# Operational measures to mitigate and reverse the potential modal shifts due to environmental legislation


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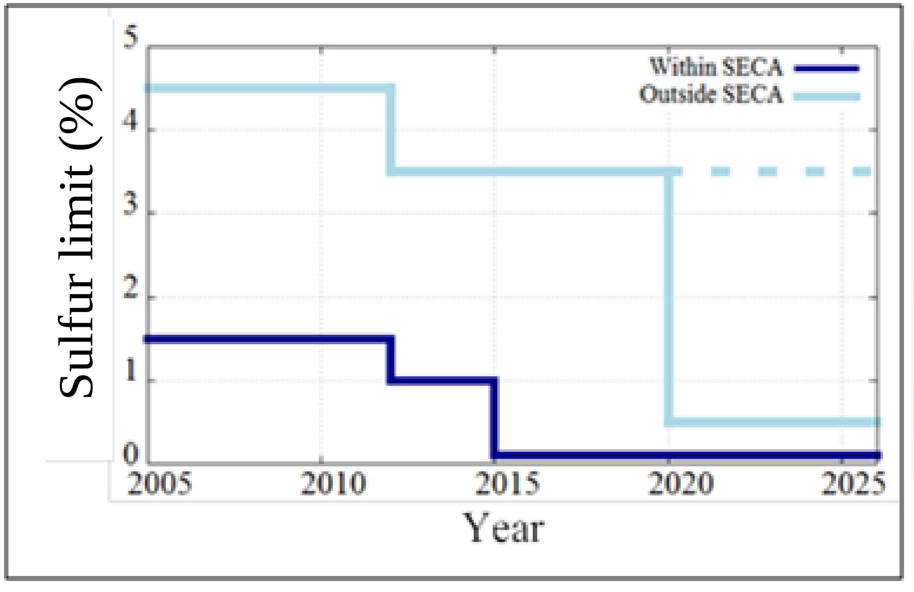
# Presentation Outline

- Background
  - The regulation
  - Objectives
  - Anticipated Impacts
  - Market picture and Fuel Prices
- Modelling Modal shifts
  - Required Data
  - A hierarchical logit model
  - The generalized cost of transport
  - Available data
- Measures from the Ro-Ro operator
  - Speed reduction
  - Sailing frequency
  - Fleet reconfiguration
  - Technological investments
- Case Studies
  - Route selection criteria
  - The examined services
  - Calibration results
  - Fuel price scenarios
- Next Steps

# Background

- As of January 1st 2015:





| | | | | Year |
|---|---|---|---|---|
| Areas | 2005-2012 | 2012-2015 | 2015-2020 | 2020 - |
| Within SECA | 1.5 | 1 | 0.1 | 0.1 |
| Outside SECA | 4.5 | 3.5 | 3.5 | 0.5 |

# Effects to stakeholders

- Ship operators can either use low-sulphur fuel, or retrofit vessels with scrubber systems

- MGO is more expensive, while scrubbers increase overall fuel consumption, and require significant capital costs

- Increased operating costs could lead to changes in
  - vessel deployment
  - frequency of service
  - sailing speed
  - existence of certain routes

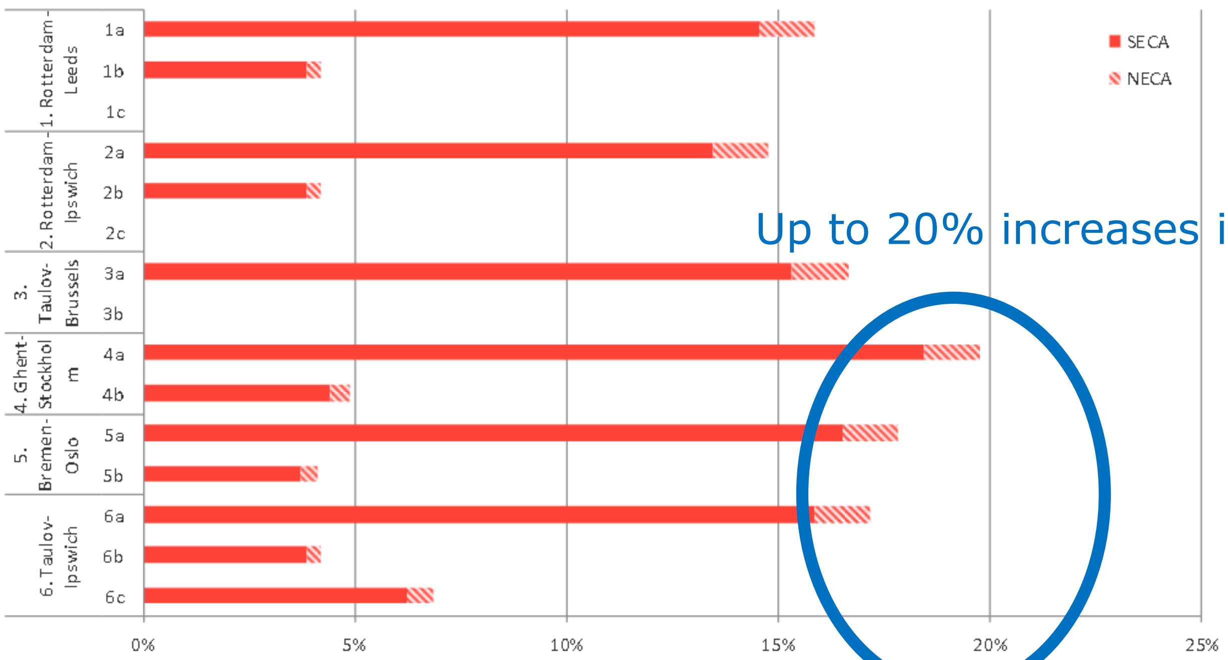
- Some of the additional costs will be passed over to clients through the Bunker Adjustment Factor (BAF – fuel surcharges)

# Objectives:

- Understand the wider implications of the new limit..
- On SECAs (is the environmental improvement significant?)
- How is Short Sea Shipping affected
- Identify the negative impacts of the regulation
- Propose options for ship operators to mitigate and reverse these

# Anticipated impacts from studies

*Figure 23: Percentage cost increase in sea-based costs due to SECA and NECA in 2015 for ro/ro routes*




Up to 20% increases in sea-based costs

Source:(North Sea Consultation Group, 2013)

# Press releases before the new limit

## SECA SHUTS DOWN TRANSFENNICA IBERIAN SERVICE

The Dutch-owned short-sea shipping line Transfennica (part of the Spliethoff Group) has announced that it is to cease its "Motorways of the Sea" ro-ro service between Bilbao, Portsmouth and Zeebrugge at the end of this month (December).

The decision is a direct result of the introduction of stricter new low-sulphur emission controls from 1 January 2015 in the Baltic Sea, the Kattegat, the North Sea and English Channel. A further SECA extends in a 200 nautical miles wide belt along the coasts of the USA and Canada.

## SECA requirements lead to new European rail link

CARRIERS: Railway company ERS is opening a new route in Europe in light of rising customer demand following the implementation of new sulphur regulations. Many customers and countries are willing to change their mode of transport in order to save money.

## DFDS closes Sassnitz-Klaipeda connection

Publication date: 2013-08-30
Tags: maritime, germany, denmark, lithuania

**DFDS Seaways has decided to close the ferry service between Sassnitz, Germany and Klaipeda, Lithuania with effect from the end of September.**

Previously a busy connection, the route has over the years become economically unviable. As Vice President of DFDS, Anders Refsgaard, stated: "We have fought hard to get new customers and improve revenue and profit, but unfortunately without success". He added, that with the outlook on continued decline in profits, and in light of the new sulphur regulations to be introduced from 1 January 2015, the company does not believe that it will be possible to turn the tide on the crossing.

# But were they right in predicting?

## Stena Line records 16% yearly growth on North Sea route


Stena Britannica sails between the UK port of Harwich and the Hook of Holland in the Netherlands

## DFDS Wraps Up Record Year, Expects Higher Revenue in 2016

Image Courtesy: DFDS

**Danish shipping and logistics company DFDS posted a profit of DKK 1.07bn (USD 151m), up by 89pct when compared to last year's DKK 571 million.**

For the full-year 2015, the group reported revenue increase of 5% to DKK 13.5bn. Organic revenue growth, adjusted for route closures and acquisitions, was 7% mainly driven by 7% higher freight shipping volumes and 8% more passengers. In the fourth quarter, organic revenue growth was 10%.

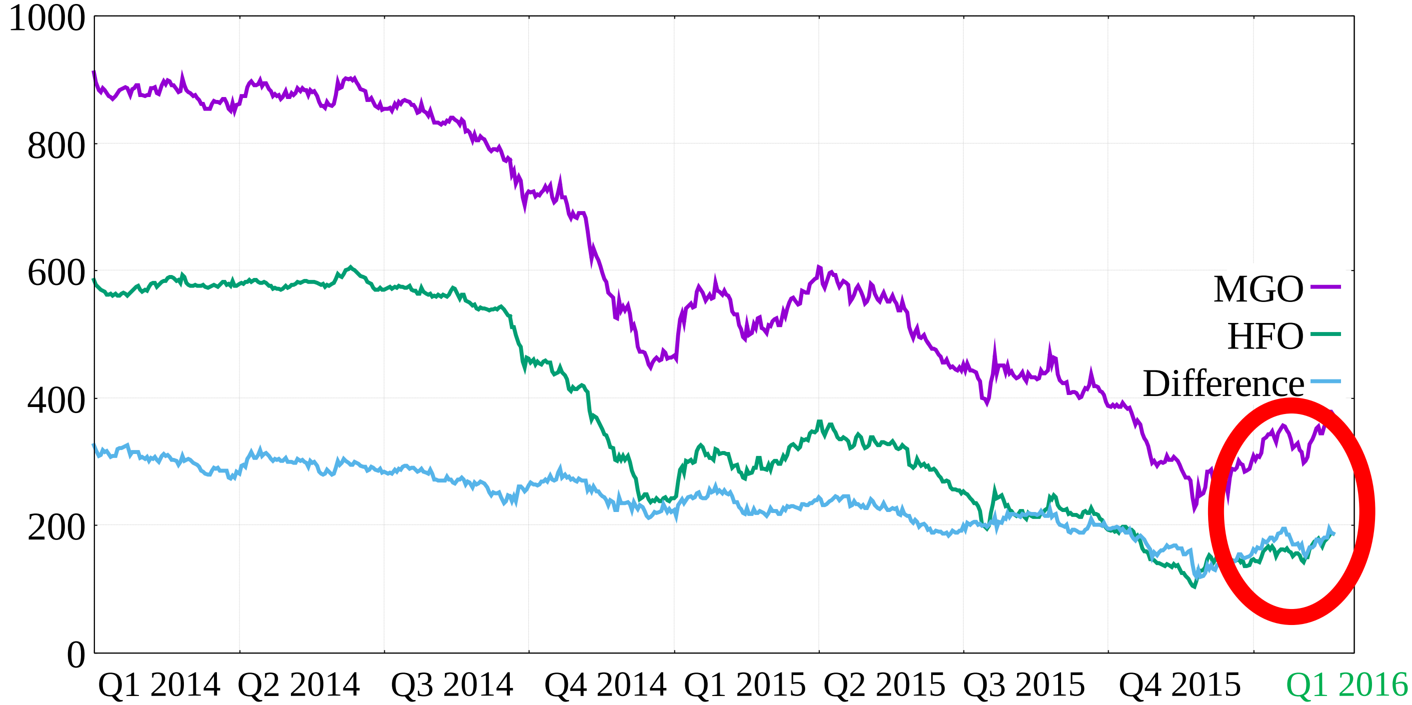
## P&O breaks Channel freight record in 2015

*By Charlie Bartlett from London*


P&O Ferries transported more freight between Dover and Calais in 2015 than any other year in its "modern history," amounting to 1,340,317 trucks.

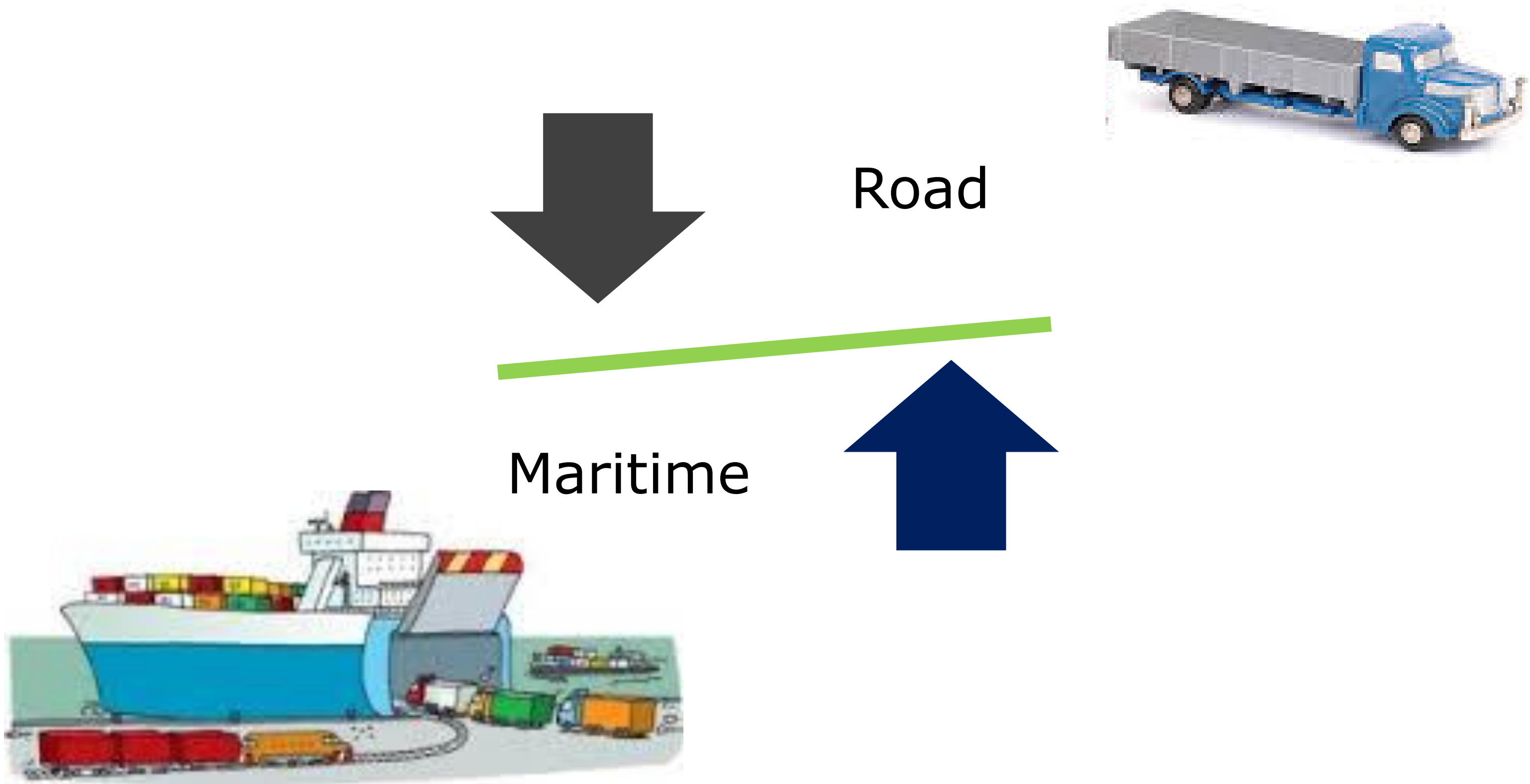
The result is a 22% year-on-year increase over 2014, and is due in part to disruptions at the channel tunnel, which caused a 172% year-on-year increase in HGVs on is separate Teesport to Zeebrugge route throughout the month of July. The group pressed a sixth ship back into service on the English Channel that month in order to increase capacity.

# Actual Fuel prices




The absolute price differential would gradually decrease
Fuel prices have started going up in 2016

# Modelling Modal Shifts



# Required Data

Data on Ro-Ro Routes:

Total sailing time (port to port)
Frequency of service
Freight rates per lanemeter of cargo
Waiting times at Ports
Connecting Road Distance after Sealeg?

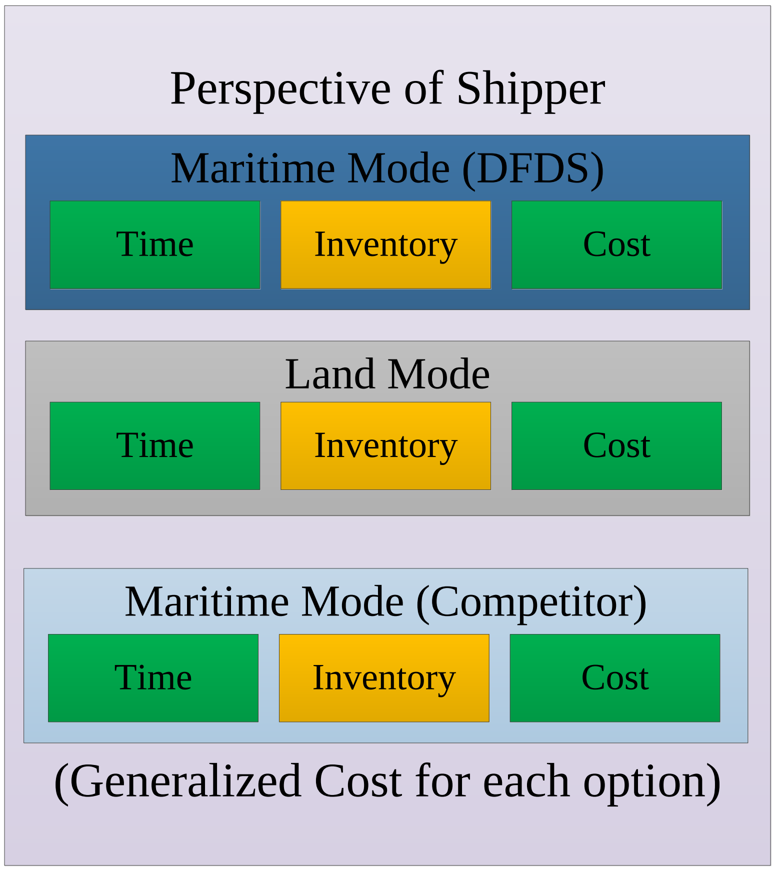
Data on Maritime Competitors:

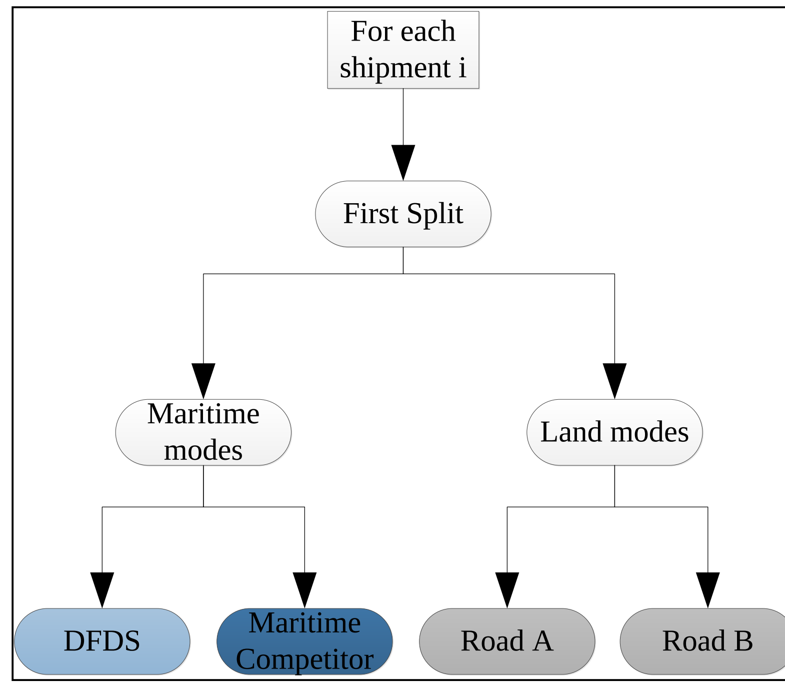
Which Service
Total sailing time (port to port)
Frequency of service
Freight rates per lanemeter of cargo
Connecting Road Distance after Sealeg?

Data on Landbased Competitors:

Is there a fully landbased option?
Total Distance
Total Travel Time
Freight Rate
Tolled Points

# A hierarchical Logit model



# Generalized Cost and probability of choice

- Probability of selecting mode i is

$$P_i = \frac{e^{-\lambda \cdot GC_i}}{\sum_{i=1}^{2} e^{-\lambda \cdot GC_i}}$$

Where GCi is the Generalized Cost of mode i:

$$\boldsymbol{GC_i = TC_i + a \cdot TT_i}$$

Where TCi is the Travel Cost (€/lm), TTi is the Travel Time (hours), ɑ is the value of time (€/lm*hours)

- λ is a scale parameter that acts as a weight attached in the choice. The larger the value, the greater the implication of a change in cost in one of the modes

# Available Data

## Data used in this paper

### Data on Ro-Ro operator

- Vessel Deployment 2014-2016
- Fuel Consumpion per Vessel-Trip
- Utilization Capacity
- Freight Rates
- Passenger Fares and Onboard Consumption

### Maritime competitors

- Schedules of maritime services
- Aggregate market share information (Eurostat)
- Trailers, Lanemeters, Pax, Cars transported (Shippax)
- Bunker Adjustment Factor information

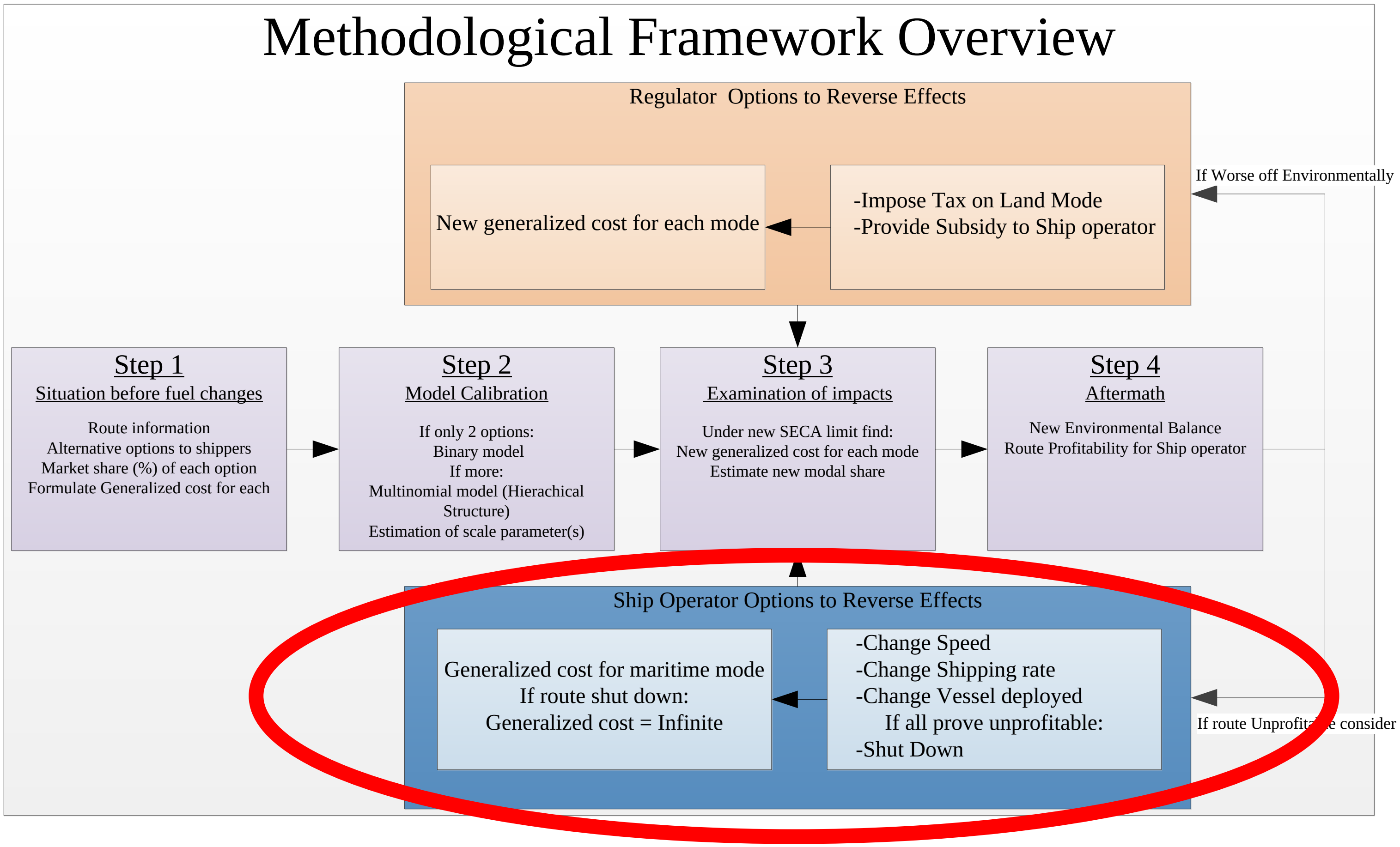
### Landbased modes information

- Distance and Cost information (GIS Network model, online sources)
- Fuel Consumption
- Freight rates (Literature, online sources)

Case Studies with Network of

DFDS

# Modelling Steps



# Measures from the Ro-Ro Operator



# Speed Reduction

- Dead slow?

  Actually.. No

- Fast services, constrained by port times
- "Integer" time of service
- Thus, increase by 0.5, 1 , 2 hours
- Saves Fuel consumption at sea, and at port
- Loses some cargo due to increased time

# Sailing Frequency

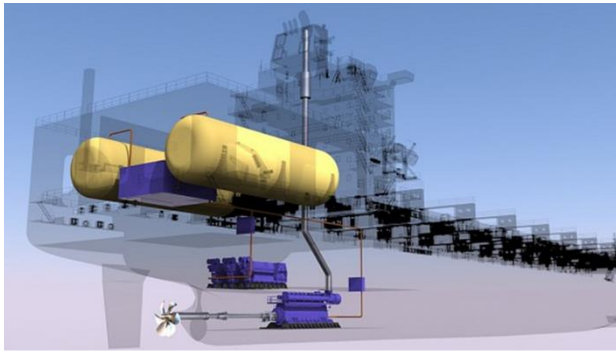
- Change in Transport Demand
- Cargo loss → Profitability threatened
- Instead of shutting down, Reduce sailing frequency
- Cargo gain → Ensure available capacity
- Increase sailing frequency, or swap vessels

# Fleet reconfiguration

- Change which vessel serves which route
- Take advantage of differences in capacity
- Constraints:
  - Type of vessel
  - Visiting port
  - Subsidy
  - Size of vessel

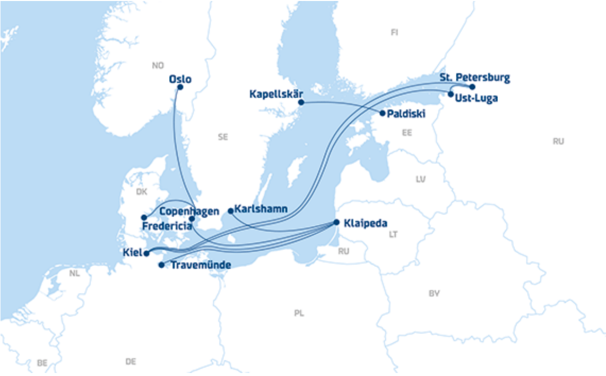
# Technological Investments


- MGO vs LNG
- Scrubbers vs Low-sulphur
- Cost of retrofits vs Increased Operational Costs



# Case Studies

DFDS


# Route selection criteria

- Geographical balance → Proportion by Region
- Chain configuration → By Sailing Distance & Frequency
- Volume → By Vessel and Route Capacity
- Commodity mixture → Cargo type and value
- Vessel types → Ro-Ro, Ro-Pax, Cruise, abatement
- Data availability

# The examined services

| Route | Year | Trips Total | Transported Cargo Volume change (%) | Cargo Rate change (%) | Revenue Change (%) | Annual Fuel Cost Change (%) |
|---|---|---|---|---|---|---|
| Gothenburg - Ghent* | 2014<br>2015 | 553<br>569 | 6.06 | -5.62 | 0.09 | -52.89 |
| Esbjerg – Immingham | 2014<br>2015 | 512<br>580 | 19.46 | -0.5 | 18.85 | -15.29 |
| Copenhagen – Oslo | 2014<br>2015 | 687<br>702 | -5.82 | 1.58 | 4.28 | -9.36 |
| Klaipeda - Kiel* | 2014<br>2015 | 611<br>615 | -4.64 | -7.71 | -8.89 | -30.05 |
| Dover – Calais | 2014<br>2015 | 6210<br>4994 | -17.66 | 9.36 | -18.04 | -50.35 |

# Calibration Results

<table>
<tr><th rowspan="2">Route</th><th colspan="3">Market Share (%)</th><th colspan="3">Scale parameter</th></tr>
<tr><th>Maritime</th><th>Maritime competitor</th><th>Land</th><th>$\lambda$</th><th>$\lambda_1$ (Maritime-Land)</th><th>$\lambda_M$ (Maritime - Mar)</th></tr>
<tr><td>Gothenburg – Ghent</td><td>24-30</td><td>21-29</td><td>39-49</td><td>NA</td><td>0.027</td><td>0.025</td></tr>
<tr><td>Esbjerg – Immingham</td><td colspan="2">60-70</td><td>30-40</td><td>0.08</td><td colspan="2" rowspan="4">NA</td></tr>
<tr><td>Copenhagen – Oslo</td><td>20-25</td><td>NA</td><td>75-80</td><td>0.108</td></tr>
<tr><td>Klaipeda – Kiel</td><td>51-61</td><td>NA</td><td>39-49</td><td>0.019</td></tr>
<tr><td>Dover – Calais</td><td>39-49</td><td>NA</td><td>51-61</td><td>0.015</td></tr>
</table>

# For more on model calibration..

ELSEVIER

Transportation Research Part D: Transport and Environment

Volume 52, Part A, May 2017, Pages 185–201

## The implications of the new sulphur limits on the European Ro-Ro sector

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Available online 16 March 2017

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https://doi.org/10.1016/j.trd.2017.03.010

# Scenarios on Fuel Price

- **Case 1: What actually happened (MGO with actual prices)**
- **Case 2: What would happen if MGO prices returned to 2014 levels**
- **Case 3: What would happen if HFO still allowed (Actual prices)**

| Scenario | HFO Price ($/ton) | MGO Price ($/ton) | Description |
|---|---|---|---|
| **Case 1** | 263 | 478 | actual fuel prices in 2015 |
| **Case 2** | 533 | 816 | This is a pessimistic scenario. |
| **Case 3** | 263 | (Not used) | Assuming use of MGO not mandatory |

# % increase in generalized cost for 1 extra hour

| Cargo Value (€/lm) | 1 extra hour of transport | | | |
|---|---|---|---|---|
| | *r=1%* | *r=3%* | *r=10%* | *r=20%* |
| Gothenburg - Ghent | | | | |
| 1000 | 0,024 | 0,007 | 0,024 | 0,048 |
| 100000 | 0,241 | 0,718 | 2,354 | 4,6 |
| Esbjerg – Immingham | | | | |
| 1000 | 0,003 | 0,008 | 0,028 | 0,056 |
| 100000 | 0,279 | 0,832 | 2,719 | 5,295 |
| Copenhagen – Oslo | | | | |
| 1000 | 0,004 | 0,013 | 0,042 | 0,084 |
| 100000 | 0,418 | 1,244 | 4,031 | 7,749 |
| Klaipeda – Kiel | | | | |
| 1000 | 0,003 | 0,01 | 0,033 | 0,066 |
| 100000 | 0,327 | 0,976 | 3,179 | 6,163 |
| Dover - Calais | | | | |
| 1000 | 0,012 | 0,037 | 0,123 | 0,246 |
| 100000 | 1,218 | 3,567 | 10,978 | 19,783 |

# Effects of Speed on fuel consumption

Gothenburg – Ghent (Normal sailing time 32 hours)

| Ship | Hours at berth | Hours sailing | Weekly fuel consumption (tonnes) | Reduction (%) |
|---|---|---|---|---|
| Baseline Sailing Speed **18.06 knots** | | | | |
| **Ship A** | 38 | 130 | **xx** | NA |
| **Ship B** | | | **xx** | |
| **Ship C** | | | **xx** | |
| **Ship D** | | | **xx** | |
| Increase Trip by **1 hour**, New Sailing Speed **17.26 knots** | | | | |
| **Ship A** | 32 | 136 | **xx** | -10.11 |
| **Ship B** | | | **xx** | -10.51 |
| **Ship C** | | | **xx** | -9.26 |
| **Ship D** | | | **xx** | -8.52 |
| Increase Trip by **2 hours**, New Sailing Speed **16.53 knots** | | | | |
| **Ship A** | 26 | 142 | **xx** | -18.36 |
| **Ship B** | | | **xx** | -18.96 |
| **Ship C** | | | **xx** | -17.55 |
| **Ship D** | | | **xx** | -16.67 |
| Increase Trip by **3 hours**, New Sailing Speed **15.86 knots** | | | | |
| **Ship A** | 20 | 148 | **xx** | -34.86 |
| **Ship B** | | | **xx** | -35.80 |
| **Ship C** | | | **xx** | -34.23 |
| **Ship D** | | | **xx** | -33.24 |

# Effects on cargo volumes, revenue, fuel cost

Gothenburg – Ghent (Normal sailing time 32 hours)

| Baseline Sailing Speed **18.06 knots** | | |
|---|---|---|
| | Transported lm | Cost of Fuel (€) |
| Fuel Case 1 | 42331 | Confidential |
| Fuel Case 2 | 39533 | |
| Fuel Case 3 | 43724 | |
| Increase Trip by **1 hour**, New Sailing Speed **17.26 knots** | | |
| | ΔTransported lm (%) | ΔCost of Fuel (%) |
| Fuel Case 1 | -0.05 | -9.98 |
| Fuel Case 2 | -0.36 | |
| Fuel Case 3 | -0.11 | |
| Increase Trip by **2 hours**, New Sailing Speed **16.53 knots** | | |
| Fuel Case 1 | -0.1 | -18.32 |
| Fuel Case 2 | -0.7 | |
| Fuel Case 3 | -0.15 | |
| Increase Trip by **3 hours**, New Sailing Speed **15.86 knots** | | |
| Fuel Case 1 | -0.16 | -34.99 |
| Fuel Case 2 | -0.76 | |
| Fuel Case 3 | -0.21 | |

# Esbjerg – Immingham

# Effects of Speed on fuel consumption

Esbjerg – Immingham (Fuel consumption per hour)

| Ship | Average Fuel ME (tonnes per hour) | Average AE (tonnes per hour, cruise) | Average Fuel port (tonnes per hour, berth) |
|---|---|---|---|
| Baseline Sailing Speed 18.11 knots | | | |
| **Ark Germania** | **xx** | **Included in ME** | **xx** |
| **Ark Dania** | **xx** | | **xx** |
| Increase Trip by 0.5 hour, New Sailing Speed 17.62 | | | |
| **Ark Germania** | **xx** | **Included in ME** | **xx** |
| **Ark Dania** | **xx** | | **xx** |
| Increase Trip by 1 hour, New Sailing Speed 17.16 | | | |
| **Ark Germania** | **xx** | **Included in ME** | **xx** |
| **Ark Dania** | **xx** | | **xx** |
| Increase Trip by 2 hours, New Sailing Speed 16.3 | | | |
| **Ark Germania** | **xx** | **Included in ME** | **xx** |
| **Ark Dania** | **xx** | | **xx** |

# Effects of Speed on fuel consumption

## Esbjerg – Immingham (Fuel consumption savings)

| Ship | Hours at berth | Hours sailing | Weekly fuel consumption (tonnes) | Reduction (%) |
|---|---|---|---|---|
| Baseline Sailing Speed 18.11 knots | | | | |
| **Ark Germania** | 60 | 108 | **xx** | NA |
| **Ark Dania** | | | **xx** | |
| Increase Trip by 0.5 hour, New Sailing Speed 17.62 | | | | |
| **Ark Germania** | 57 | 111 | **xx** | -6.47 |
| **Ark Dania** | | | **xx** | -14.19 |
| Increase Trip by 1 hour, New Sailing Speed 16.53 | | | | |
| **Ark Germania** | 54 | 114 | **xx** | -12.40 |
| **Ark Dania** | | | **xx** | -19.72 |
| Increase Trip by 2 hours, New Sailing Speed 15.86 | | | | |
| **Ark Germania** | 48 | 120 | **xx** | -22.87 |
| **Ark Dania** | | | **xx** | -29.38 |

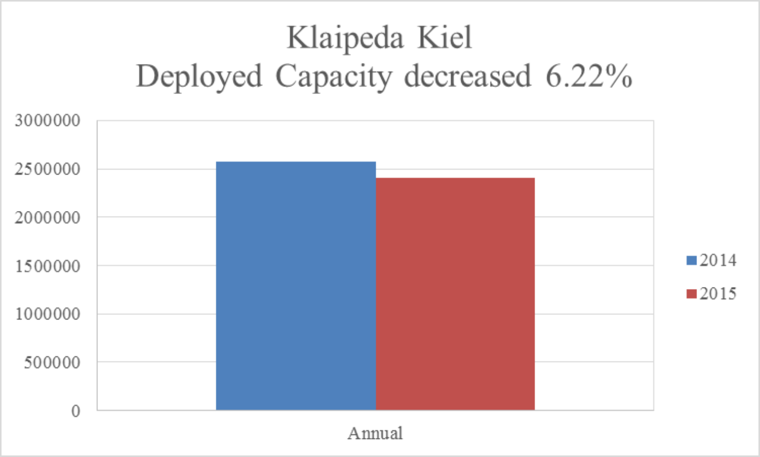
# Copenhagen – Oslo

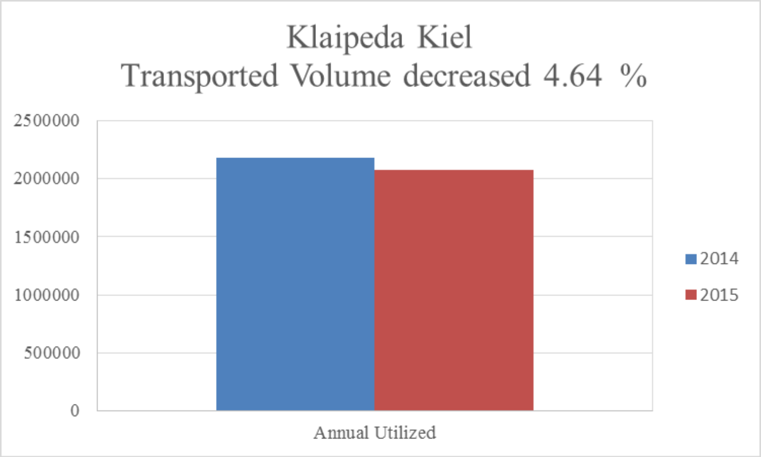
# Effects of Speed on fuel consumption

Copenhagen – Oslo (Fuel consumption per hour)

| Ship | Average Fuel ME (tonnes per hour) | Average AE (tonnes per hour, cruise) | Average Fuel port (tonnes per hour, berth) |
|---|---|---|---|
| Baseline Sailing Speed 15.54 knots | | | |
| **Crown Seaways** | **xx** | **xx** | **xx** |
| **Pearl Seaways** | **xx** | **xx** | **xx** |
| Increase Trip by 0.5 hour, New Sailing Speed 15.11 | | | |
| **Crown Seaways** | **xx** | | **xx** |
| **Pearl Seaways** | **xx** | **xx** | **xx** |
| Increase Trip by 1 hour, New Sailing Speed 14.70 | | | |
| **Crown Seaways** | **xx** | | **xx** |
| **Pearl Seaways** | **xx** | **xx** | **xx** |

# Klaipeda – Kiel

# Effects of Speed on fuel consumption

Klaipeda – Kiel (Fuel consumption per hour)

| Ship | Average Fuel ME (tonnes per hour) | Average AE (tonnes per hour, cruise) | Average Fuel port (tonnes per hour, berth) |
|---|---|---|---|
| Baseline Sailing Speed 18.39 knots | | | |
| **Victoria Seaways** | **xx** | **xx** | **xx** |
| **Optima Seaways** | **xx** | **xx** | **xx** |
| Increase Trip by 0.5 hour, New Sailing Speed 17.98 | | | |
| **Victoria Seaways** | **xx** | **xx** | **xx** |
| **Optima Seaways** | **xx** | | **xx** |
| Decrease Trip by 1.5 hour, New Sailing Speed 19.77 | | | |
| **Victoria Seaways** | **xx** | **xx** | **xx** |
| **Optima Seaways** | **xx** | | **xx** |

# Effects of Speed on fuel consumption

Klaipeda – Kiel (Fuel consumption change)

| Ship | Hours at berth | Hours sailing | Fuel consumption (tonnes) | Change (%) |
|---|---|---|---|---|
| Baseline Sailing Speed 18.39 knots | | | | |
| **Victoria Seaways** | 17 | 151 | **xx** | NA |
| **Optima Seaways** | | | **xx** | |
| Increase Trip by 0.5 hour, New Sailing Speed 17.98 | | | | |
| **Victoria Seaways** | 13.4 | 154.6 | **xx** | -4.77 |
| **Optima Seaways** | | | **xx** | -5.22 |
| Decrease Trip by 1.5 hour, New Sailing Speed 19.77 | | | | |
| **Victoria Seaways** | 27.4 | 140.6 | **xx** | 16.51 |
| **Optima Seaways** | | | **xx** | 18.04 |

# Effects of new sailing frequency

Esbjerg – Immingham (Normal frequency 6 sailings per week)

| | New sailing frequency | New Transported lm | New capacity utilization | ΔRevenue (€) | ΔFuel Cost (€) |
|---|---|---|---|---|---|
| Fuel Case 2 | 5 | 29060 | **xx** | -112273 | -33579 |
| Fuel Case 3 | 7 | 34475 | **xx** | 39897 | 16569 |

Klaipeda – Kiel (Normal frequency 7 sailings per week)

| | New sailing frequency | New Transported lm | New capacity utilization | ΔRevenue | ΔFuel Cost |
|---|---|---|---|---|---|
| Fuel Case 1 | 6 | 26900 | **xx** | -32419 | -28172 |
| Fuel Case 2 | 6 | 25950 | **xx** | -25082 | -57093 |

Dover – Calais (Normal frequency 99 sailings per week)

| | New sailing frequency | New Transported lm | New capacity utilization | ΔRevenue | ΔFuel Cost |
|---|---|---|---|---|---|
| Fuel Case 1 | 75 | 131724 | **xx** | -56039 | -58844 |
| Fuel Case 2 | 75 | 130760 | **xx** | -74580 | -119255 |

# Vessel swapping (for 1 week)

Gothenburg – Ghent (Illustrative, some crude assumptions)

| | Capacity utilization | ΔFuel Cost (€) |
|---|---|---|
| Fuel Case 1 | **xx** | -4662 |
| Fuel Case 2 | **xx** | -9447 |
| Fuel Case 3 | **xx** | -4526 |

Esbjerg – Immingham

| | Capacity utilization | ΔFuel Cost (€) |
|---|---|---|
| Fuel Case 1 | **xx** | -11033 |
| Fuel Case 2 | **xx** | -22358 |
| Fuel Case 3 | **xx** | -10711 |

# Payback period of scrubbers

- DFDS has retrofitted 18 of its vessels.
- In the examined routes there are 9 vessels running on low-sulphur fuel
- Assumed a retrofit on the ship with the highest fuel consumption (Ro-Ro)

| *Fuel prices* | *HFO (€/ton)* | *MGO (€/ton)* | *Annual Savings (M€)* | *Payback period (years)* |
|---|---|---|---|---|
| December 2015 | 135 | 304 | 1.21 | 4.3 |
| October 2015 | 237 | 480 | 1.731 | 2.9 |
| November 2014 | 590 | 880 | 1.998 | 2.4 |
| February 2014 | 803 | 1212 | 2.825 | 1.3 |

- Considering the global cap coming in 2020, perhaps waiting is an option
  - Different fuel price differential
  - Newer technologies
  - New subsidies to operators may come

# General measures

- LNG as fuel

| *HFO (€/ton)* | *MGO (€/ton)* | *LNG (€/ton)* | *Annual LNG Savings (M€)* | *LNG Payback period (years)* |
|---|---|---|---|---|
| 135 | 304 | 250 | 727121 | 23 |
| 237 | 480 | 485 | 605132 | 35 |
| 590 | 880 | 610 | 2788661 | 4.9 |
| 803 | 1212 | 740 | 4443090 | 2.5 |

# Conclusion and further work

- **Freight Rate** is the most important component
- **Time** is **not crucial**, except for high-value cargoes. Speed reduction can help in times of high fuel prices
- Changes in sailing frequency can help with capacity utilization rates
- Technology investments depend on fuel prices, and returns are currently delayed
- **Profitability** of ship operator is **masking the negative effects** of the regulation – a happy coincidence
- Requirements for policy measures to mitigate potential modal shifts

# Thank you - Questions?

The work presented has been in the context of the project:


**"Mitigating and reversing the side-effects of environmental legislation on Ro-Ro shipping in Northern Europe"**
**funded by the Danish Maritime Fund.**

**Participation to this conference was co-funded by the Otto Mønsteds Fond**


**More Information:**

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