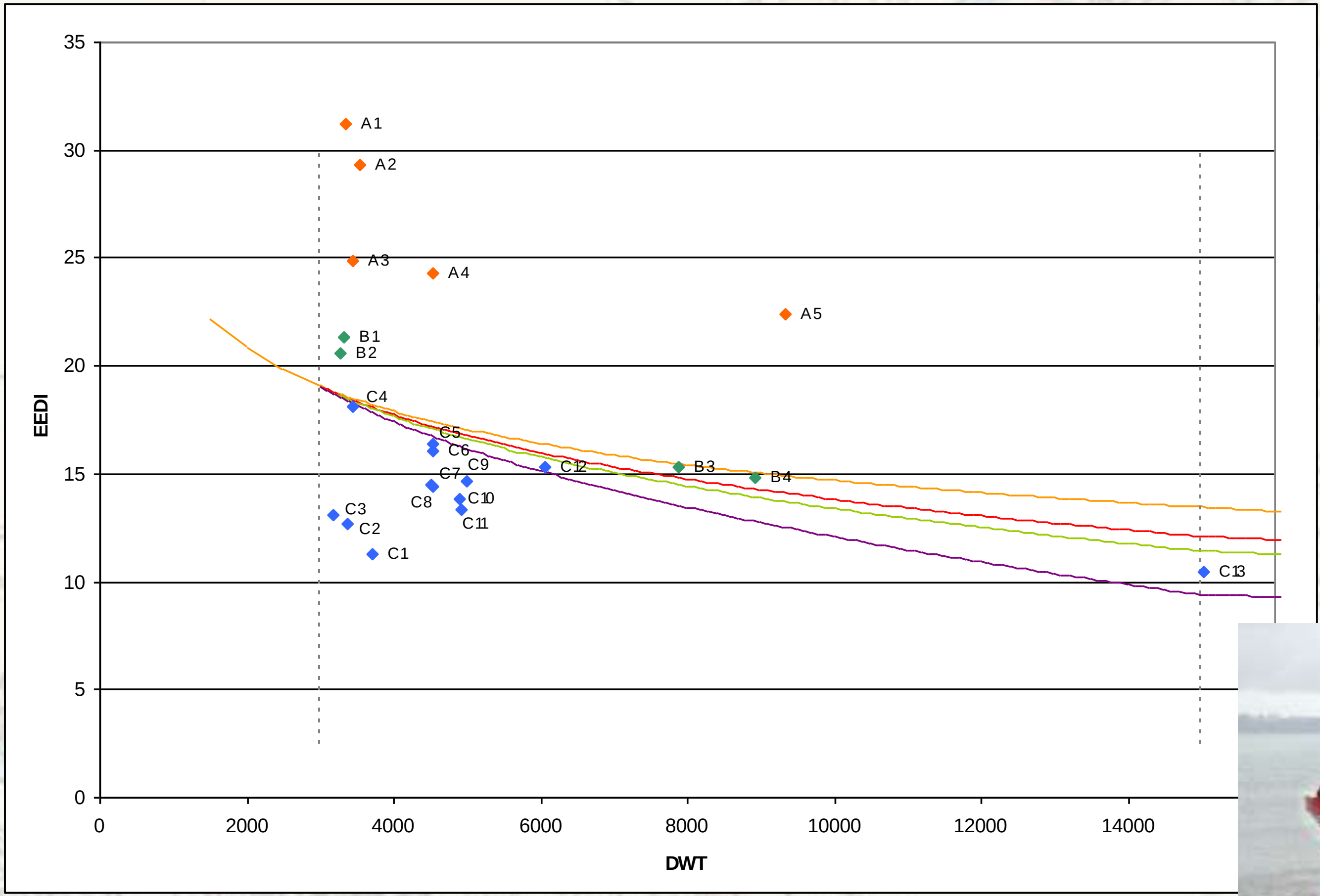
# Wide spread of EEDI- values for small Gen.Cargo Ships



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# Proposed correction factors EEDI, small Gen Cargo Ships

- Correction factor  for loss of deadweight by cargo handling gear (cranes, side-loaders ed)
- Correction factor for loss of deadweight by heavier construction for specific class notations (grab unloading)
- Correction factor for operational profile requiring higher speed

Conoship & MARIN made analysis,
Proposal and presentation for IMO:

Corrections included in IMO regulation

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# 3. eCONOlogy optimisation: ConoDuctTail (1)

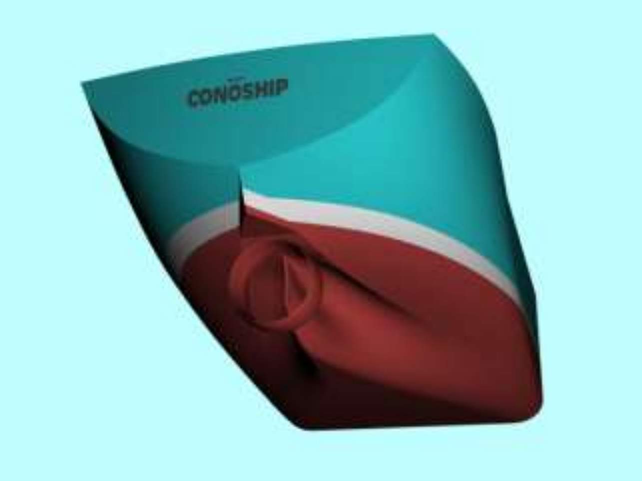
EEDI + economy + ecology => eCONOlogy

Focus Conoship: innovative hull forms !

– Reduction of emissions and fuel consumption
– Optimal behavior in seaway
– 1e focus: aftship ConoDuctTail

Goal: best energy efficiency !

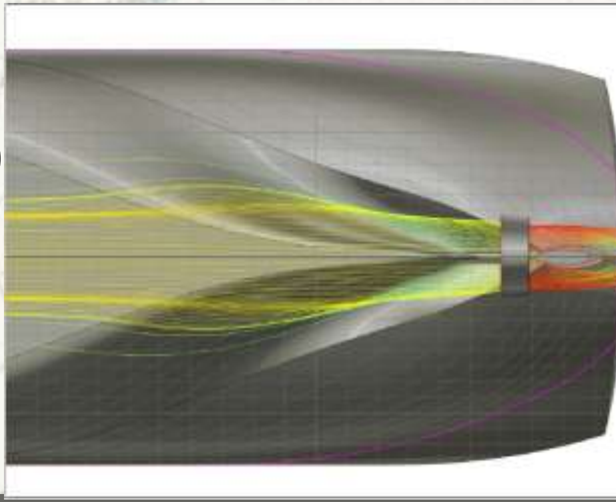
(= more than lowest resistance...)



# R&D study optimisation aft-ship forms (1)

Conoship performed R&D project with MARIN en TU Delft : analysis of aft-ship forms:

- Diesel-driven single prop most efficient
- Propeller diameter mostly not maximum
- 3 types of forms:
    - Extreme pram-shape (modern)
    - Tunnel-shapes (shallow draught)
    - Moderated pram-type



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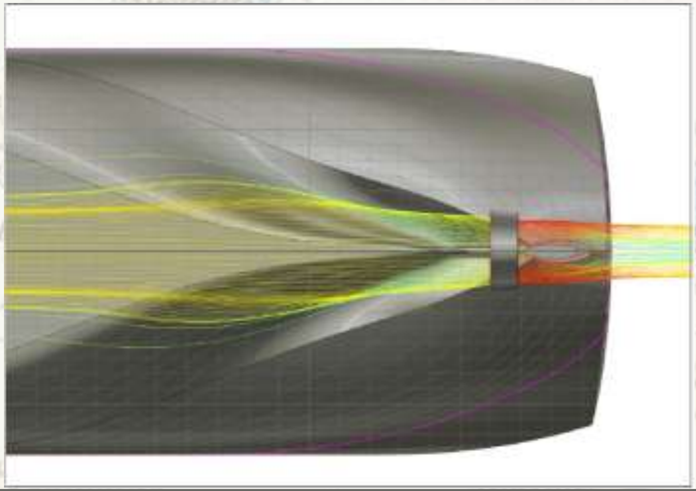
# Development ConoDuctTail (1)

Goal: integral optimisation of aft-ship form, tunnel, nozzle & propeller design

- Maximum propeller diameter
- Nozzle integrated in tunnel
- Minimising resistance to level of moderated pram-form
- Propeller design tuned to high wake and maximum propulsive efficiency



# Development  ConoDuctTail (2)

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Integral optimisation of aft-ship form, tunnel, nozzle & propeller design :

– Cooperation with best specialists

– CFD analyses with Van Oossanen

– Propeller & nozzle design with SasTech

– Modeltests MARIN & DST Duisburg

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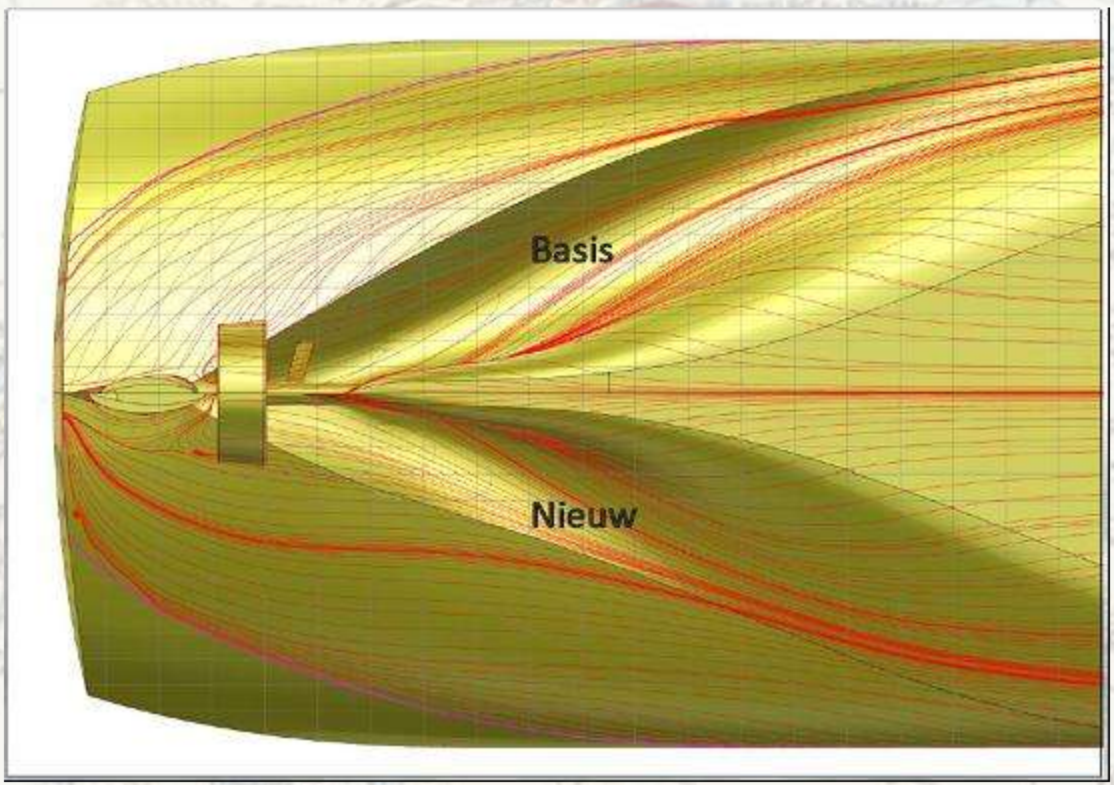
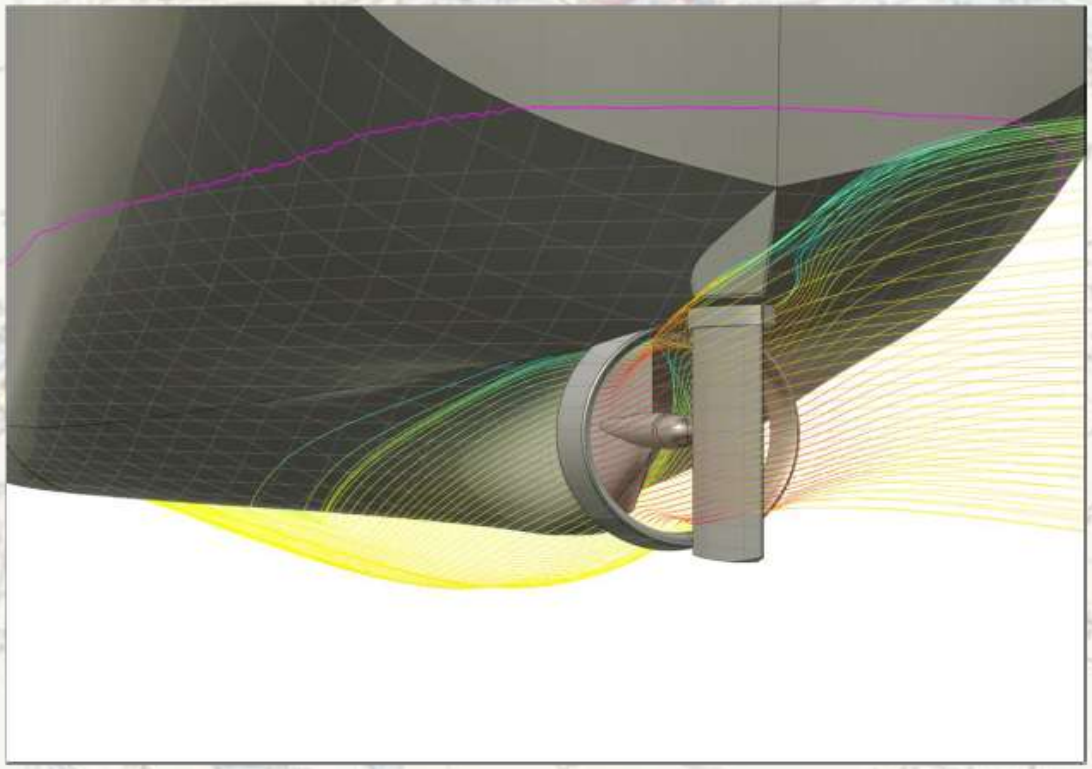
# Development ConoDuctTail (3)

CFD optimisation of aft-ship form, tunnel, nozzle & propeller design :



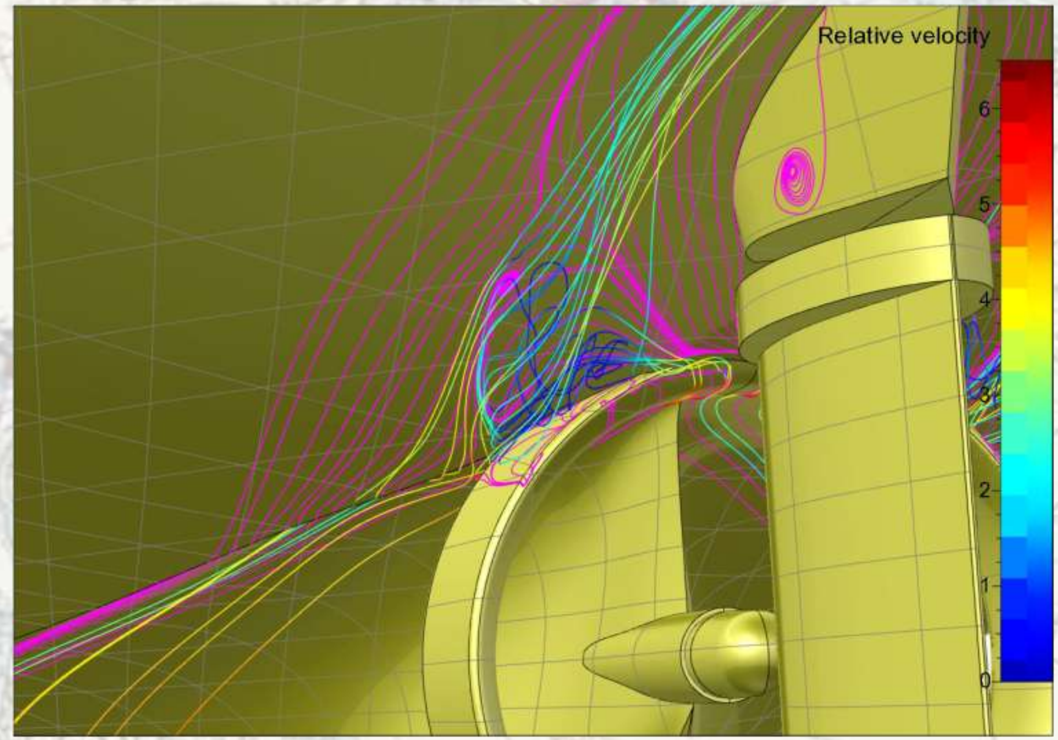
# Development ConoDuctTail (4)

CFD optimisation of aft-ship form, tunnel, nozzle & propeller design :



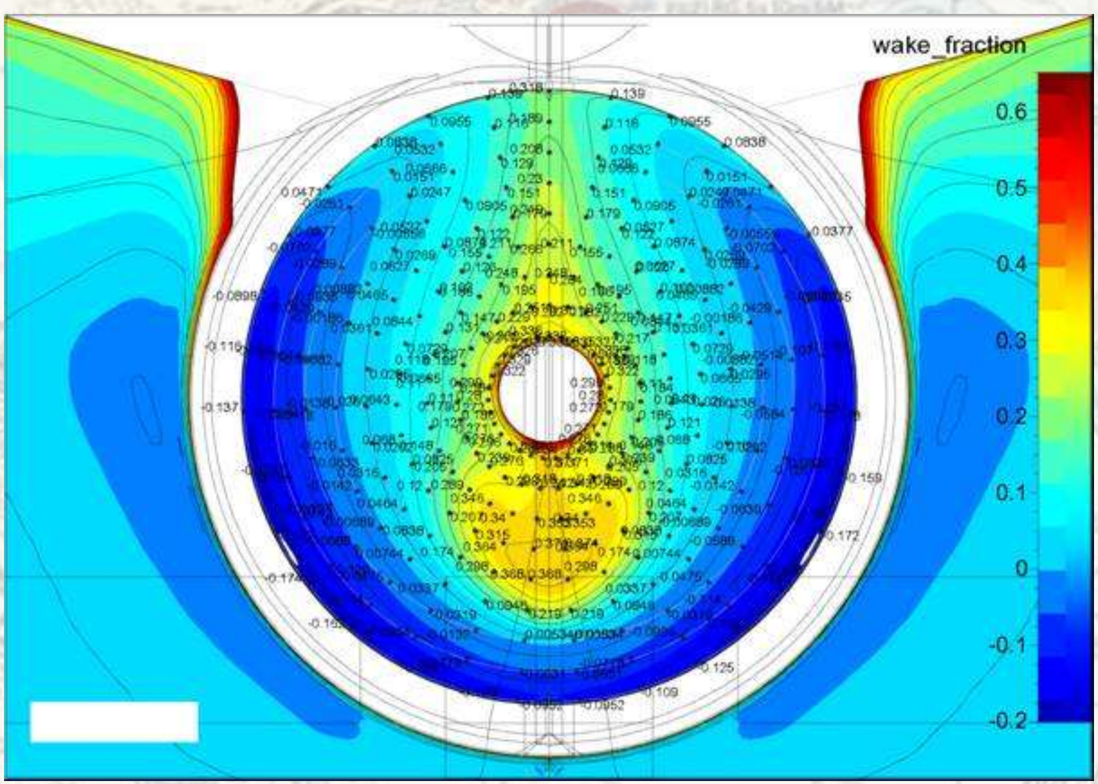
# Development ConoDuctTail (5)

CFD optimisation of aft-ship form, tunnel, nozzle & propeller design :



# Development ConoDuctTail (6)

CFD optimisation of aft-ship form, tunnel, nozzle & propeller design :

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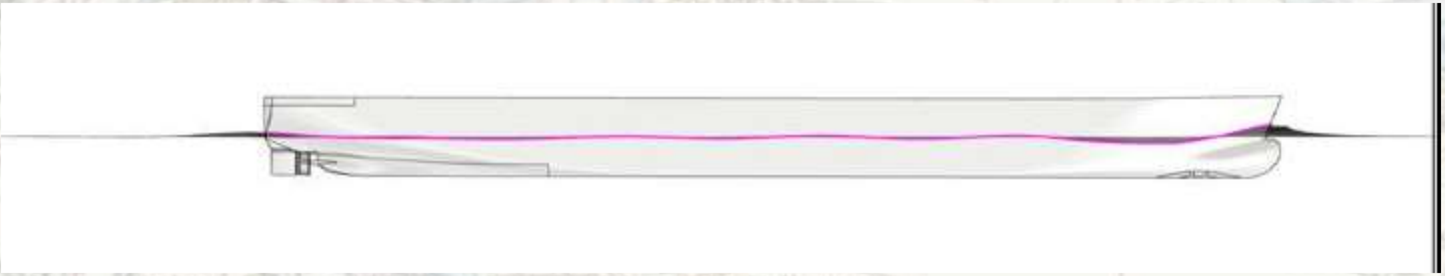
- CFD-Optimisation of complete hullform:
  17 %  reduction in resistance !
- Expected speeds at design draught @ 749 kW MCR:
  - DST  model tests: 10.0 kn
  - MARIN correction propeller&nozzle: 10.3 kn
  - SasTech prediction optimised prop design: 10.5 kn



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# Practical application eCONOlogy ConoDuctTail: Lady Anna (1)

- Trail speed @ design draught of 4.30 m , at 749 kW MCR: 10.8 kn !

# Practical application eCONOlogy ConoDuctTail: Lady Anna (2)

- Service speed abt.10 kn, with 3000 to 3500 ton cargo, at average power below 700 kW
- Fuel consumption less than 3.0 ton/day, trips reported at 2.7 ton/day !
- Keeping of thrust in heavy seaways is fine ! (added resistance in waves quite high)

# EEDI & eCONOlogy: reduced installed power

- 3700 tdw @ 749 kW => EEDI = 11,3
- Tunnel & nozzle => keeping thrust in heavy waves
- IMO in EEDI : Minimum Power Requirement

# Intro minimum power reqs

- IMO Minimum Power Requirements are applicable to tankers, bulkcarriers and combination carriers, > 20.000 DWT in phase 0 of EEDI
- 1e Focus is on smaller tankers;
- Tankers between 4.000 DWT and 20.000 DWT are excluded in phase 0, but expected to get problems with actual reglutions
- MARIN & Conoship analyse smaller tankers for CMTI/Holland Shipbuilding Association

# Assessment power reqs.

1. IMO defined two optional assessment methods to determine Minimum required power:
    1. Minimum power line assessment method;
    2. "Simplified assessment" method;

2. Three case-study ships are selected to determine:
    1. Attained en Required EEDI (in Phase 1!);
    2. Minimum required power based on the minimum power line method;
    1. Minimum required power based on the simplified assessment method.


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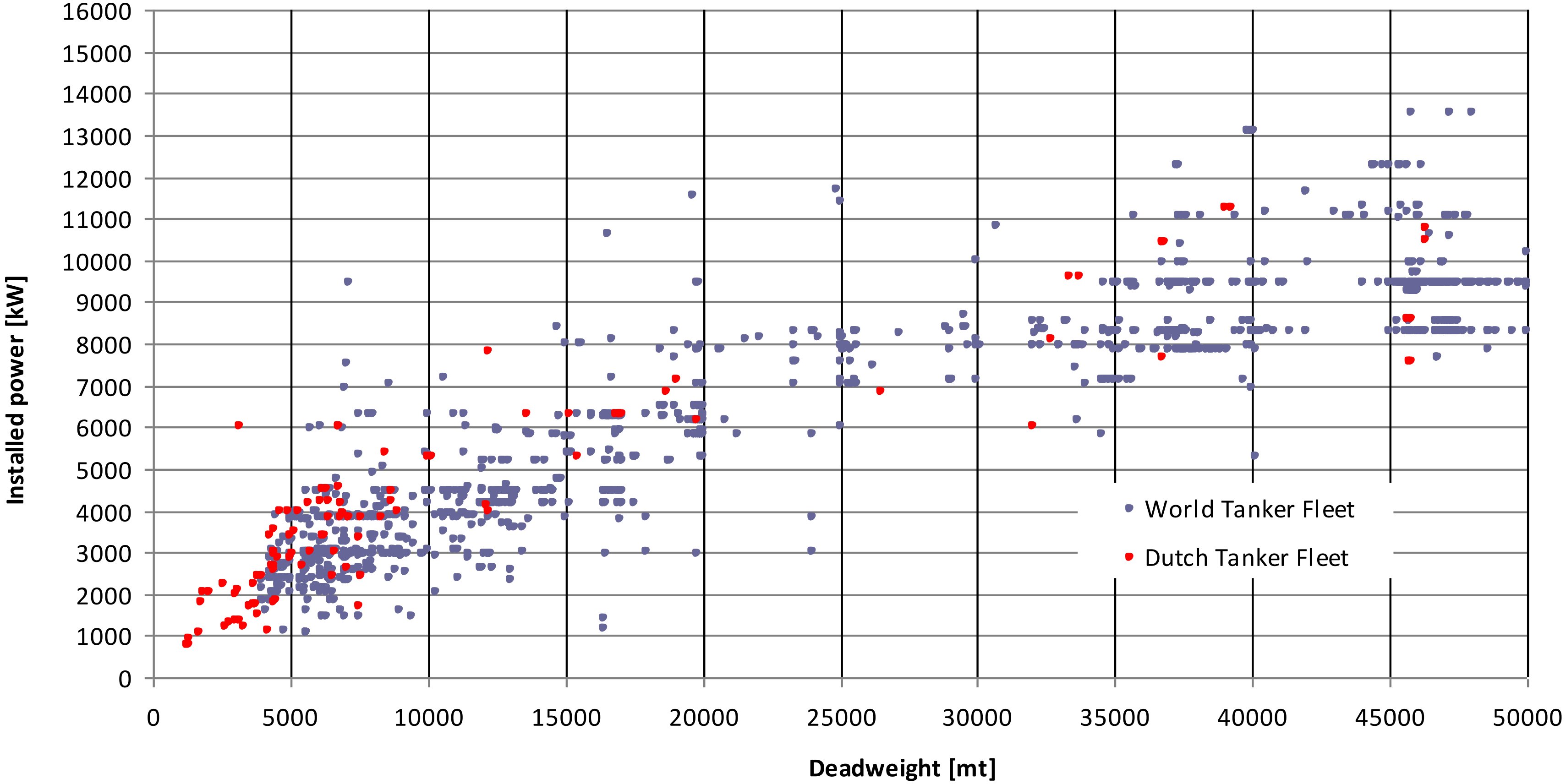
## Installed power vs. deadweight values of 4370 Tankers of the World Tanker Fleet; 152 Tankers of the Dutch Fleet





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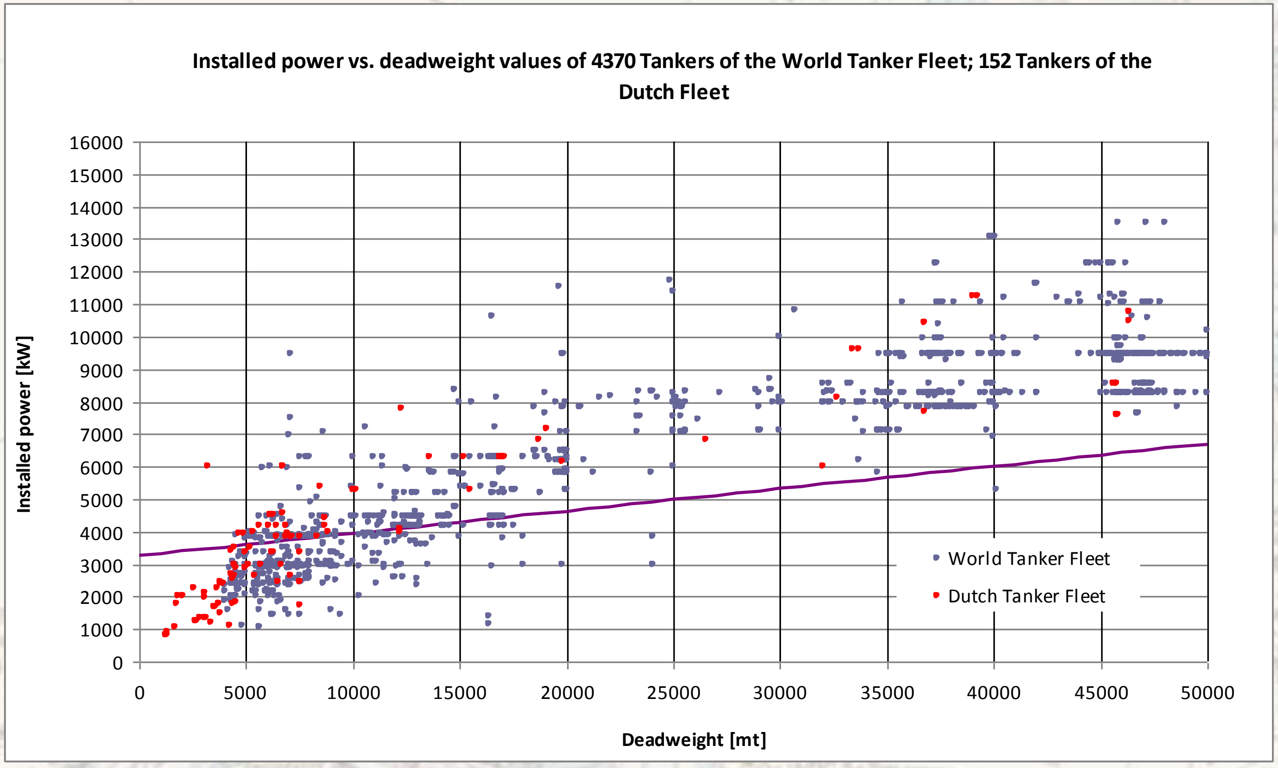
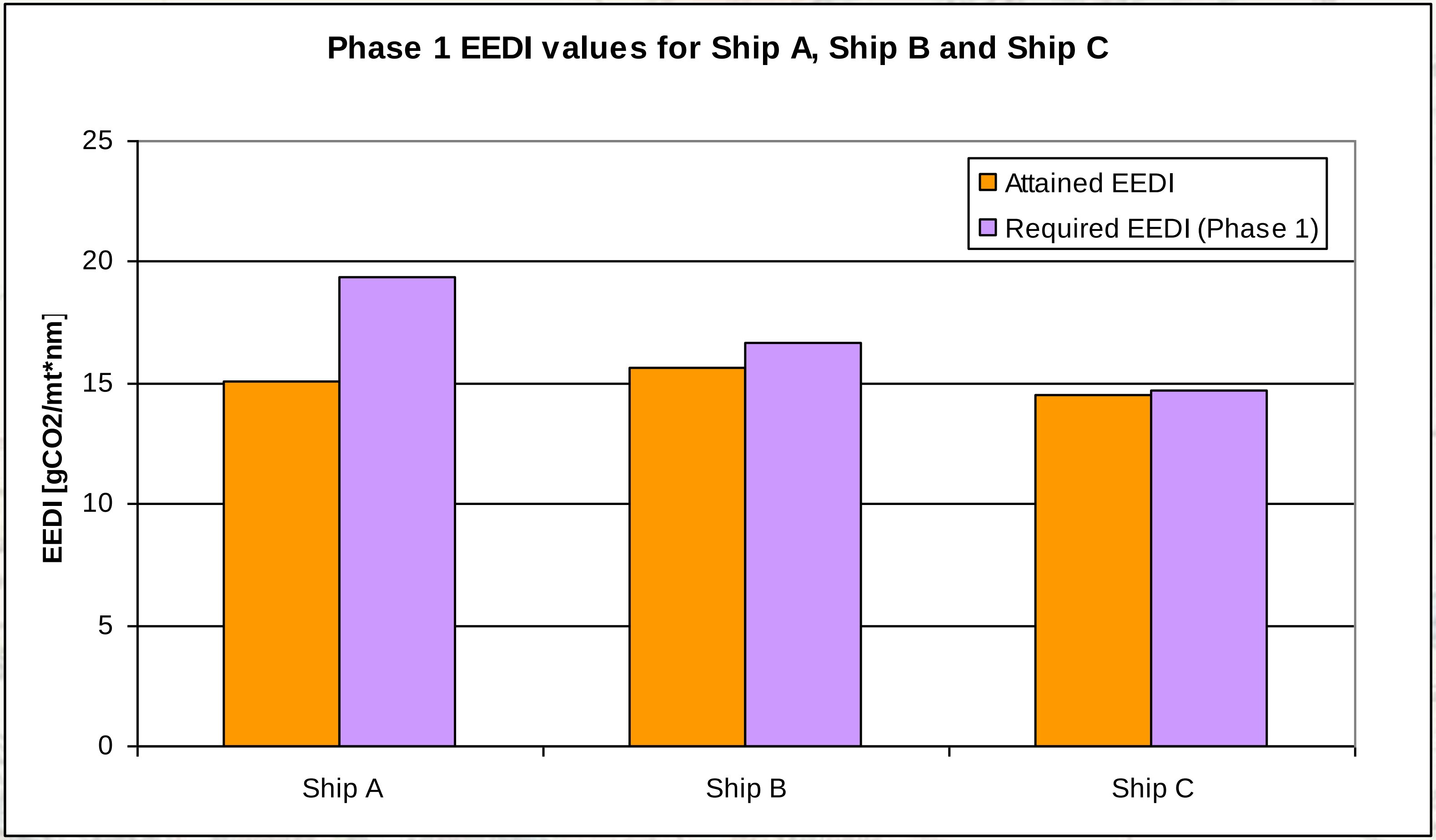



- The minimum power line is unrealistically high, especially for the tankers below 10.000 DWT;
- this assessment method is not suited for the smaller ships;

# Case-study tankers

| | | Ship A | Ship B | Ship C |
|---|---|---|---|---|
| $L_{pp}$ | [m] | 105.8 | 111.2 | 110.0 |
| $T_m$ | [m] | 5.6 | 6.4 | 6.8 |
| $B_{wl}$ | [m] | 13.5 | 17.0 | 16.5 |
| Deadweight | [mt] | **4794** | **6377** | **8093** |
| $C_b$ | [-] | 0.833 | 0.728 | 0.849 |
| Design speed | [knots] | 12.5 | 15.5 | 12.5 |
| Propeller type | [-] | Cpp (nozzle) | Cpp | Cpp |
| No. propellers | [-] | 1 | 1 | 1 |
| $P_{B,installed}$ | [kW] | **1800** | **3840** | **2880** |
| Ice class | [-] | 1C | 1A | - |
| Shaft Generator | [-] | No | Yes | Yes |

# EEDI values





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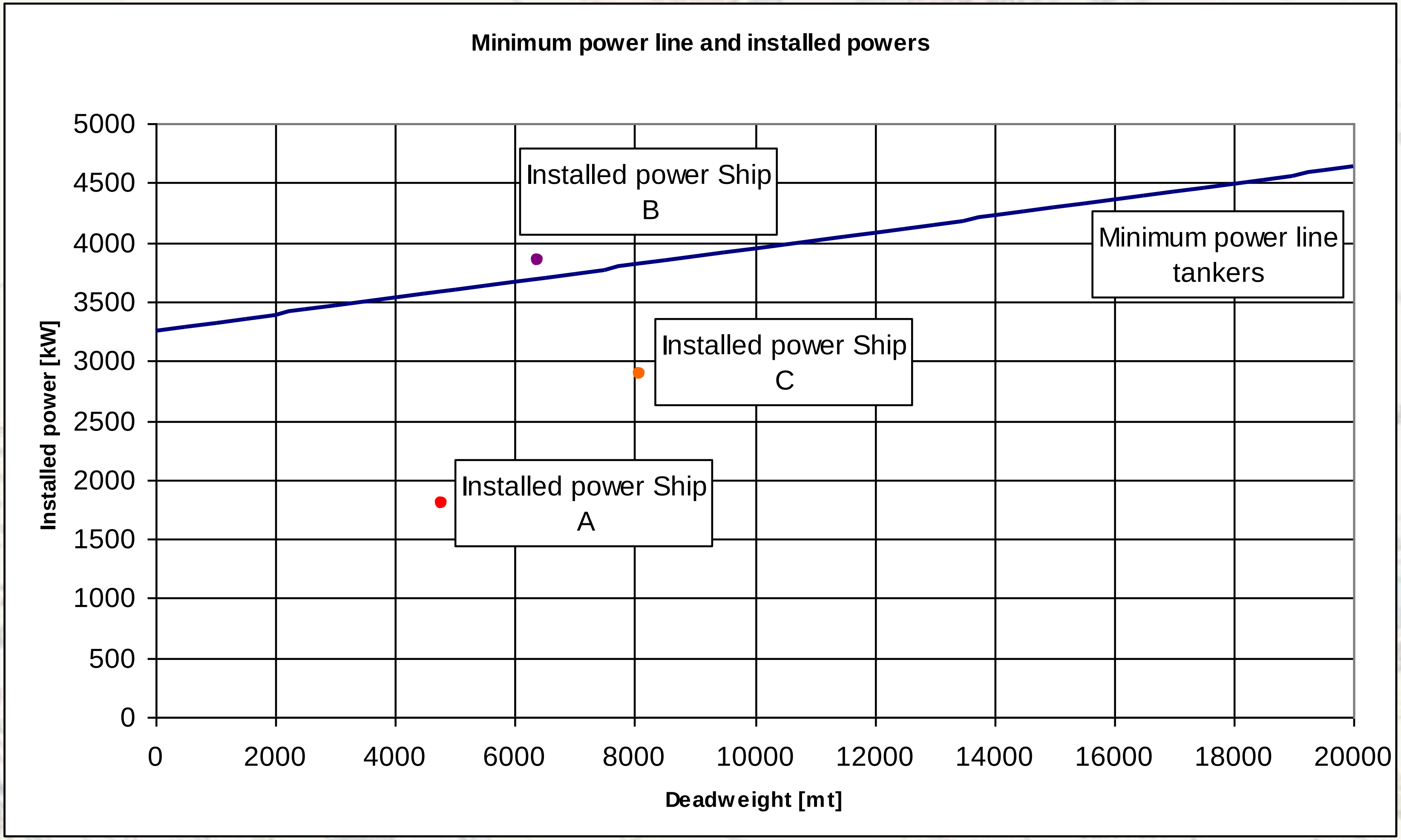
# Minimum power line assessment

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# Simplified assessment – Step 1

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- Method is based on the principle that
  - if ship has sufficient installed power to move with a certain **advance speed in head waves and wind**,
  - the ship will also be able to keep course in waves and wind from other direction (IMO).
- 1e determine the speed, or 'Ship Advance Speed', for which the minimum power needs to be determined:
- Ship Ádvance Speed is the course keeping speed (Vck), minimum 4.0 knots;
- Vck Course keeping speed can be determined on the basis of design parameters including length, breadth, draught and rudder area.
- Ship Advance Speeds are:
  - Ship A: 5.4 knots
  - Ship B: 4.0 knots
  - Ship C: 4.0 knots

$$V_{ck} = V_{ck,\,ref} - 10.0 \times (A_{R\%} - 0.9)$$

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# Simplified assessment – Step 2

- Required thrust T:

$$T = (R_{cw} + R_{air} + R_{aw} + R_{app})/(1 - t)$$

- Calm water resistance:

$$R_{cw} = (1 + k)C_F \frac{1}{2}\rho S V_s^2$$

- Aerodynamic resistance:

$$R_{air} = C_{air}\frac{1}{2}\rho_a A_F V_{w,rel}^2$$

- Added resistance in waves. The transfer functions need to be determined (CFD/Model tests):

$$R_{aw} = 2\int_0^{\infty} \frac{R_{aw}(V_s, \omega)}{\zeta_a^2} S_{\zeta\zeta}(\omega)\,d\omega$$

- When the required thrust is known,

  the required power can be determined.



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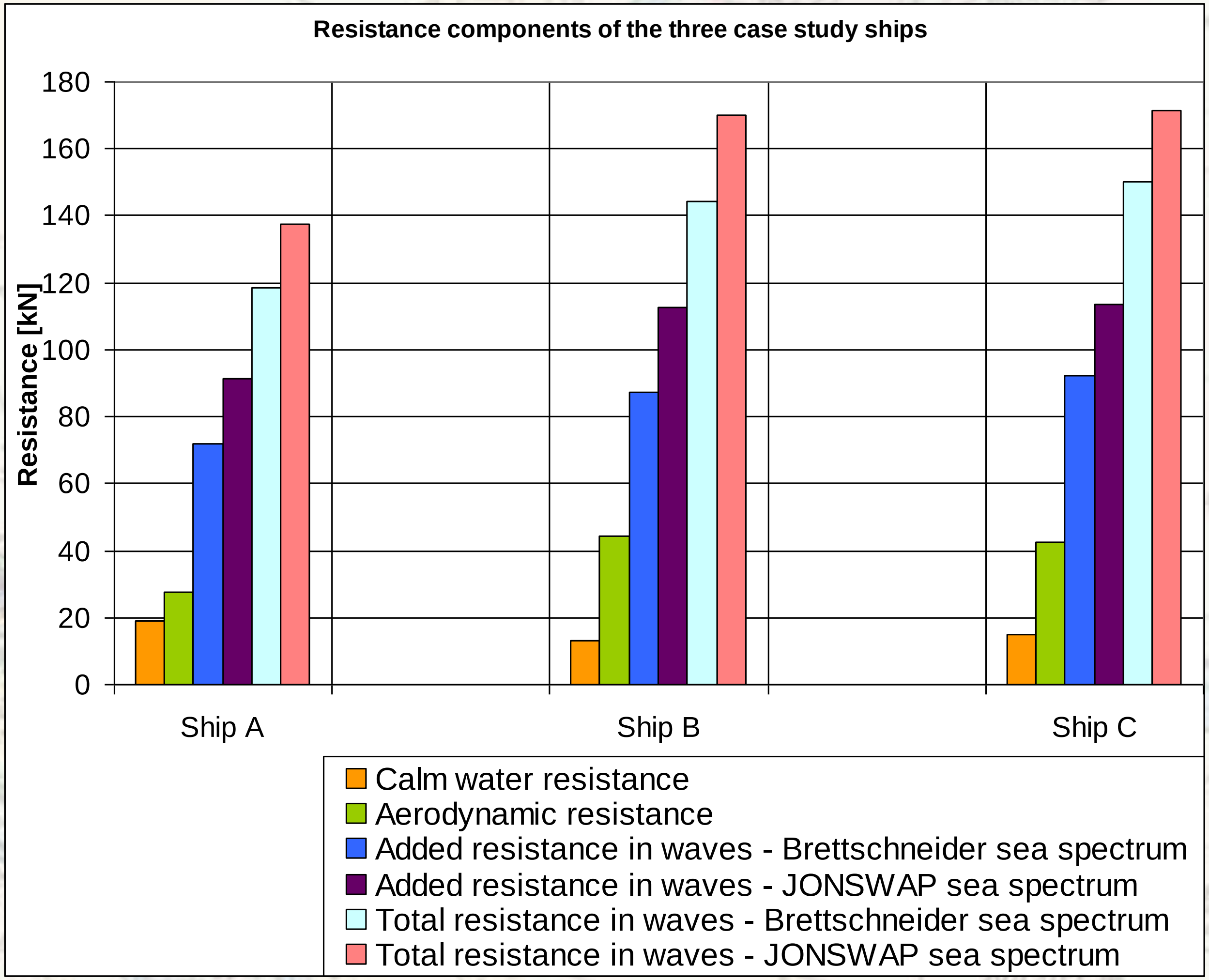
# Resistance components

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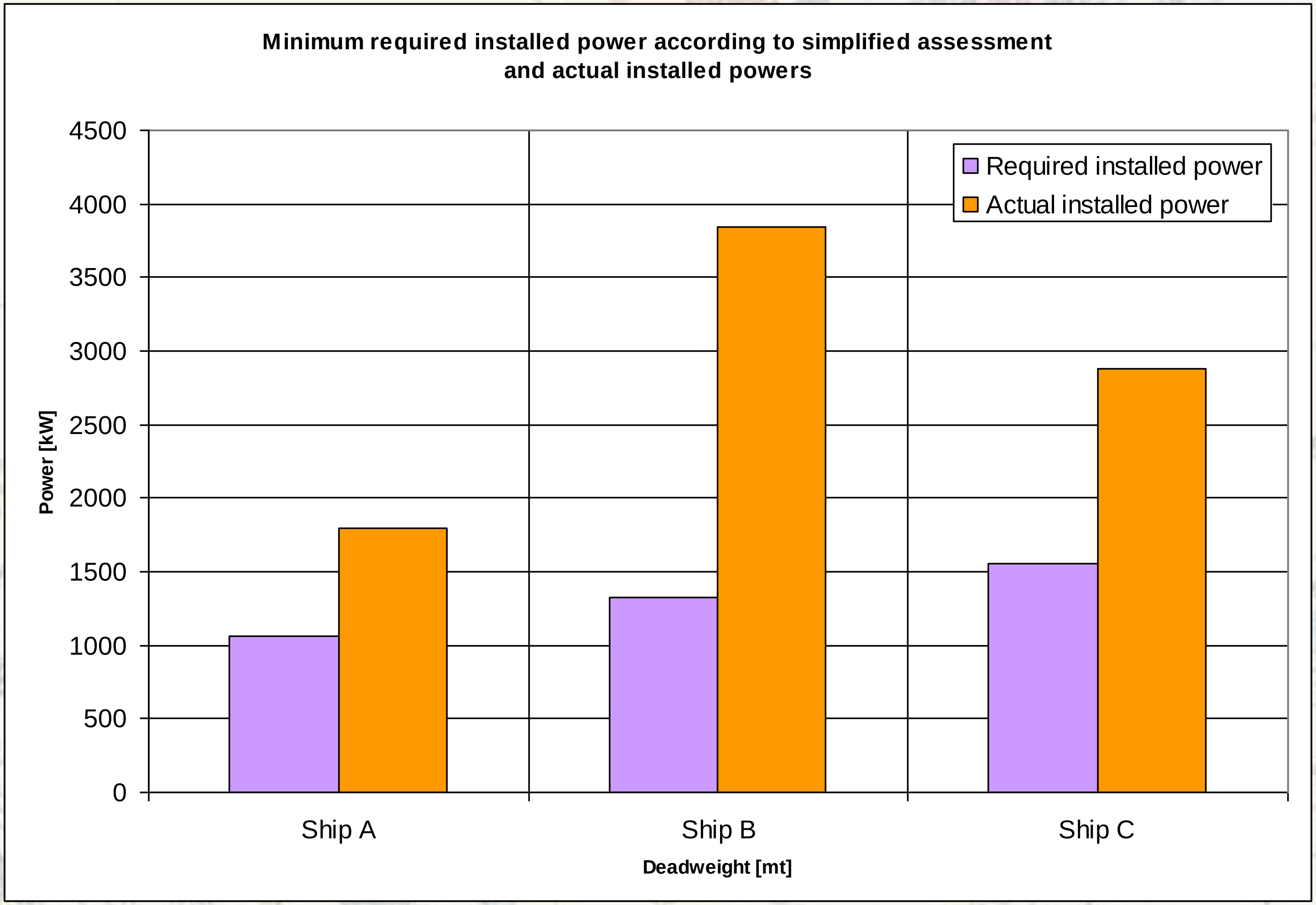
# Result simplified assessment

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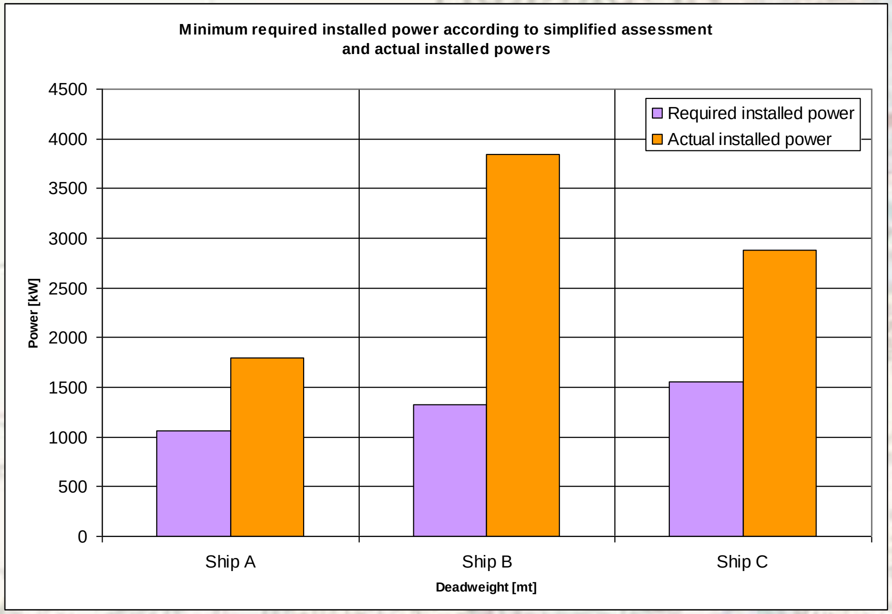
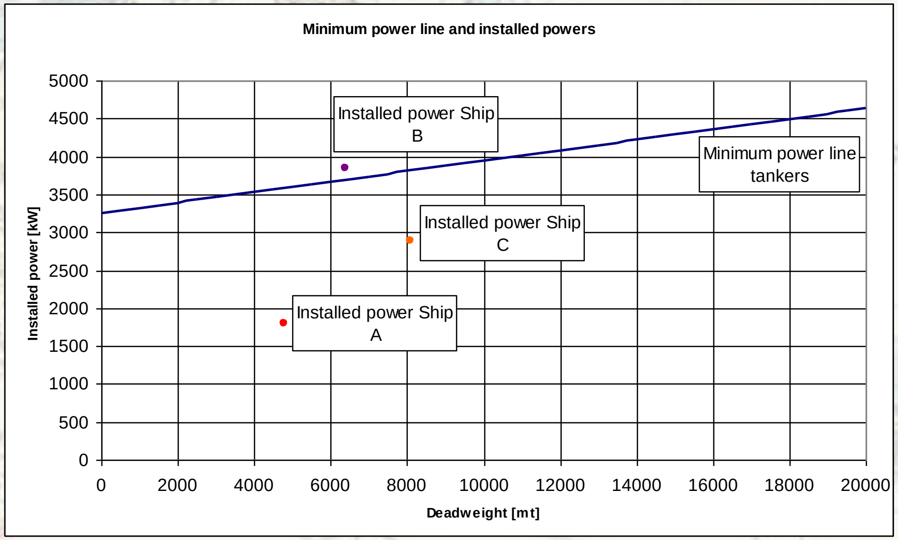
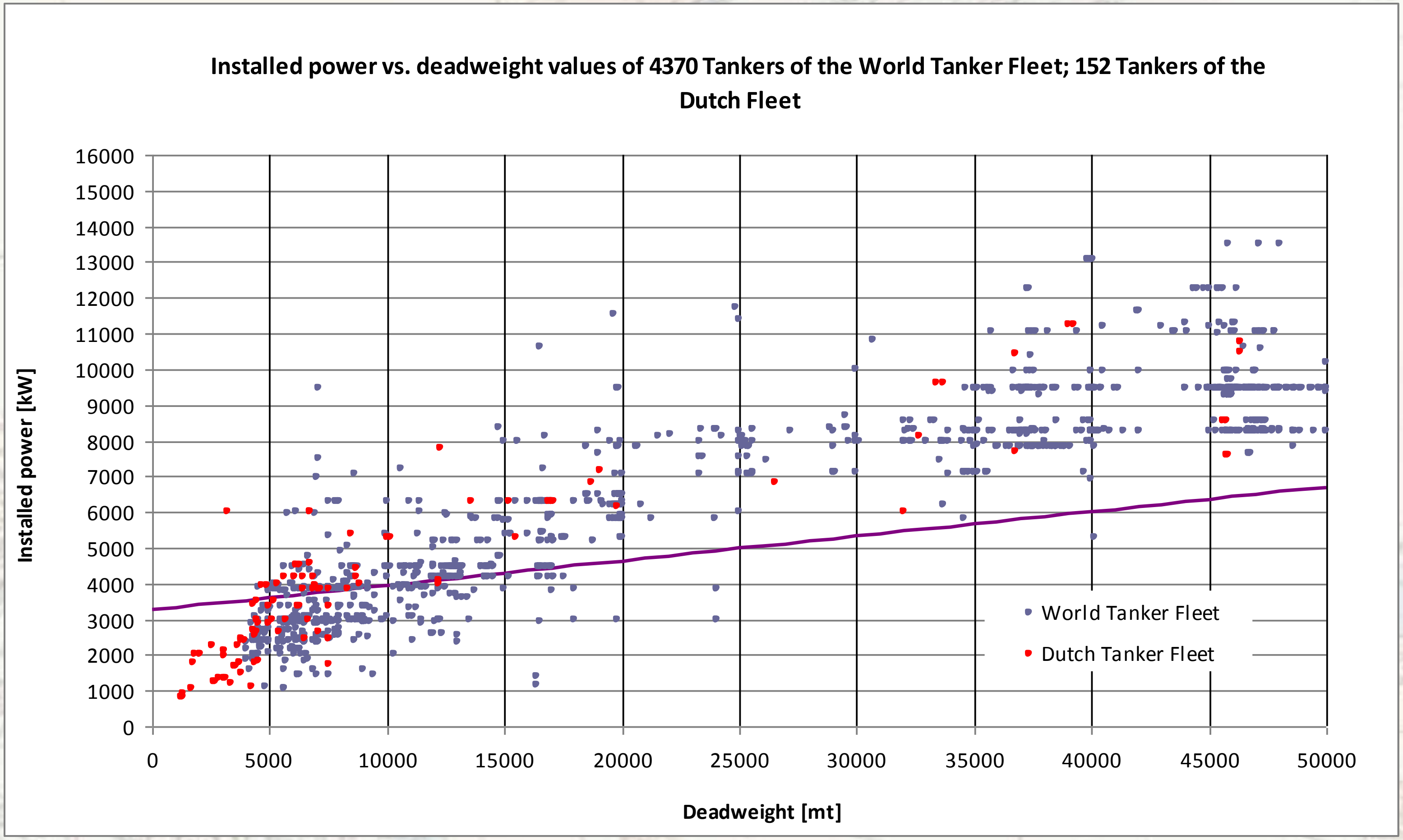
# Comparing assessment methods



# Minimum required Power line might be improved

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# Findings

- Minimum power line is unrealistically high for tankers below 20.000 DWT;
- Minimum power based on simplified assessment method is much lower (more realistic), but still quite complex: transfer function (RAO);
- Sailing in headwaves may not be the most critical situation for many ships, sailing in oblique waves may cause additional problems.

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# Recommendations

1. Further simplification of the simplified method;
   1. Estimation of the added resistance;
   2. Modified minimum power line for vessels below 20.000 DWT.

To further decrease the $CO_2$ emissions => smaller engines, without compromising safety !

⇒ Additional research is necessary to increase the understanding of minimum required power to ensure safe ships.

Further investigation into sailing into oblique waves – does the current procedure ensure ‘safe’ ships (what is safe?);

# Integrating eCONOlogy & Safety: challenging compromise !

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***Thanks for your attention***

***Question(s)?***

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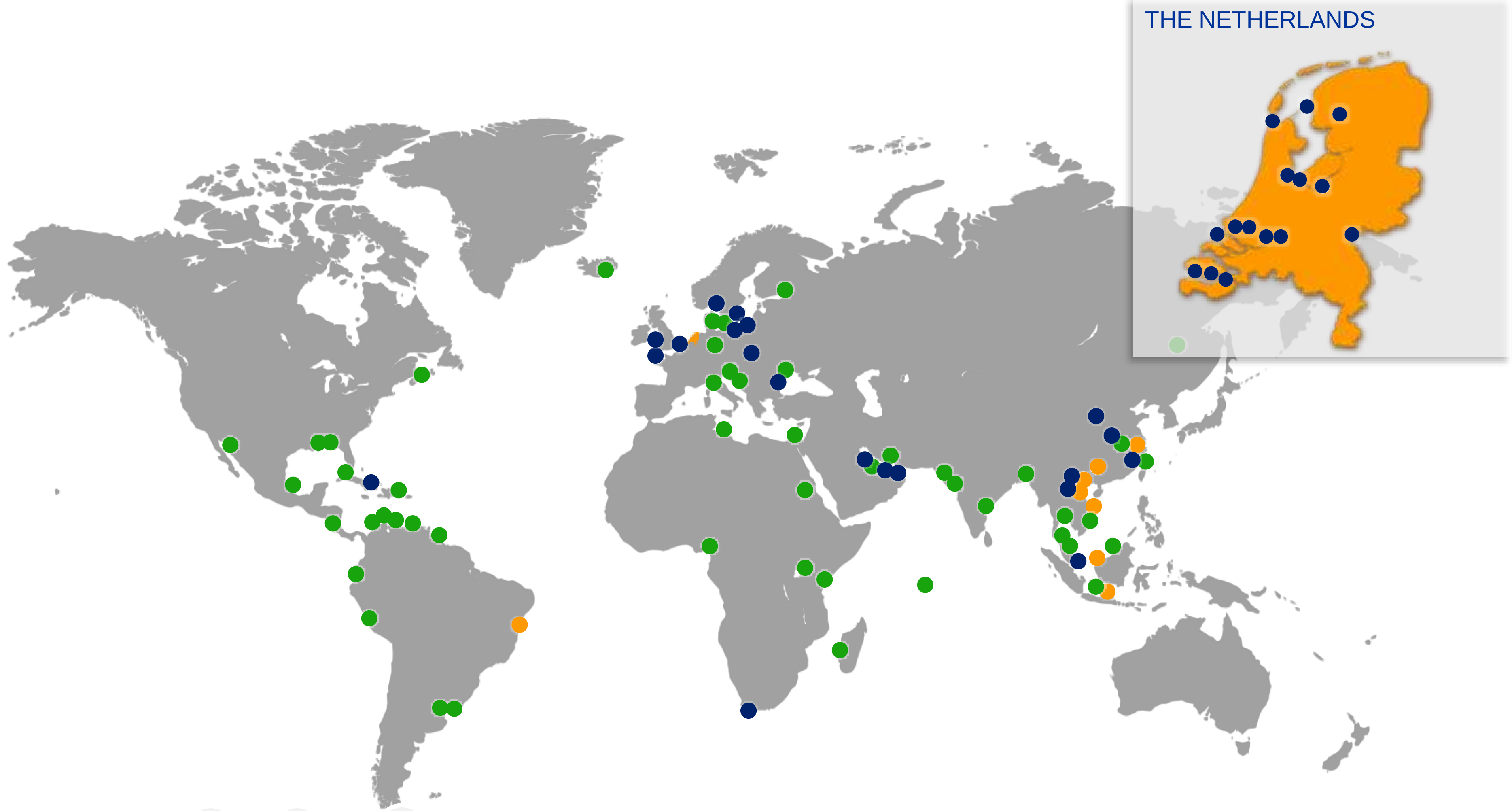
**Real Efficient Ships**

*What is the future?*




DAMEN YARD 15 + 20 → 35

BUSINESS COOPERATION 8

PARTNER YARD > 40

# DAMEN STANDARD

- Short delivery times
- Competitive pricing
- High R&D effort at low cost and time
- Proven technology
- Continuous improvement
- Guaranteed performance
- High resale value

# PROVEN PERFORMANCE HAS LED TO A DIVERSE PORTFOLIO

ABOUT DAMEN

SHIPBUILDING

SHIPREPAIR & CONVERSION

SERVICES



ASD TUG

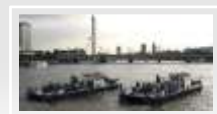

ATD TUG


STAN TUG


MULTICAT


SHOALBUSTER


PUSHBUSTER


SKIMMER


FAST CREW SUPPLIER

PLATFORM SUPPLY VESSEL

ANCHOR HANDLING TUG SUPPLIER

MULTI PURPOSE VESSEL

STANDBY SAFETY VESSEL

OFFSHORE CARRIER

RESEARCH VESSEL

DAMEN


FAST CREW SUPPLIER

SHOALBUSTER

OFFSHORE CARRIER

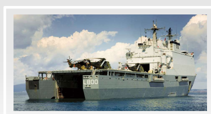
WIND FARM MAINTENANCE BARGE


INTERCEPTOR


STAN PATROL


SIGMA-CLASS CORVETTE


SIGMA-CLASS FRIGATE


LANDING PLATFORM DOCK


HYDROGRAPHIC SURVEY VESSEL


JOINT SUPPORT SHIP

CSD

TSHD

DOP SUBMERSIBLE DREDGE PUMP

TSP SYSTEMS

BOOSTER STATIONS

DREDGING COMPONENTS

DAMEN



RIVER LINER


RIVER TANKER


COMBI COASTER


COMBI FREIGHTER


CONTAINER FEEDER


TANKER


OFFSHORE CARRIER



BEAM TRAWLER


FLYSHOOTER SEINER


SHELLFISH DREDGER


MUSSEL DREDGER


OYSTER DREDGER



WATER TAXIS


WATER BUS


FAST FERRIES


FAST ROPAX FERRIES


MOTOR FERRIES


RIVER FERRIES


ROPAX FERRIES

STAN PONTOON

MULTI PURPOSE PONTOON

DRILLING PIPELAY BARGE

CRANE BARGE

LIGHTER BARGE

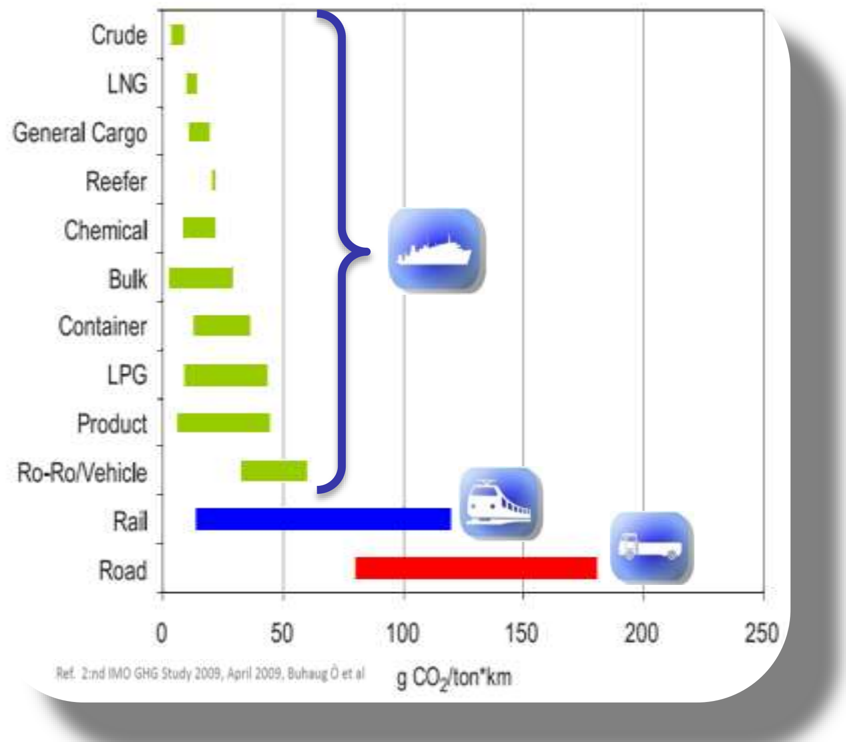
MODULAR BARGE

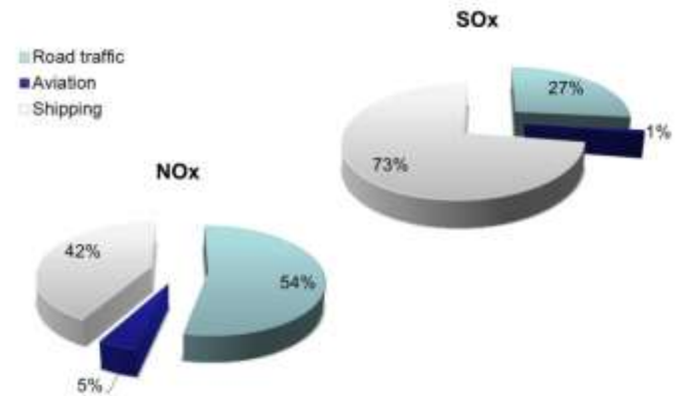

LIMITED EDITION

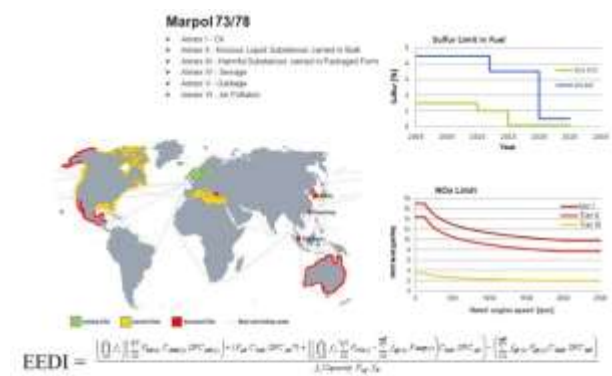
FAST YACHT SUPPORT

Arthur C. Clarke - 1964

# The efficiency of shipping



## Energy and emission reduction; options

Reducing Energy Consumption

- Design for operations approach **2 Examples**
- Resistance reduction **ACES**

Improving the efficiency of energy conversion

- Improving engine efficiency and matching the propulsion system configuration and engines to Operational Profile
- Efficient propulsors
- Fuel Cells

Pre-, while- and aftertreatment of fuel and emissions

Alternative fuels (LNG) **IWT application**

Renewable energy

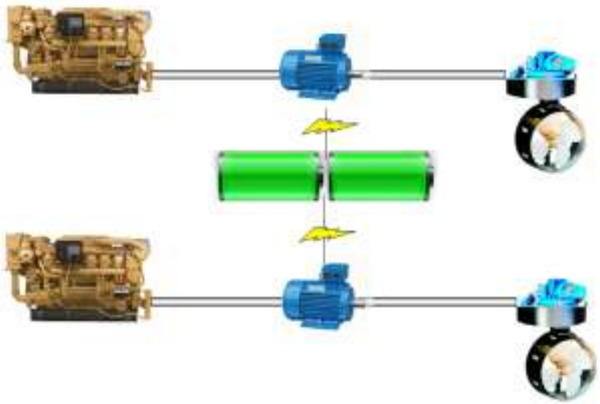
Crew behaviour and operational strategy with a focus on fuel saving.

The SEA AXE Development

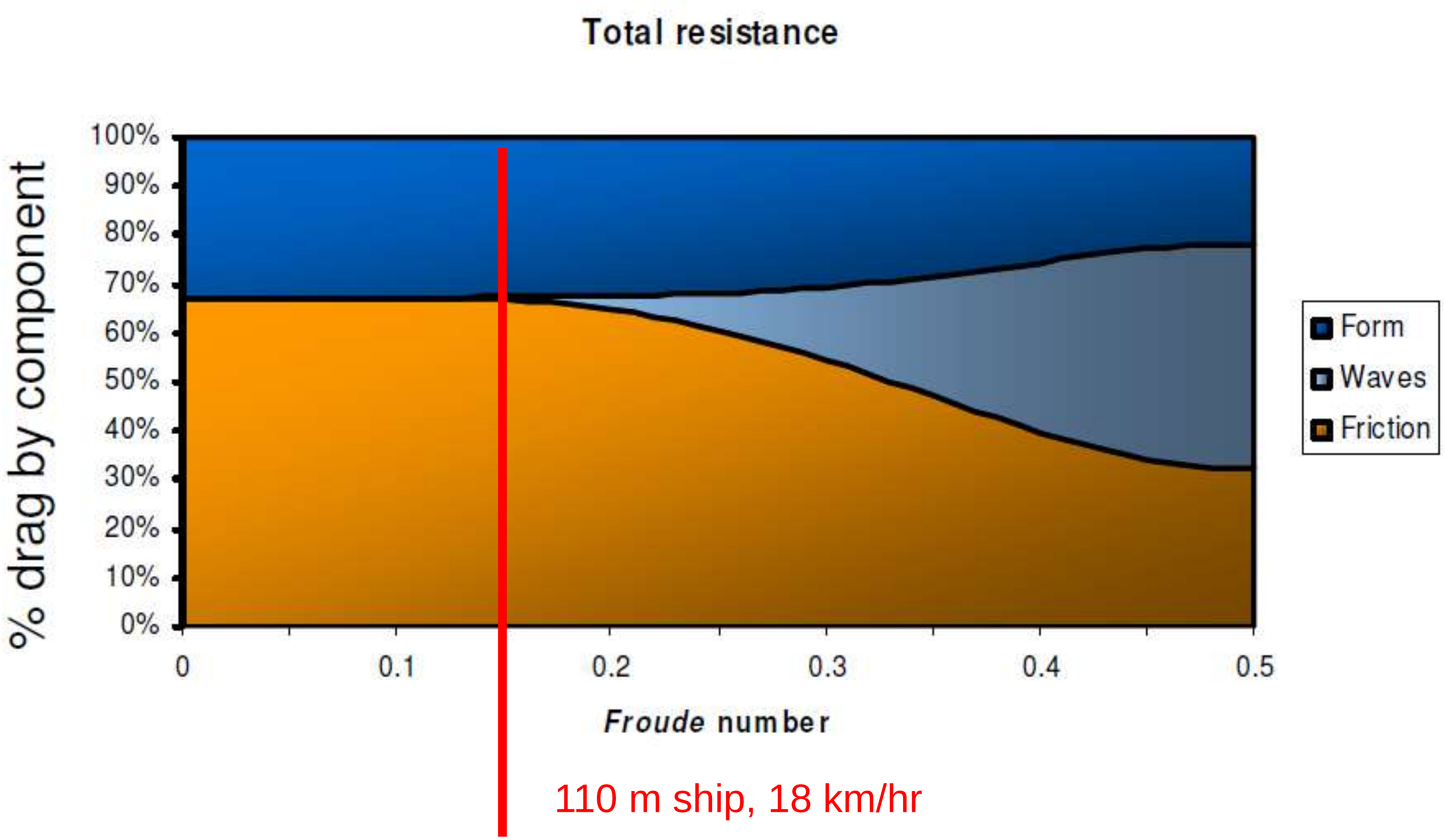
- Ship motions optimised for crew comfort and safety
- Significantly reduced resistance in a seaway
- 20% fuel consumption reduction in operational conditions

## The E3 – Tug

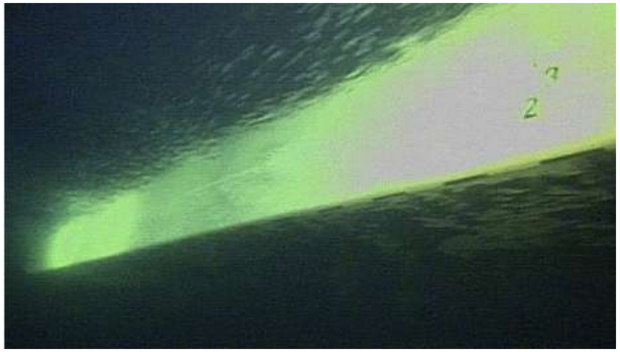
- Design optimized for operational profile
- Hybrid E&P configuration
- 35% environmental impact reduction

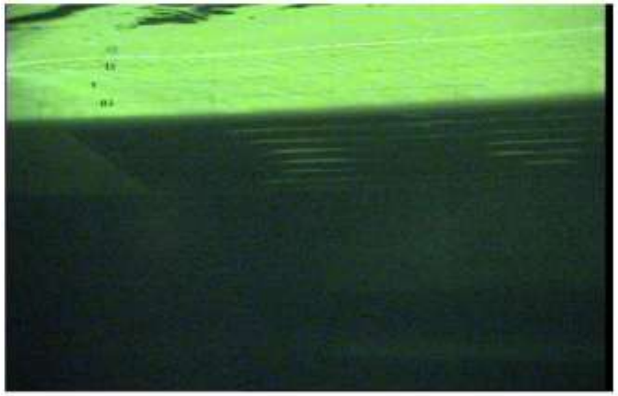



Ecoliner
Ecoliner


Total resistance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% drag by component
0
0.1
0.2
0.3
0.4
0.5
Froude number
Form
Waves
Friction
110 m ship, 18 km/hr

- An (enduring) sleek surface
  - Anti-foulings
  - maintenance
- Air lubrication
  - By airbubbles
  - By airsheet
  - By air cavity chambers



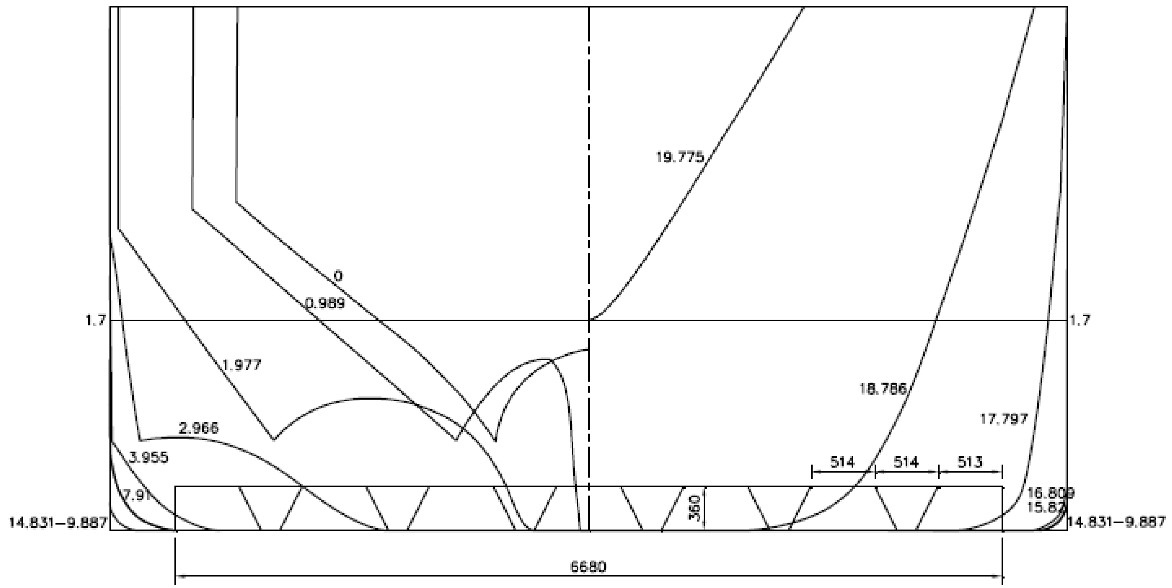


Insight in physics

- Resistance reduction of two-phase flows and stability thereof
- Resistance reduction by airfilms and air cavity chambers
- Scale effects
- Numerical modeling

Design knowledge

- Insight into the design consequences of airlubrication




Patented Air Chamber Energy Saving System:

Cost effective combination of air chamber concept and structural design

SHIP MODEL No. : 8910 DRAUGHT AFT : 1.700 m

SHIP SPEED $V_s$ : 13.00 KM/H

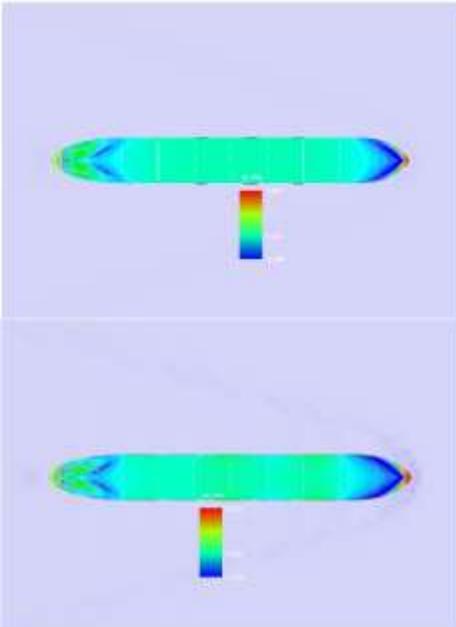
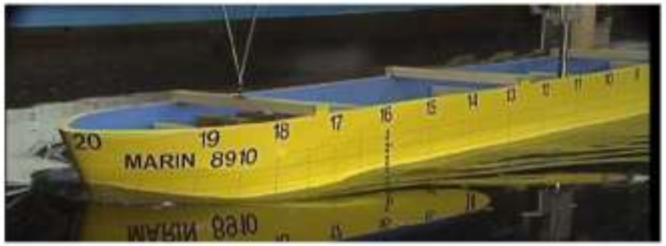
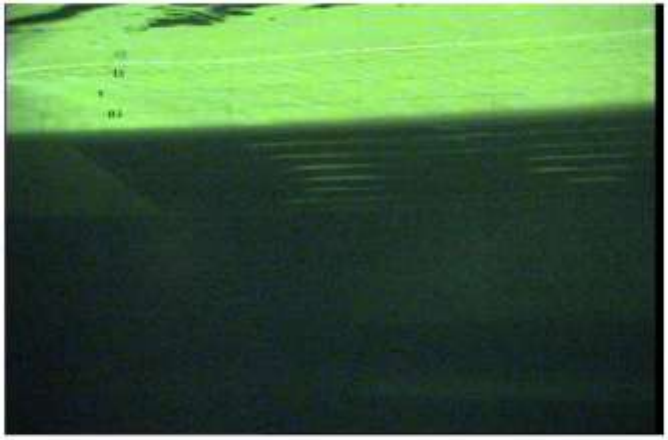


Figure 2 Dimensionless pressure distribution on the ship hull at 13 and 19 km/h. The pressure distribution is reasonably flat between frames 4 and 16½ where the air cavities are situated. As the ship speed increases, transverse waves are formed that visibly influences the pressure distribution on the hull.





WAVE PROFILES



13 km

| | | |
|---|---|---|
| Length between perpendiculars | 62.200 | m |
| Breadth moulded | 7.740 | m |
| Design draught moulded | 1.700 | m |
| Displacement volume moulded | 685.0 | m3 |

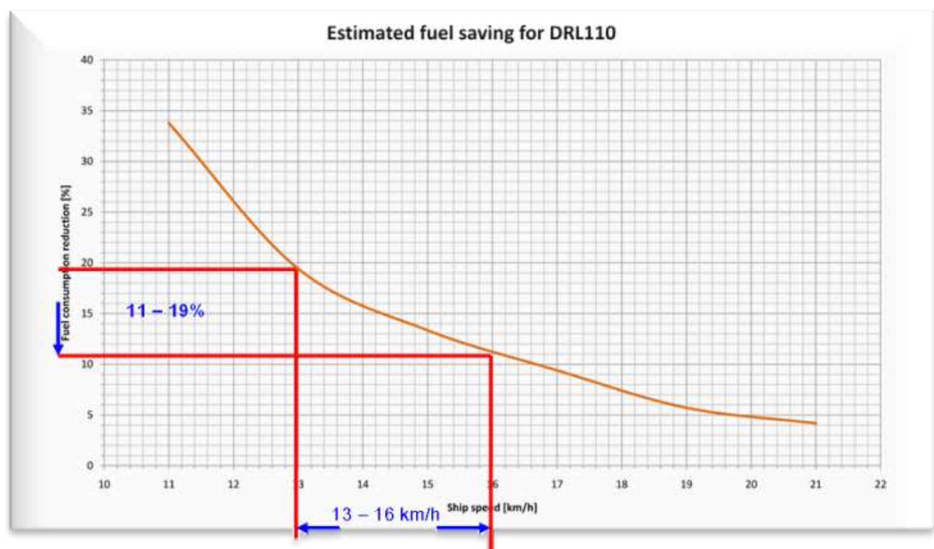
CFD calculations and modeltests with a number of air chamber configurations: Resistance reductions in excess of 10% predicted for full scale

Full scale reference tests

Refit of air chambers to ship

Air chamber tests


Depending on speed and loading condition a power reduction of 15% was obtained.



What does this mean for the environment?

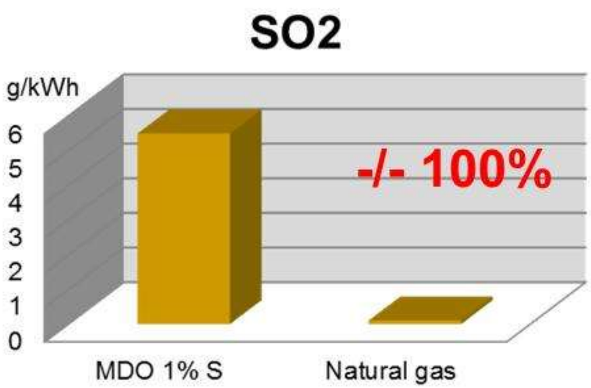
| | |
|---|---|
| 5000 | Dutch inland ships |
| 800 | kW average installed power per ship |
| 80.00% | load |
| 180 | g/kwh specific fuel consumption |
| 4500 | Sailing hours per year |
| | |
| 2592000 | ton fuel per year |
| 8084448 | ton CO2 |
| 1212667.2 | ton CO2 savings at 15% resistance reduction |
| 700 | g/vkm HGV (CE Delft) |
| 1732 | mln equivalent Heavy Goods Vehiclekm's |

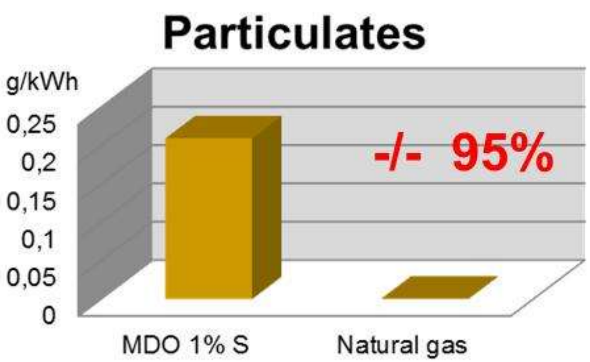
What does it mean for the inland shipping operator ?

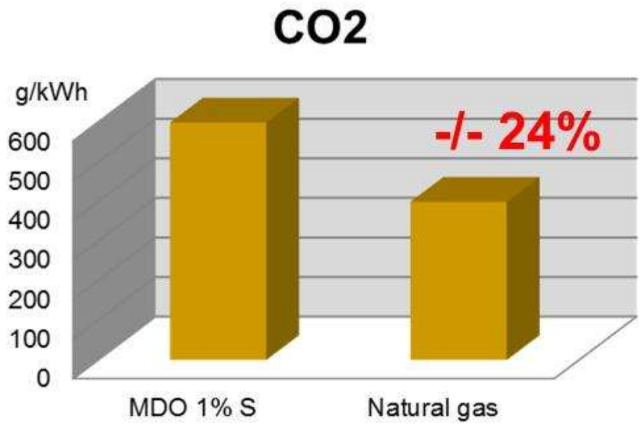
| | |
|---|---|
| **800** | **kW average installed power per ship** |
| **80.00%** | **load** |
| **180** | **g/kwh specific fuel consumption** |
| **4500** | **Average sailing hours per year** |
| | |
| **612748.8** | **liter fuel per year** |
| **775** | **€/ 1000 liter** |
| **474880** | **€/year** |
| **71232** | **€ fuel cost savings** |

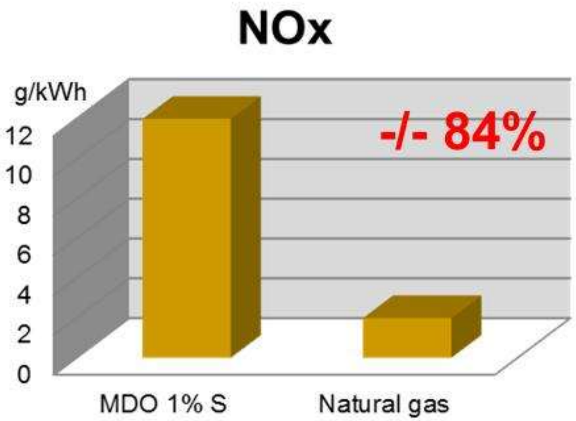
1. Shallow water effects research – Confirmation of savings
2. Prototype air supply system development and validation of power requirement
3. Application to a new standard Ecoliner

# LNG


SO2
g/kWh
6
5
4
3
2
1
0
-/- 100%
MDO 1% S
Natural gas


Particulates
g/kWh
0,25
0,2
0,15
0,1
0,05
0
-/- 95%
MDO 1% S
Natural gas


CO2
g/kWh
600
500
400
300
200
100
0
-/- 24%
MDO 1% S
Natural gas


NOx
g/kWh
12
10
8
6
4
2
0
-/- 84%
MDO 1% S
Natural gas

Damen Ecoliner

On resistance reduction:
STW projects SHIPDRAC and Air leakage control

On Efficiency improvements:
Refit2save JIP
HYBRID 111 JIP and STW SHIPDRIVE
FP7 JOULES project
HYSEAS JIP on fuel cells

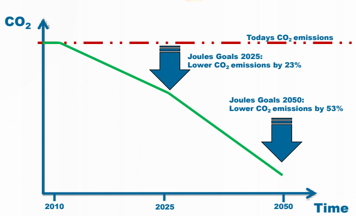
On Renewable Energy:
FP7 JOULES and Damen – TU Delft Research

DAMEN

# Joint Operation for Ultra Low Emission Shipping

## Application Cases






## JOULES

is a collaborative research project co-founded by the European Commission within the 7th Framework Programme

- EC Grant Number 605190
- Total project budget 14.2 million Euro
- Total EC funding 8.5 million Euro

## Problem addressed

Reducing emissions from shipping has increasingly become a challenge over the last years, both as a counter measure against global climate change and to protect local environments and population from waste, exhaust gas emissions and noise.

## Expected Impact

Significantly reduce the gas emissions of European built ships, including CO2, SOx, NOx and particulate matters

## Project Goals

Improved ship designs for 11 different ship types for Europe with specific optimal solutions for emission reduction and energy efficiency tuned to their operational profil.

## Partnership

**38 Partners from 10 countries**

**www.joules-project.eu**

**Project Manager:**
Rolf Nagel
nagel@fsg-ship.de
Tel: +49 461 4940-523

**EC Scientific Officer:**
Ronald Vopel
DG Maritime Affairs and Fishery

This project is co-funded by the European Union

Figure 2: Guiding objectives 2050

| | | | GUIDING OBJECTIVES 2050 |
|---|---|---|---|
| Towards Zero Accidents | Pre-incident prevention | All Vessels | • Collision / grounding avoidance (-30%)<br>• Fire avoidance (-15%)<br>• Structural breakdown avoidance (-10%)<br>• Adverse conditions avoidance (-20%) |
| | During-incident prevention | Cargo | • Cargo loss avoidance (-50%)<br>• Damage stability (-20%)<br>• Fire resistance (variable) |
| | | Passengers | • Damage stability (-80%)<br>• Fire resistance (-25%) |
| | | Complex | • Cargo loss avoidance (-50%)<br>• Damage stability (-20%) |
| | | All Vessels | • Structural damage resilience (-20%)<br>• Excessive motions and accelerations (-30%) |
| | Post-incident prevention | Complex | • Environmental damage (-50%) |
| | | All Vessels | • Inability to return to port (-50%)<br>• Casualties (-80%) |
| The Eco-Efficient Vessel | Emission Reduction<br>$CO_2$,<br>NOx,<br>SOx | All Vessels | $CO_2$: >80%<br>NOx: ≈100%<br>SOx: ≈100% |
| | Noise Reduction | All Vessels | Decibels: -10 |

The best way to predict the future is to create it


Ministerie van Infrastructuur en Milieu

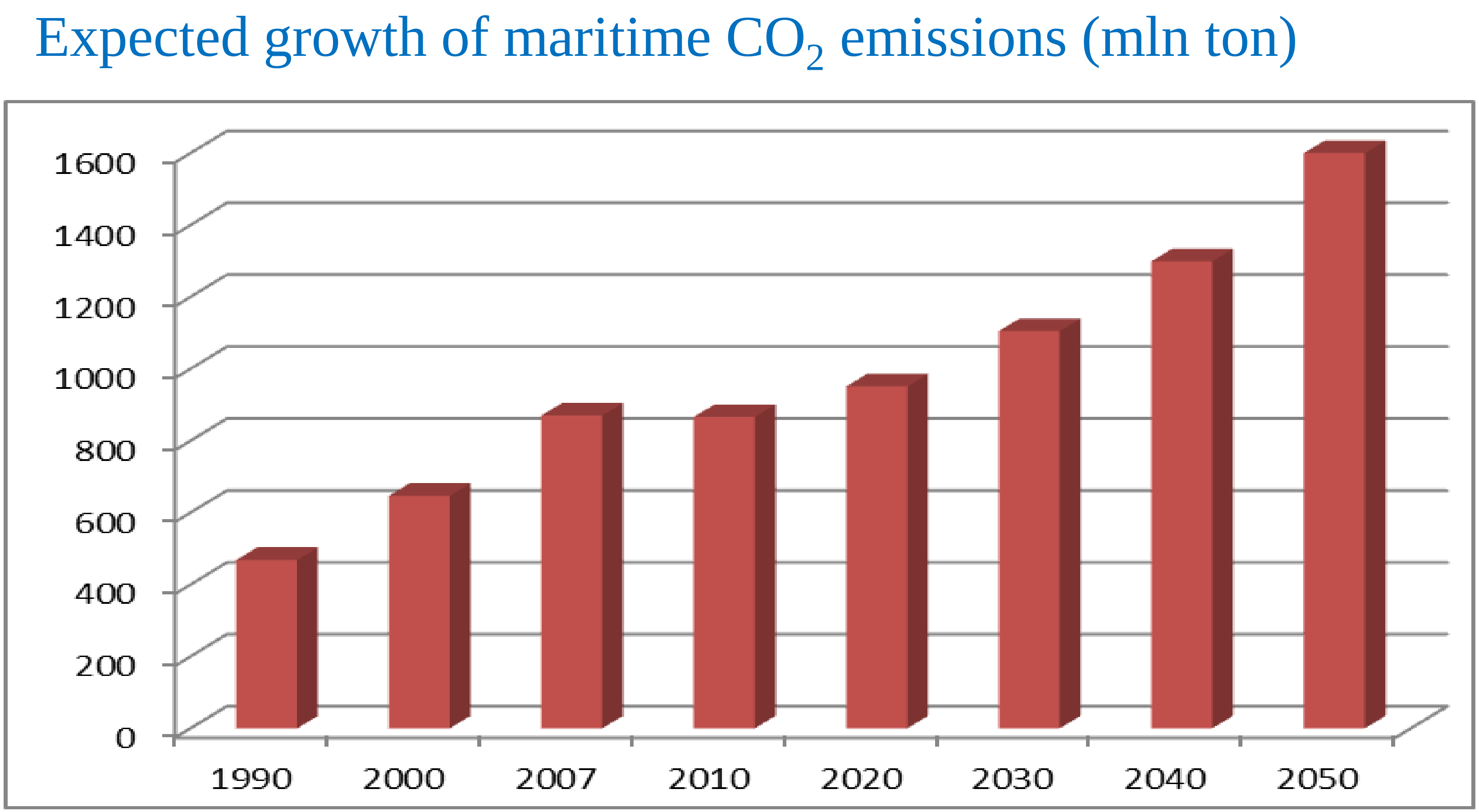
# CO2: Measuring, monitoring and reducing $CO_2$ emissions

1. Proposal European Commission for Monitoring, Reporting and Verification of maritime $CO_2$ emissions (EU MRV)

2. Debate in the International Maritime Organisation on data collection and energy efficiency

20 december 2013

# Studies show: growing maritime $CO_2$ emissions



# 1. Intro – further measures necessary

- July 2011 agreement in IMO (International Maritime Organisation) on:
  - Energy efficiency design index (EEDI; new ships)
  - Ship energy efficiency management plan (SEEMP; all ships)

- IMO recognizes that further measures are necessary
- Huge potential for technical and operational measures
- However: obstacles for realising those measures, such as ‘split incentives’
- No results expected soon regarding Market Based Measures (MBM’s)

- Communication European Commission; phased approach necessary:
- MRV; setting target reduction; MBM’s

# EU MRV – Proposed Regulation (1)

- Lessons aviation ETS
  - No maritime ETS
  - Favouring global measures

- Debate in IMO on data collection and energy efficiency
- Trying to align to and support that debate in IMO

- EU MRV proposal must facilitate IMO debate
- Align with IMO methodes
- Keep administrative burden as low as possible
- Deliver robust data to be used i.a. to set reduction targets

# EU MRV – Proposed Regulation (2)

- Scope
  - Voyages to, in, and from EU ports
  - 5000gt and more
  - Only $CO_2$
  - Including Energy efficiency

- Shipowners can choose from existing monitoring methods (such as Bunker Delivery Notes, as well as measuring emissions)

- Making use of private verifiers:
  - Approving monitoring plan shipowners
  - Approving emission plan shipowners
  - Issue a Document of Compliance

# 2. IMO Environment committee (MEPC)

- The climate measures that are being discussed in IMO
  - Technical measures
  - Operational measures
  - Market Based Measures

- Present measures (EEDI en SEEMP) insufficient
- Market Based Measures considered necessary (MBM), however no results expected soon

- US proposal for a phased approach
  - data collection (as broad as possible)
  - Setting energy efficiency standard stimulating technical and operational measures

# IMO - US proposal data collection

- US proposal includes the monitoring and reporting of:
  - Fuel consumption (joules, aggregated on a yearly basis)
  - ‘Service hours’ (when transportation takes place)
  - The efficiency (transport / amount of fuel)
  - Basic information (ship name, IMO number, deadweight tonnage and Flag State)
- all ships above 400gt

# IMO - US proposal data collection and energy efficiency

- Analyse the data after two years
  - All ship types > 400gt

- Develop a Baseline
  - In principle for all ship types
  - But maybe for a limited number of ships and/or ship types

  *If data don't support a baseline, check whether individual ship baseline is possible*

- Decision on Efficiency standard; percentage reduction below the baseline

# IMO - alternative proposals data collection and energy efficiency

- Energy Efficiency Operational Indicator
- gram $CO_2$/ton-mile (same as in EEDI)
  - Fuel consumption
  - Distance
  - Deadweight
- Averaging Fluctuations by longer reporting period, e.g. one year

# IMO - alternative proposals data collection and energy efficiency

- Individual Ship Performance Indicator; gram $CO_2$/mile
  - Not only operational, but design efficiency as well through the *Estimated Index Value*
  - Combined with the *Energy Efficiency Standard Value* for the ship type

Deciding on the *Efficency Improvement Target*

# IMO - alternative proposals data collection and energy efficiency

- Fuel Oil Reduction Strategy

  - Yearly reduction target based on ship specific reference value
  - Ship specific reference value based on installed power in relation with operational criteria

    (*used in the IMO GHG Study: average operation time; average load; average specific fuel oil consumption)*

KEY IN HEAVY LIFT

**Arne Hubregtse**
**Platform Clean Shipping**
**18 December 2013**

BIGLIFT
KEY IN HEAVY LIFT

# CONTENTS

- BigLift
- Environmental strategy
- Emission reduction
- Conclusions

BIGLIFT

KEY IN HEAVY LIFT

# spliethoff group

- BigLift Shipping is 100% owned by Spliethoff

- Close relations with other Spliethoff Group subsidiaries

- Operating over 100 short sea / breakbulk / RoRo / project cargo / heavy lift vessels, offering flexibility and capacity

BIGLIFT
KEY IN HEAVY LIFT

spliethoff group

spliethoff | BIGLIFT | wijnne barends | TRANSFENNICA

## SPLIETHOFF

- Fleet of multi-purpose vessels
- DWT from 12,000 to 23,000 mt
- Own cranes ranging 3x40 – 3x120 mt
- 14 S-type vessels equipped with side loaders
- 1A Ice class vessels
- Dutch flag
- Specialized in break bulk, project and heavy-lift cargo

BIGLIFT
KEY IN HEAVY LIFT

spliethoff group

spliethoff | BIGLIFT | wijnne barends | TRANSFENNICA

## SEVENSTAR YACHT TRANSPORT

- Worldwide Yacht Transport service
- Leading provider of yacht transportation services on 'lift-on, lift-off' and 'float-on, float-off' basis
- Utilizing Spliethoff, Transfennica and BigLift fleet
- 1400 yachts transported (2012)
- Recently purchased DYT
    - SS4 and Yacht Express

BIGLIFT
KEY IN HEAVY LIFT

splietthoff group

## WIJNNE BARENDS

- Gearless multi-purpose vessels
- DWT from 2,000 to 5,500 mt
- Navigation area: White Sea to the Black Sea i.e. Scandinavia, the Baltic States, Western Europe and the Mediterranean.
- Specialized in Short Sea Shipping of e.g. timber (products), peatmoss, steel sheets and cables, wheat, fertilisers, aluminium, general cargo and bulk bags, containers, project cargo.

splIethoff group

## TRANSFENNICA

- Liner-shipping carrier operating specialized multi-purpose, highly ice-strengthened Ro-Ro vessels which serve the European market.
- All vessels have ice-class 1A Super
- Fast scheduled services between main European ports

# BIGLIFT SHIPPING

- World leading heavy lift shipping company
- Former Mammoet Shipping
- Fleet of 14 heavy lift Vessels
  - Dutch flag
  - FS 1A ice class
  - Upto 2x900 mt
- Happy Star will join the fleet in 2014
- Worldwide operation and vast network of representative offices and agents
- 40 year anniversary in 2013
- BigRoll

# BIGLIFT FLEET

HAPPY STAR

HAPPY SKY

HAPPY BUCCANEER

HAPPY R-TYPE

HAPPY D-TYPE

TRA-TYPE

# FINNISH / SWEDISH ICE CLASS 1A

Happy S-type
Happy D-type
Happy R-type

# SUPER FLYJIB

BIGLIFT
KEY IN HEAVY LIFT

# LATEST DEVELOPMENT – BIGROLL SHIPPING

KEY IN HEAVY LIFT

# MARKETS

MINING

PORT DEVELOPMENT

OFFSHORE

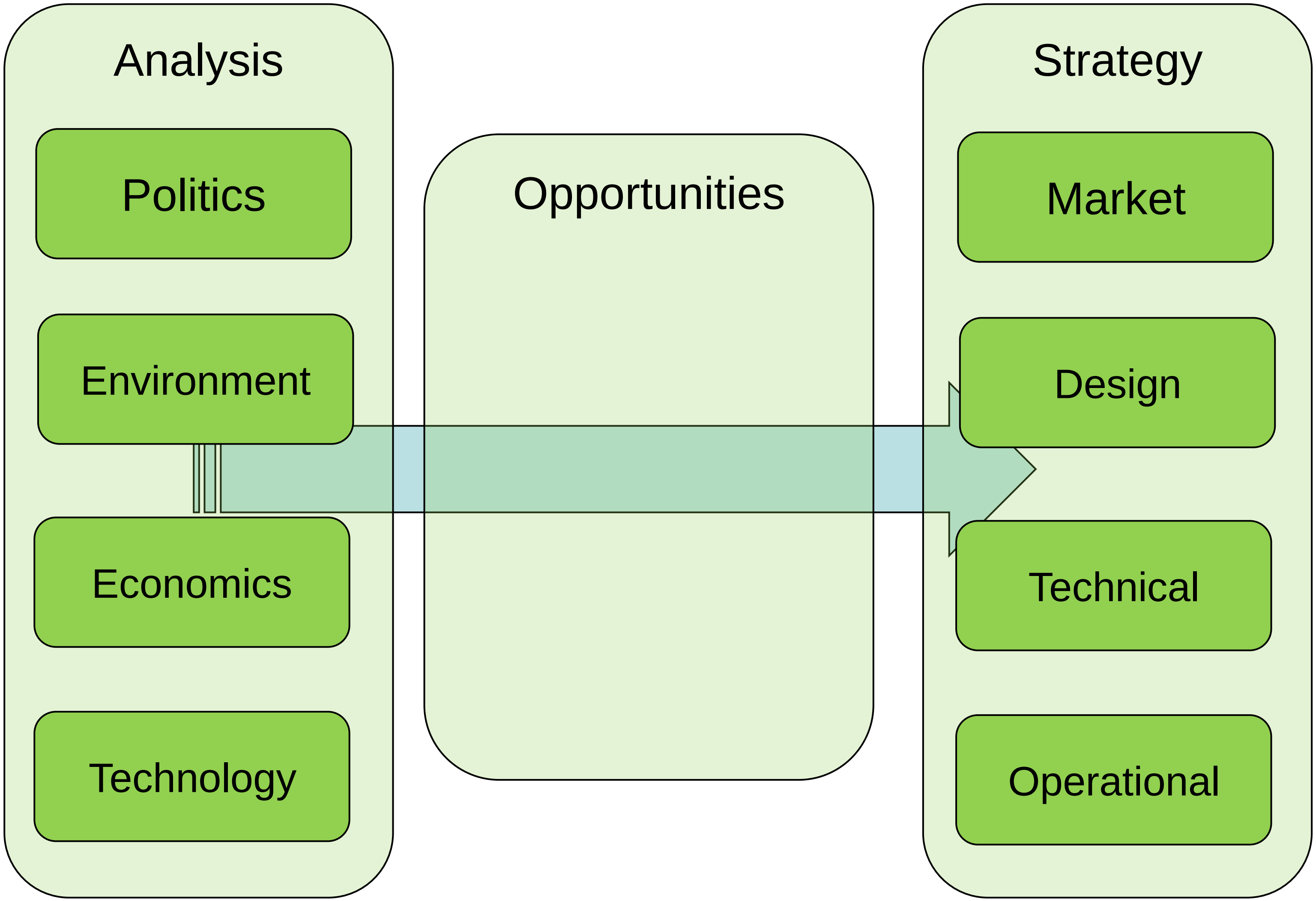
PETROCHEMICAL | POWER | LNG

FLOATING EQUIPMENT

ROLLING EQUIPMENT

BIGLIFT KEY IN HEAVY LIFT

# Environmental Strategy Spliethoff Group



BIGLIFT KEY IN HEAVY LIFT

# Environmental Strategy

- Emission reduction
- Water Ballast Treatment
  - ??? Shooting at a moving target
  - No ratification, US legislation different from IMO
  - New vessels have WBTS, IMO and USCG AMS approved (5yr)
  - Docking in 2014 ???
  - € 30-40 million investment
- Alternative fuels – LNG
  - Studied for various new projects
  - SOx, NOx, $CO_2$ reduction
  - Investment vs bunker location/costs and LNG price development
  - For BigLift's  world wide trading currently LNG no option
- Sulfur emissions
  - Successful trial period of scrubber on Plyca
  - Scrubbers ordered for all CONRO vessels (Baltic trading)
  - Installed in 2014

# PLYCA with scrubber installed

# Emission reduction

Emission reduction plan/ SEEMP

1. Fuel efficient ship
   - Hull form
   - Efficient propulsion set up
2. Reduce energy use
   - Optimum trim
   - Energy use on board systems
3. Optimum speed
4. Operational routing
   - Just in time arrival

BIGLIFT KEY IN HEAVY LIFT

# Emission reduction

## EEDI

- Not applicable yet for BigLift
- Energy efficiency vs. ship safety
  - Beam for safety / slender for fuel

## SEEMP

- Clear overview of measures and good implementation system
- Implemented for fleet
- But focus on $CO_2$ only
- EEOI is difficult index
  - Mass $CO_2$ / transport works
  - How to define transport works
  - Wharfdecks – container cranes – carousels/reels – shiploaders
  - Time required to build a reference line
- ISO 14000 offers a broader field and continuous improvement

# Fuel efficient ship

Fuel efficient hull form

1. Service speed as design speed
2. Design speed range and draft range
3. Multi objective optimization hull parameters/ hull form
4. Efficiency propulsion line (engine, gearbox, propeller)

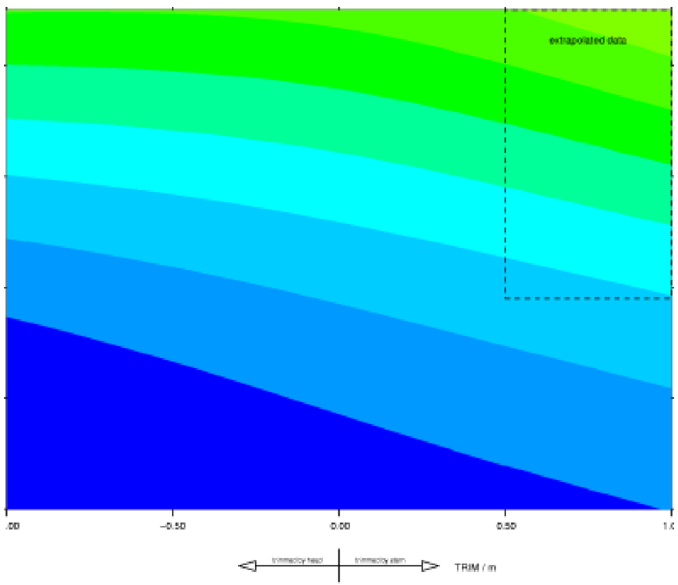
Energy saving in ship systems

1. In design and specification
2. Reuse of heat, economizers
3. Low energy systems
4. Low energy lights
5. Insulation

# Reduce consumption

Reduce energy use on board

1. Operational instructions for on board saving
   - Use of lights
   - Temperature control
   - System use
2. Clean propeller and hull – operations
   - Propeller cleaning ROI 8 to 10 days
   - Hull cleaning ROI 30-40 days
3. Optimum trim
   - Optimum trim tables for most vessels
   - Developed by model tests and calculations
   - Operational instruction to vessels

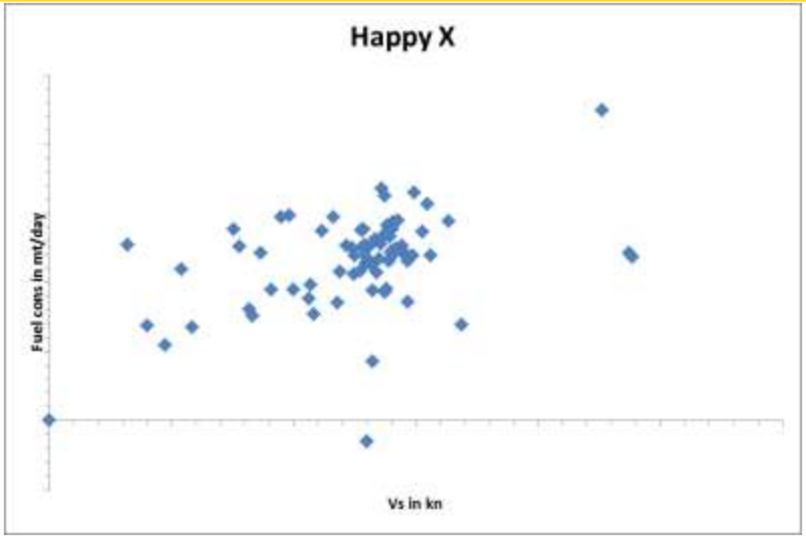


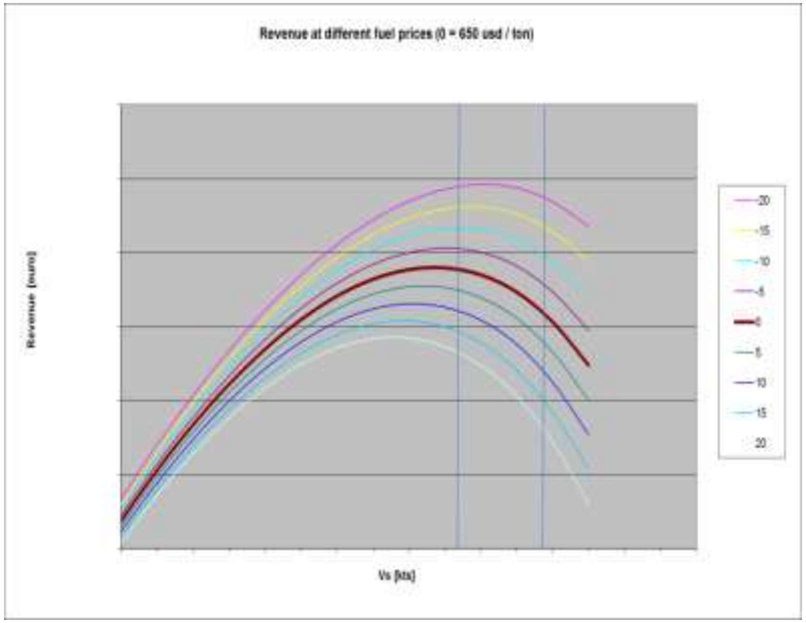
# Optimum speed

Optimum speed

1. Speed vs fuel
   - No reliable speed measurement available
   - Large variation
   - Long voyages
   - => Service speed vs. fuel consumption

2. Optimum speed
   - Emission vs earnings
   - Ship owners green heart
   - Optimum speed per fuel price
   - Accounting for lost time
   - Dependency on fuel price and vessel earnings
   - Arrival time vs. port operations

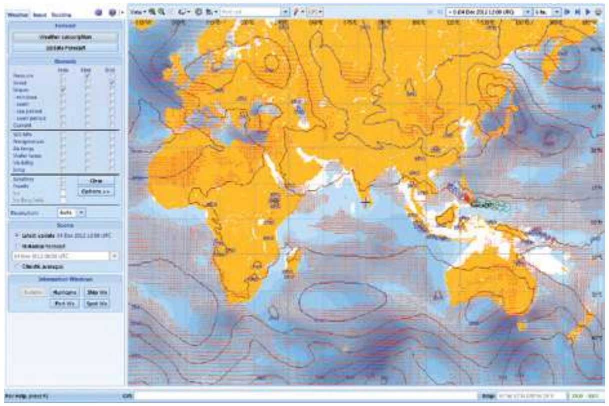


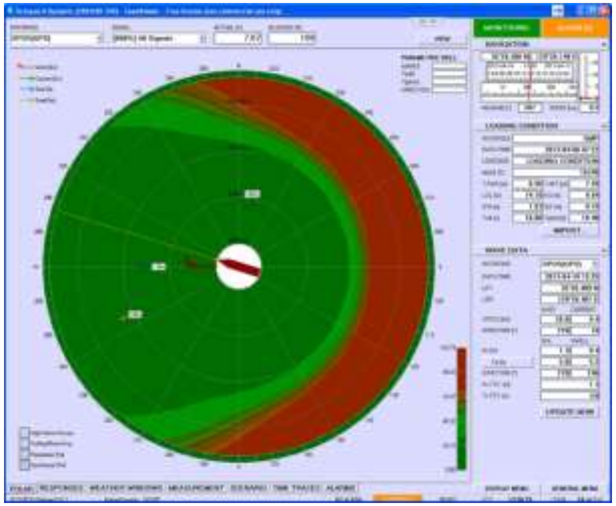



# Operational optimization

Operational performance

1. Vessel routing
    - SPOS weather information - routing
    - Safe transit – Octopus – acc on cargo - routing
    - Fuel vs. safety trade off?
2. Just in time arrival
    - Crew responsibility
    - Information and tools available
3. Developments
    - Installation of flow meters
        - Better registration
        - Consumption awareness
    - Test of routing systems
        - Accounting for voyage weather
    - Office operational support to ship





BIGLIFT KEY IN HEAVY LIFT

# Conclusions

- Too many single environmental issues, an environmental strategy provides clarity on focus and opportunities
- Regulations are changing, in need of ratification or postponed. This is not workable, multi million investments and significant lead times
- SEEMP implement, covers $CO_2$ only, EEOI not workable
- ISO 14000 covers full environmental area
- Emission reduction programs need crew involvement through tools, information, instructions and maybe accountability
- Objective of lower emissions and optimization of earnings coincide.
- Reference lines needs to be established, accurate vessel speed is key
- Just in time arrival time routing systems under evaluation

KEY IN HEAVY LIFT

# THANK YOU

# Options for monitoring fuel and emissions

## Costs and benefits

Jasper Faber, Dagmar Nelissen

Rotterdam 18 December 2013

CE Delft
Committed to the Environment

# CE Delft

- Independent, not-for profit consultancy, founded in 1978
- Based in Delft, the Netherlands
- Transport, Energy, Economy
- 15+ years of experience with environmental policies for shipping
- Clients include UNFCCC, IMO, European Commission, national governments, ports, shipping companies, NGOs

# Introduction

- Possible regulations for monitoring and reporting of fuel consumption and emissions are discussed in several fora
- The EC proposal allows for four different monitoring methods
- The monitoring methods have different characteristics
- This presentation discusses
  - The costs and accuracy of the four monitoring methods.
  - The additional costs that will have to be incurred by the different stakeholders.
  - The potential environmental benefit in terms of $CO_2$ reduction.

# MRV proposals

- Regulatory monitoring of fuel is discussed both at EU and IMO level

- EU: three-phased approach towards MBM
- MRV is first phase

- COM(2013) 480 final
  - Monitor, report and verify
    - $CO_2$ emitted;
    - distance travelled;
    - time spent at sea;
    - amount of cargo carried or number of passengers.

# MRV proposals

- Regulatory monitoring of fuel is discussed both at EU and IMO level

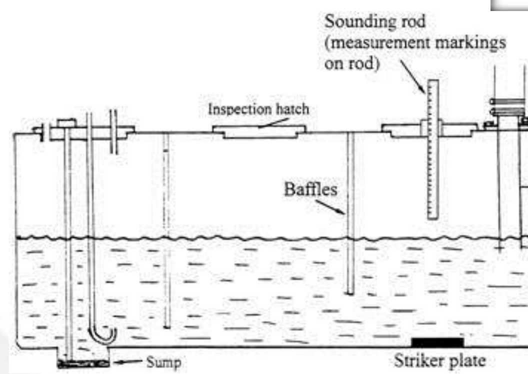
- IMO: efficiency measures for existing ships
- MRV as a necessary element

- IMO (MEPC 65/4/19; MEPC 65/4/30)
  - Monitor and report
    - Fuel use (amount of fuel, energy content)
    - Distance
    - Hours in service
    - Cargo or dwt

# Monitoring methods

EC specifies four monitoring methods

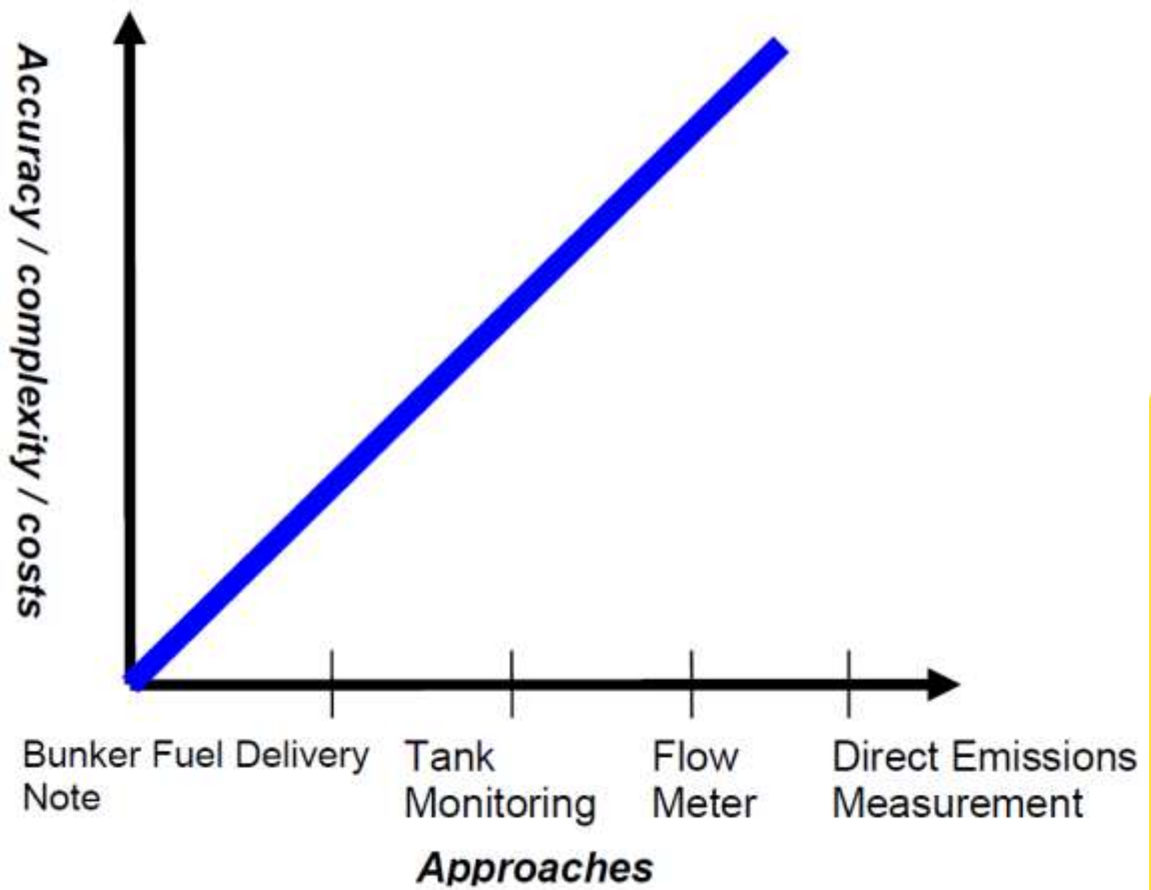
1. Bunker Fuel Delivery Note (BDN) and periodic stocktakes of fuel tanks;
2. Bunker fuel tank monitoring on board;
3. Flow meters for applicable combustion processes;
4. Direct emissions measurements.



## Monitoring methods

According to IMarEST, costs and accuracy are linearly correlated (MEPC 65/INF.3)

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# Costs and accuracy of monitoring methods

- Higher equipment costs could be offset by lower reporting costs
- Differences in accuracy are significant

| | Equipment costs | Monitoring& verification costs | Accuracy |
|---|---|---|---|
| BDN and stock-takings | No equipment cost. | Could be high as a result of use of paper records. | ±5% |
| Tank soundings | USD 1,000 per tank.<br>Standard on most ships. | Modest if automatically monitored. | Electronically: ±5% |
| Fuel flow meters | USD 15,000-60,000.<br>Standard on many newer ships | Modest if automatically monitored. | Depending on type<br>±0,2%<br>± 3% |
| Continuous emissions measurements | USD 100,000.<br>Not yet implemented on ships | Modest if automatically monitored. | ±2% |

# Administrative costs

- Automated systems have lower operational MRV costs than bunker delivery notes
- Potential regulatory cost saving from reduced need for MARPOL Annex VI inspections

| | EC Impact Assessment | Potential savings |
|---|---|---|
| Ship owners / operators | € 76 million | € 5 – 9 million<br>(only for automated systems) |
| Regulators | € 5 million | € 0.4 – 1.5 million<br>(fewer MARPOL Annex VI inspections for continuous emissions monitoring) |

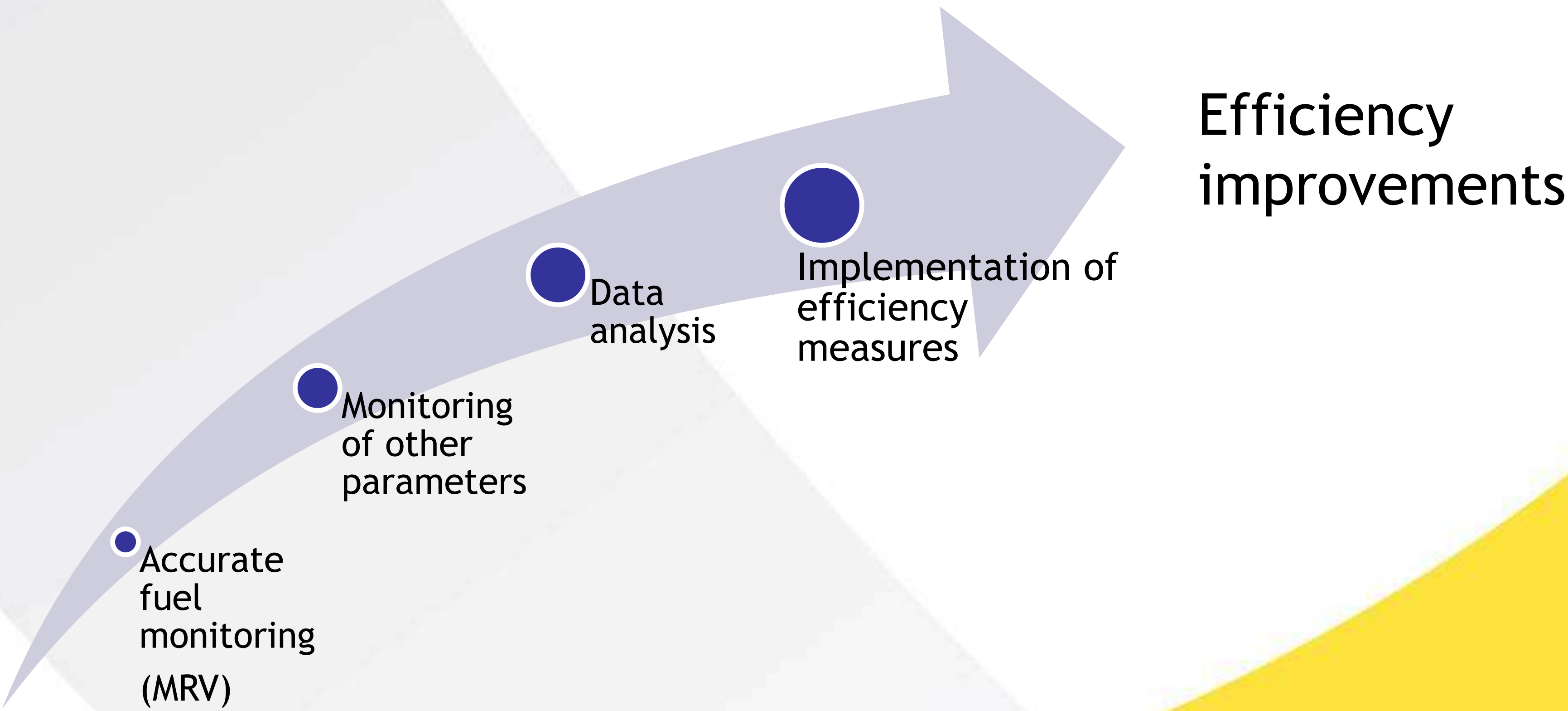
# Potential environmental benefits

- Monitoring does not reduce fuel use or improve efficiency by itself
- However, it can be the first step in a series of actions:
  - Monitor fuel use or efficiency
  - Monitor other relevant data (weather, speed, etc)
  - Analyse data
  - Implement operational and/or technical measures to reduce fuel consumption or improve efficiency

# Potential environmental benefits

- We have surveyed a number of shipping companies and service providers that have improved their efficiency based on MRV.
  - All companies have invested in data analysis capacities in-house or external
    - Fuel consumption and efficiency data show a large variation due to speed, weather, load and other factors
  - Most companies monitor more data than required in the EC MRV proposal
  - Most companies have invested in accurate fuel monitoring equipment
    - Fuel flow meters
  - By using accurate monitoring methods, analysing data and implementing measures, shipping companies have realised efficiency improvements well in excess of the 2% expected in the Impact Assessment

## Potential environmental benefits



# Conclusions

- There is a large difference in the accuracy of monitoring methods
- Equipment costs are a share of total MRV costs
- Monitoring, reporting and verification costs are lower for more accurate monitoring methods
- More accurate monitoring methods enable efficiency analysis, which enables implementation of efficiency-enhancing measures
- CEMS allows for monitoring of other emissions, which could reduce the costs of MARPOL Annex VI inspections

# Sources


EC impact assessment, SWD(2013) 237 final/2

IMarEST, 2013, Goal-based approach to fuel and $CO_2$ emissions monitoring and reporting, MEPC 65/INF.3

CSC, 2013, Comments on possible approaches to monitoring, reporting and verifying fuel consumption and $CO_2$ emissions from ships, MEPC 65/4/34

CE Delft, 2013, Monitoring of bunker fuel consumption

CE Delft, 2013, Economic impacts of MRV of fuel and emissions in maritime transport