PVS

Marine Engine Optimization

vir2sense

virtual sensor technology

www.vir2sense.com

Outline

- Vir2sense core competence
- Industries
- Challenges
- PVS
- Market introduction

Idea

Target group

Understanding of requirements

Product

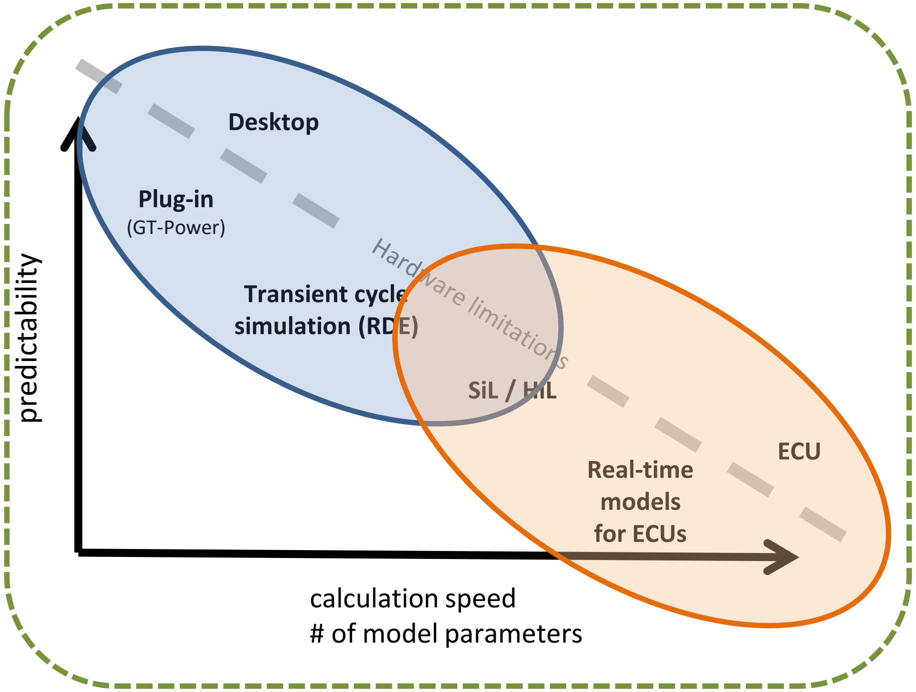
Business model

Vir2sense Core Competence

Vir2sense operates a **platform of engine performance and emission models** enabling optimization of the engine's settings:

(Hardware and Software)

- to operate the engine at the least possible fuel consumption
- to respect emission legislation limits (in all test procedures)



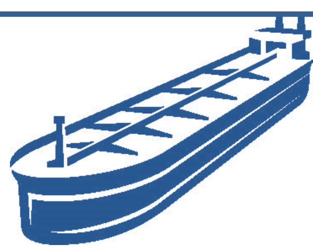
Combustion Engines Application

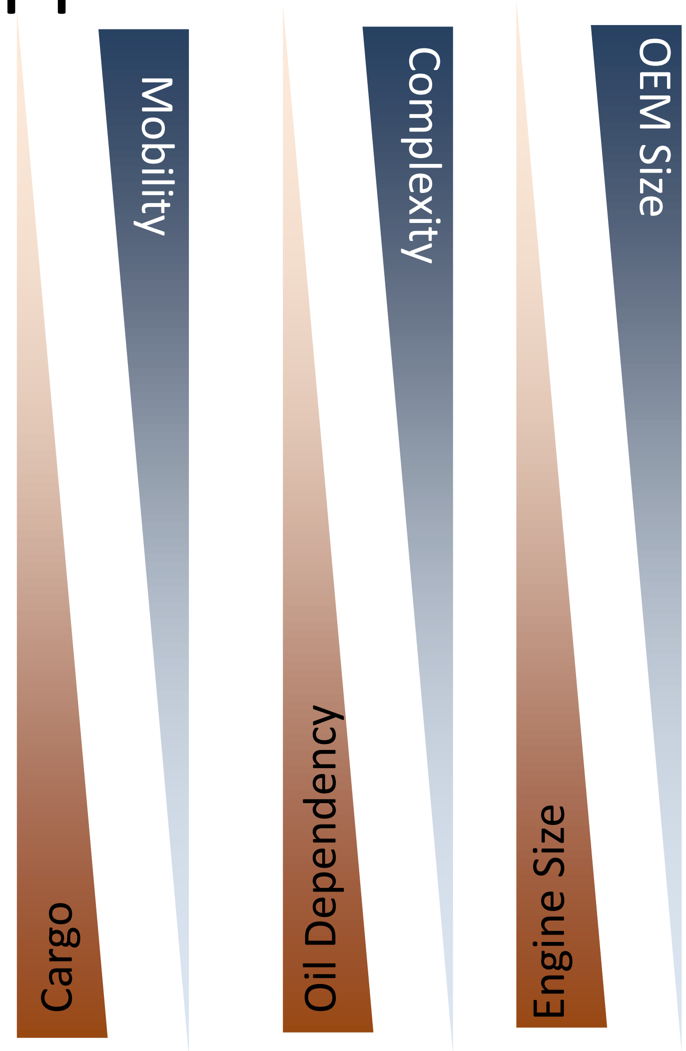
Automotive Industry
- RDE
- Fleet CO_2 –emission limit

Heavy Duty Industry (Trucks, Construction Machines, etc.)
- Fuel economy
- Variable application with various emission legislation

4-Stroke Marine Industry (Tug boats, Ferries, Cruise ships)
- Fuel economy
- «Close-coast» operation (emission limits)

2-Stroke Marine Industry (Carriers, Tankers)
- Fuel economy at “slow steaming”
- NO_x-emission limits / taxes

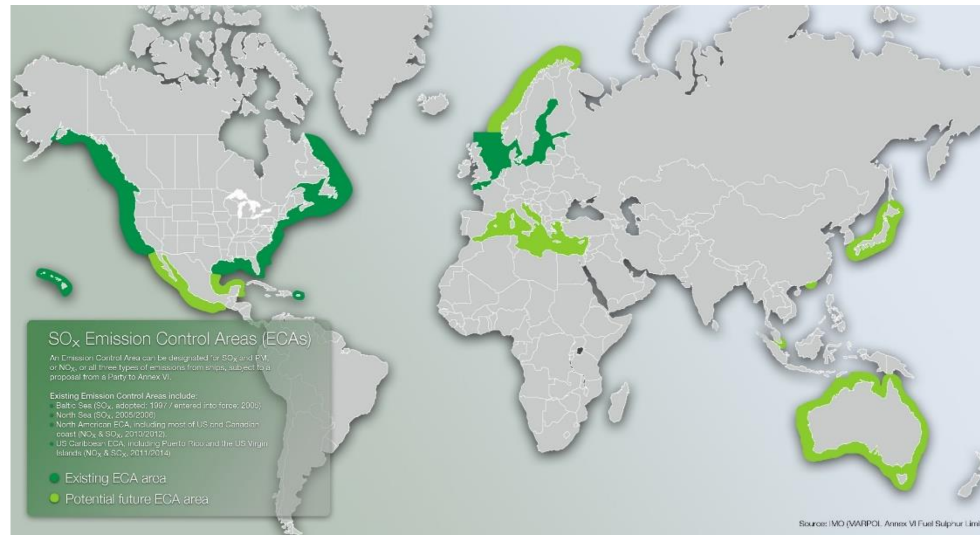


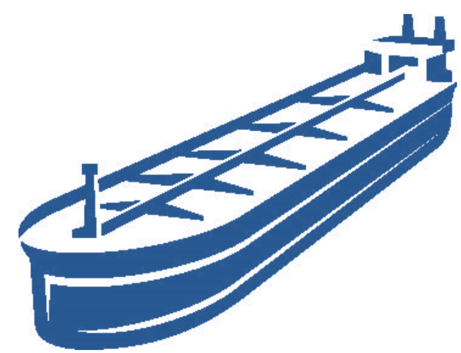


Ship Operator's Current Situation

- High financial pressure of efficient operation
  - Fuel consumption 15t/h
  - Fuel bill 30 m$/year
- Increasingly stringent emission legislations (Emission controlled areas NOx and SOx)
- NOx and fuel consumption are in trade-off
- Total transport capacity determined by # of ships and velocity
  - Influenced by demand and fuel price
  - Demand and fuel price prediction time << life time of ship

Flexible engines are required





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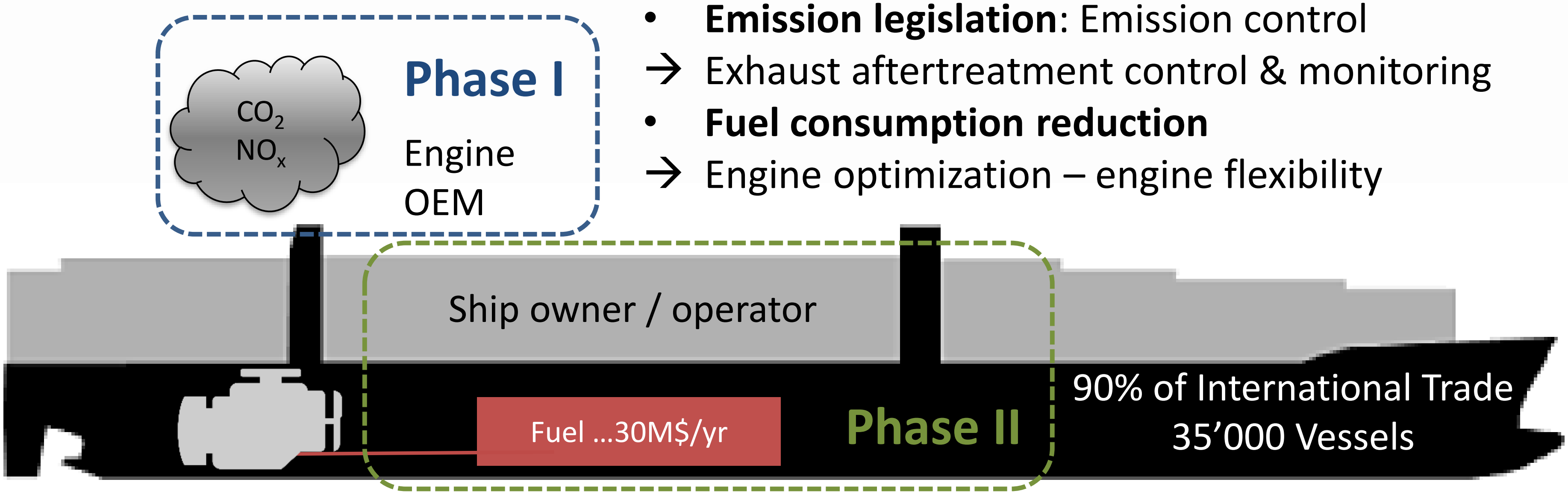
Source: INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Challenges

- **Emission legislation**: Emission control
→ Exhaust aftertreatment control & monitoring
- **Fuel consumption reduction**
→ Engine optimization – engine flexibility



- Solution: **Continuous Emission Monitoring**
  - **Problems**: lifetime/reliability, complexity and cost!

- Offer to engine makers for emission control
- Offer to ship owners for performance optimization and increased engine flexibility

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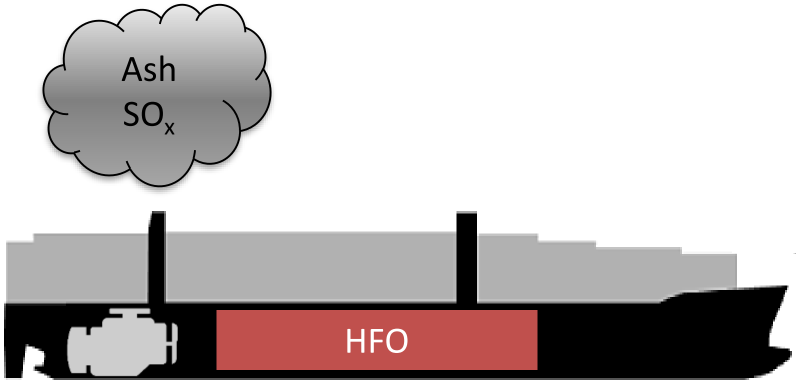
NOx Sensors in Marine Application



Physical Sensors

- Independent on changes in conditions
- Exhaust gas exposure

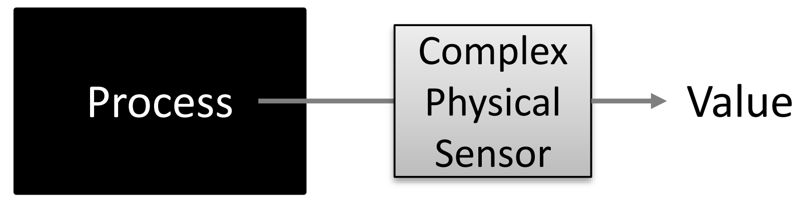
- Exhaust gas exposure
  - Clogging due to high ash content of HFO
  - Poisoning due to high sulfur content of HFO
  - Exposure time limited or expensive

➡ Use of virtual sensors

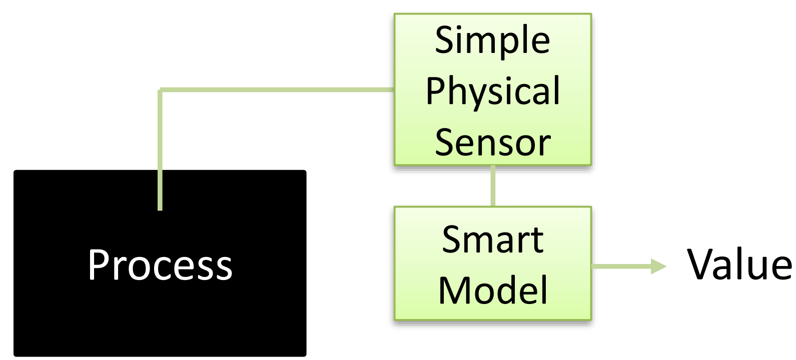
What is a Virtual Sensor?

- **Physical sensors:**
  - Sensors using a physical process to obtain the required quantity
  - ✓ Accuracy
  - \- Reliability
  - \- Cost/Complexity
- **Virtual sensors:**
  - “Smart” sensors which use reliable data to calculate the required quantity
  - ✓ Reliability-lifetime
  - ✓ Cost
  - \- Accuracy under changing conditions

Physical Sensor



Virtual Sensor



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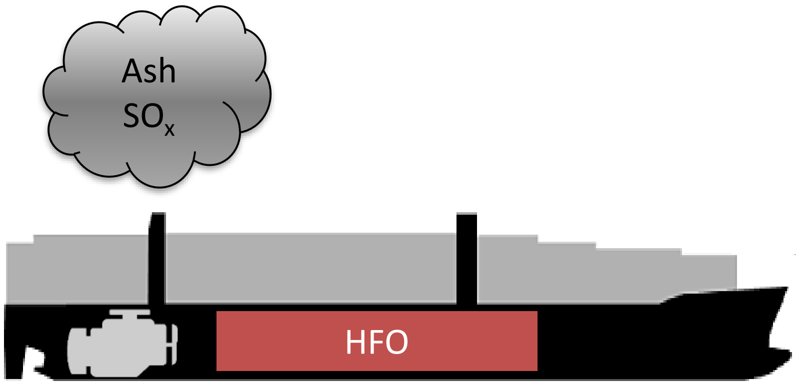
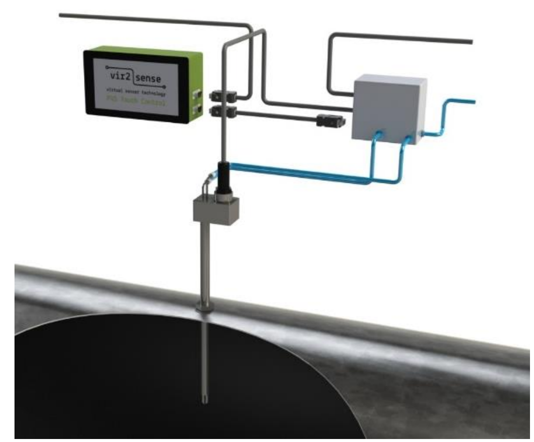
NOx Sensors in Marine Application



Physical Sensors
- Independent on changes in conditions
- Exhaust gas exposure

Virtual Sensors
- No exhaust gas exposure
- Dependent on changes in conditions

- Exhaust gas exposure
  - Clogging due to high ash content of HFO
  - Poisoning due to high sulfur content of HFO
  - Exposure time limited or expensive
- Changes in conditions
  - Changes in environmental conditions and fuel composition need to be measured and integrated into the model description
  - Component ageing not captured



Combination of a **physical** and a **virtual sensor**

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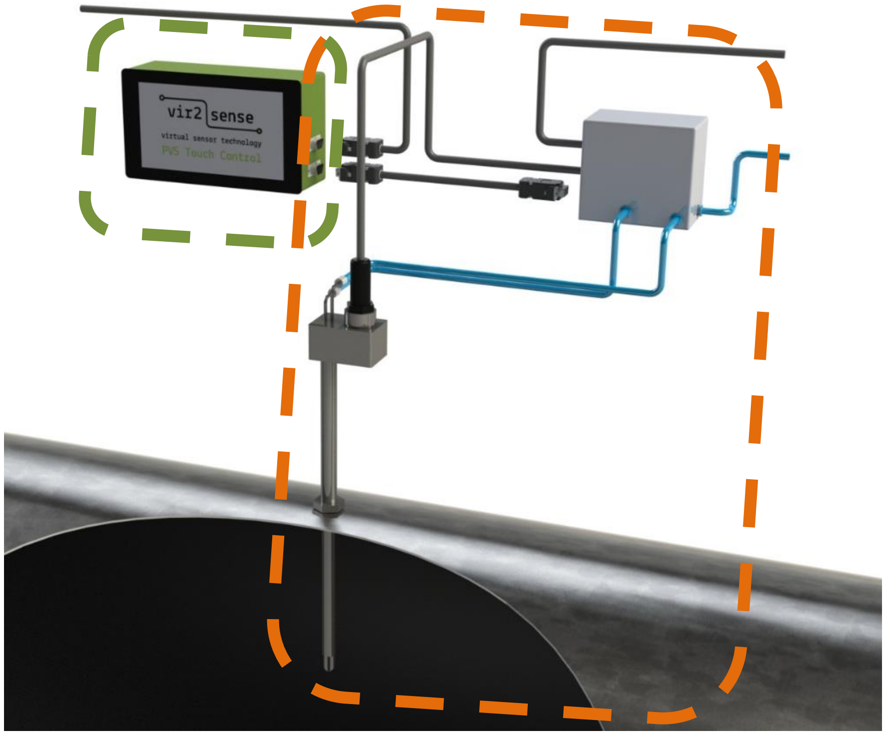
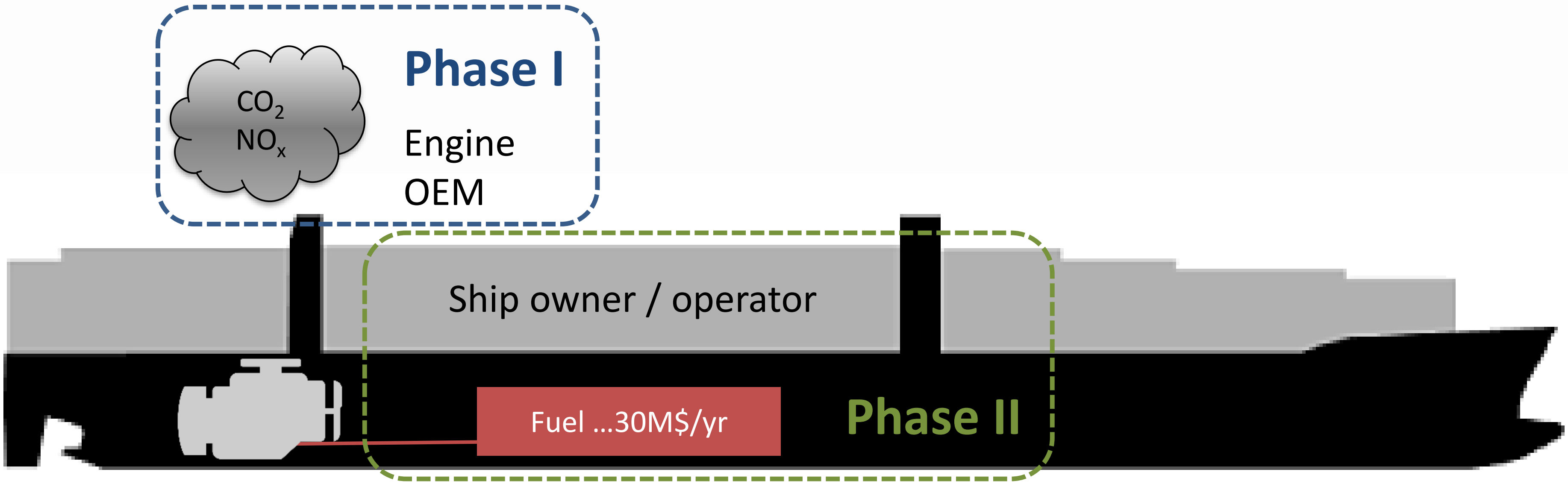
Physically-assisted Virtual Sensor (PVS):

- **Combination** of a physical and a virtual **sensor**;
  - ✓ Lifetime/Reliability (virtual sensor)
  - ✓ Accuracy (physical sensor)



- Technology based on:
  - Automotive (cheap) sensor and clever **sensor protection system**
  - **Physically-consistent,** simple models
  - to be **automatically retuned**

Phase I Engine OEMs



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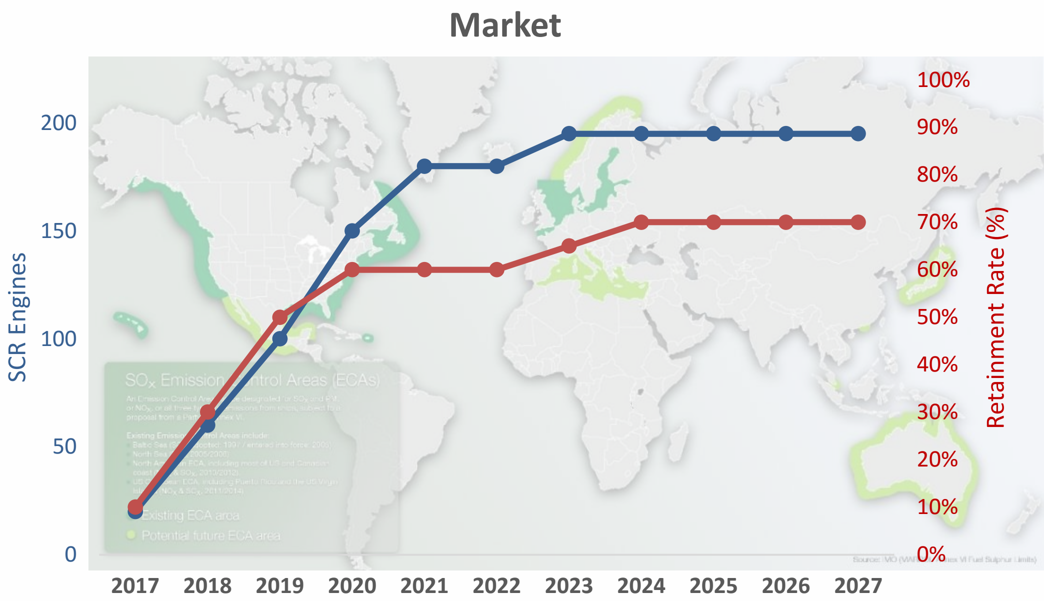
Physically-assisted Virtual Sensor

- Offer to engine makers for emission control
- Offer to ship owners for performance optimization and increased engine flexibility

Phase I – Emission Control

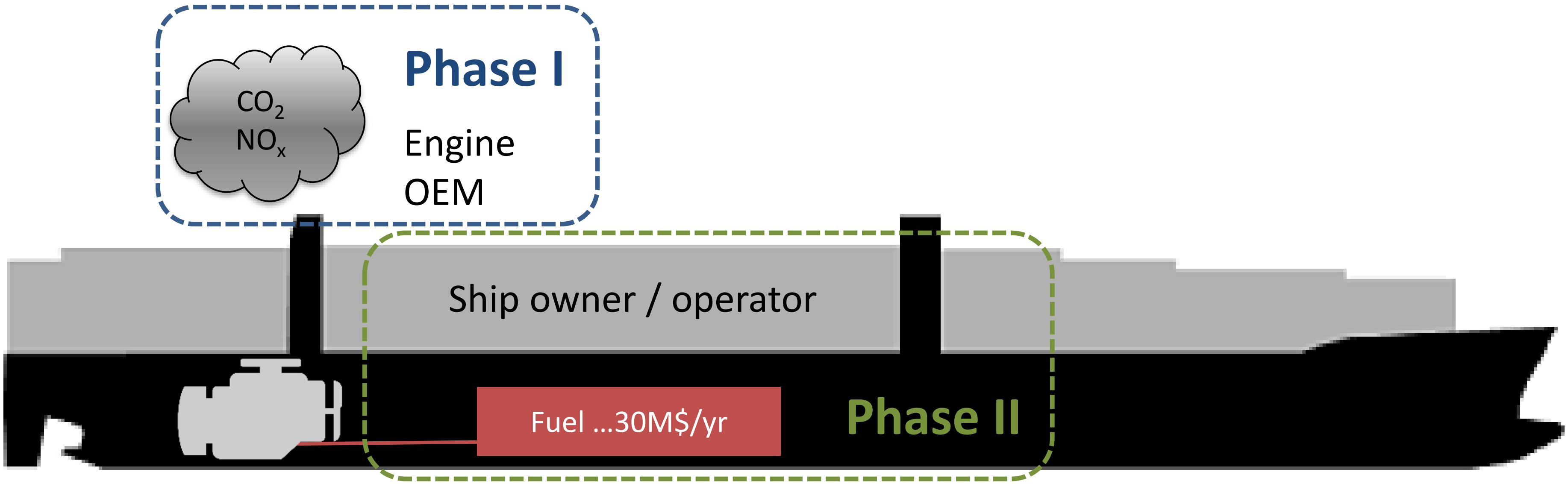
- New **Emission Control Areas**
- PVS can be used as a NO_x-Sensor for HFO operation
- **Urea SCR** control and condition monitoring
- Virtual part is used to minimize physical sensor exposure time

- Collaboration with **Engine OEM**
  - ✓Access to ECU
  - ✓Access to market
  - ✓Data acquisition from multiple ships



Source: *INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION*

Phase II Ship owners



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Physically-assisted Virtual Sensor

- Offer to engine makers for emission control
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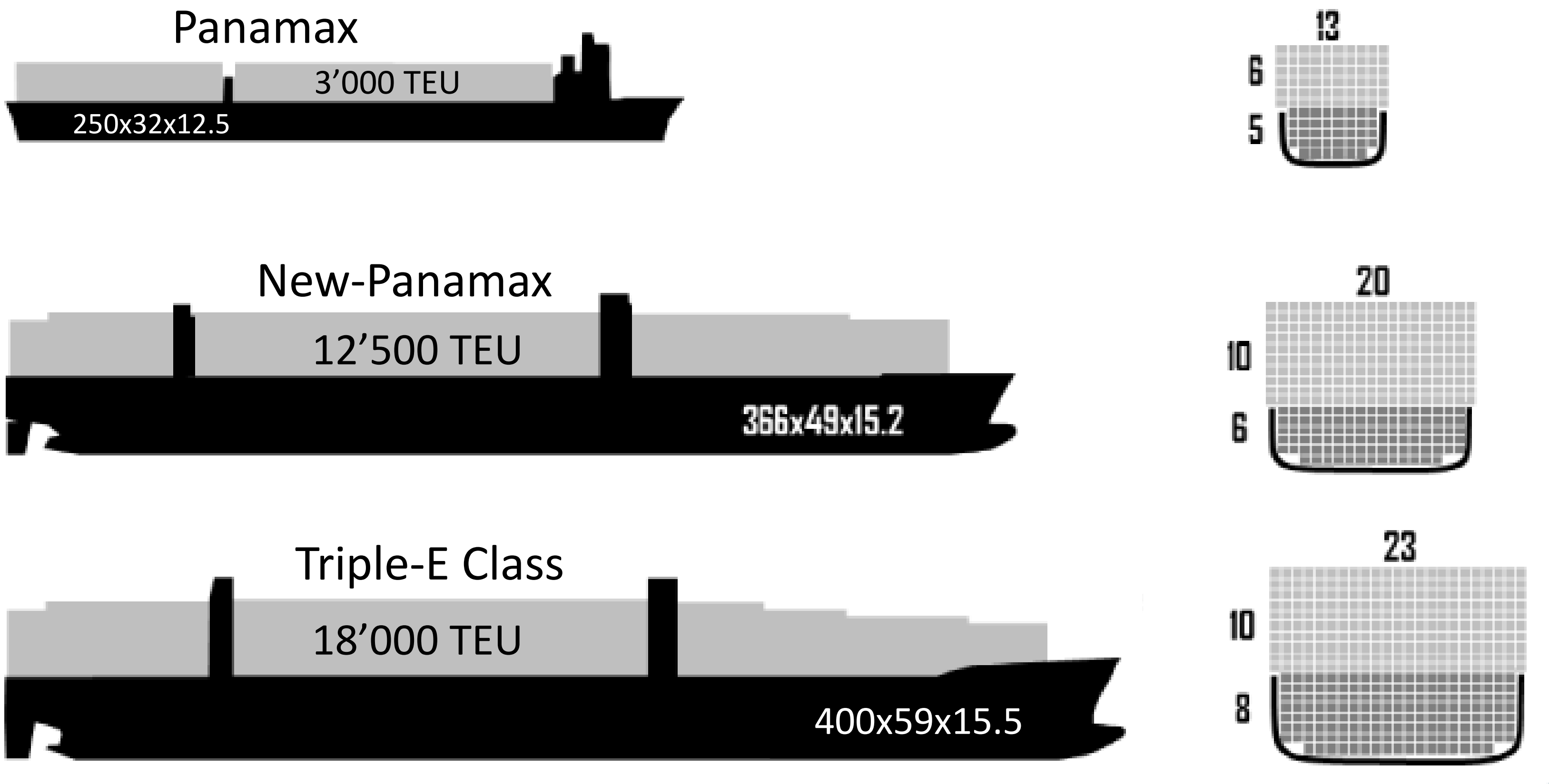
Vessel Size



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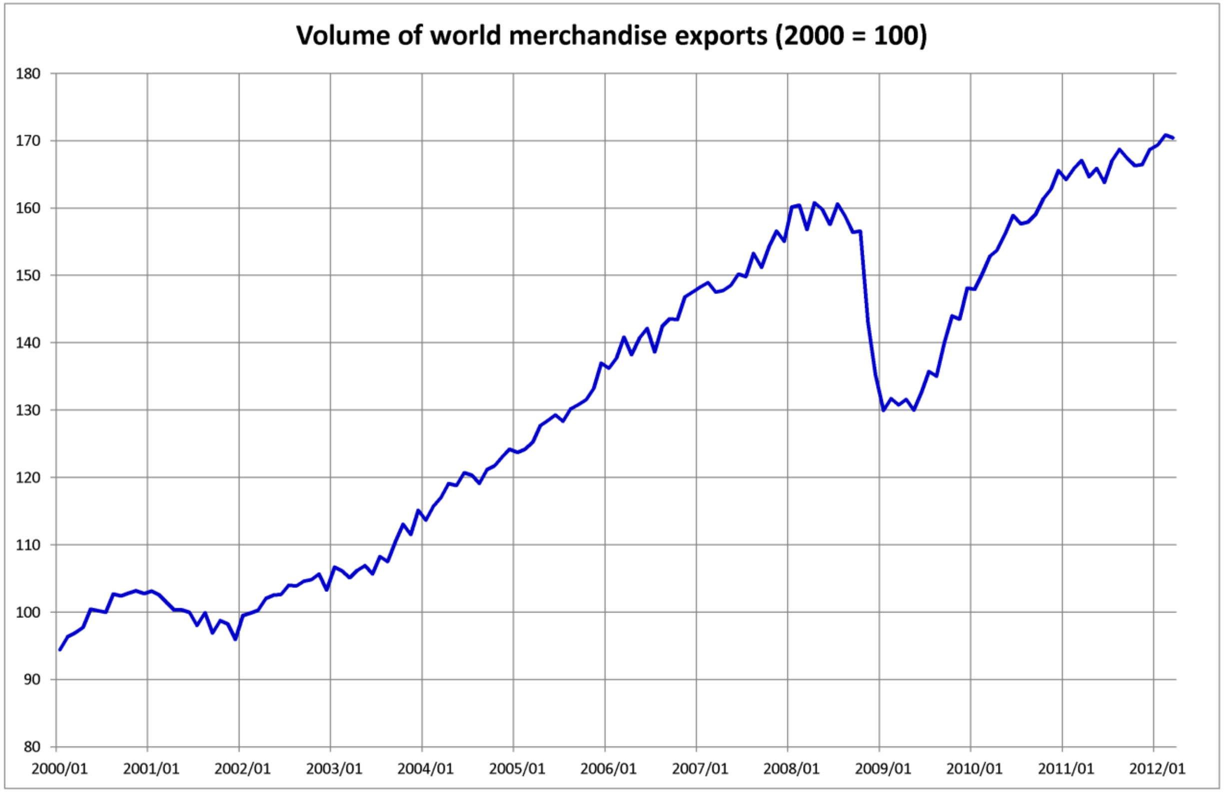
Source: Ashar and Rodrigue, 2012

International Trade



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Source: Bureau for Economic Policy Analysis

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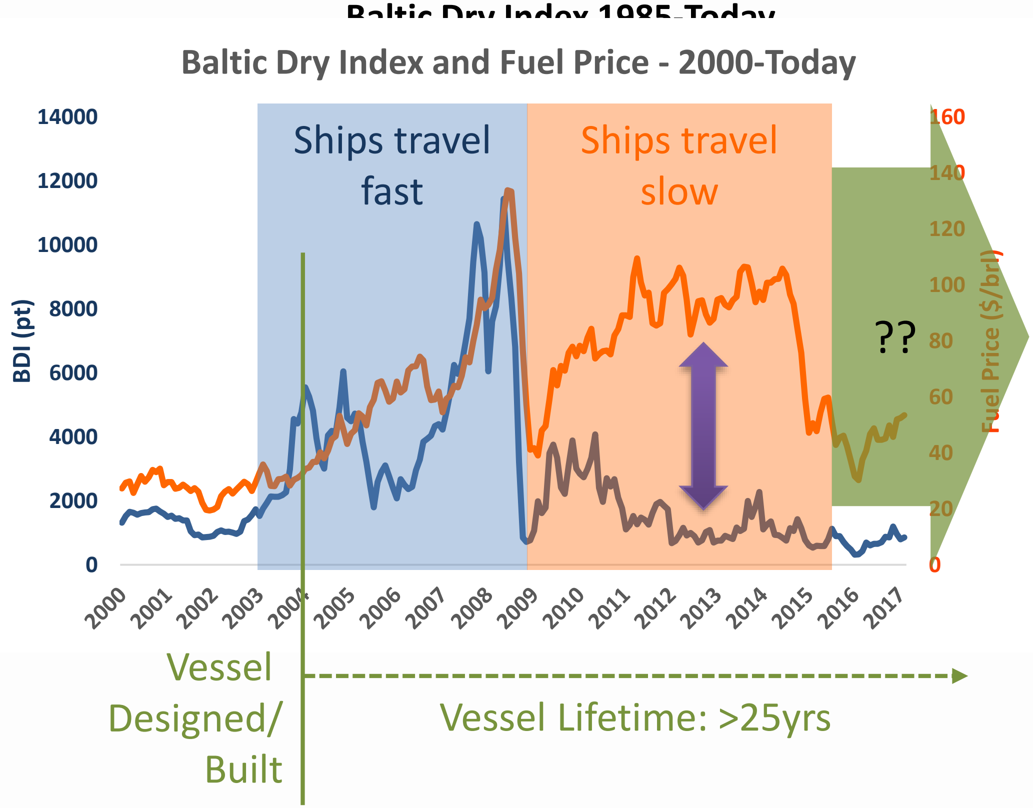
Phase II – Why Engine Optimization?

- Large volatility of market:
  - Freight rate (revenue)
  - Fuel price (cost)
- Interest of ship owner/operators for "more adaptable engines"



*"An **adaptable engine** would bring **significant advantages** in terms of **decision making** when **designing a vessel** and **in operation**"*

P. Renaud

Manager Efficiency
& Tech. Dpt. CMAShips

CMA CGM

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Source: *fred.stlouisfed.org* and *www.tradingeconomics.com*

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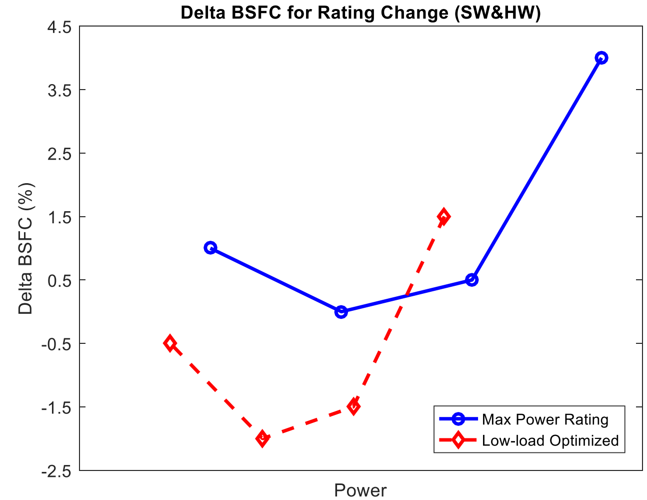
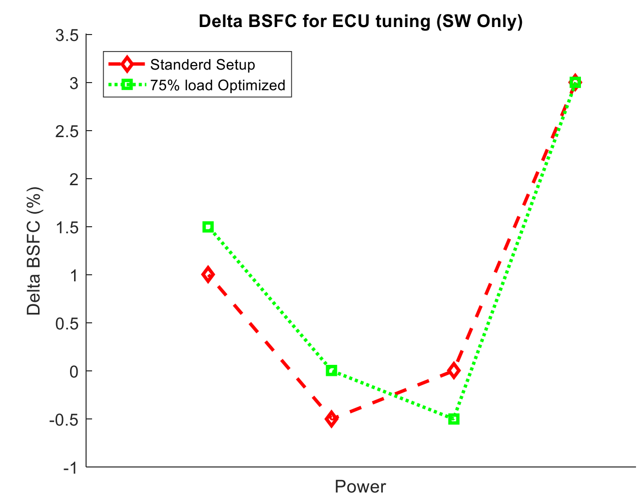
Benefits of Engine Optimization

Test cycle type E3	Speed	100%	91%	80%	63%
	Power	100%	75%	50%	25%
	Weighting factor	0.2	0.5	0.15	0.15

- Estimated **fuel savings** with continuous engine optimization 0.5-2%; Changes in settings for:
  - Changes in **environmental conditions** – daily
  - Changes in **fuel quality/type** – weekly
  - Changes in **performance demands** – monthly
  - **Component aging** – quarterly/yearly
- **Engine rating optimization** based on:
  - Current performance demands
  - Current bunker prices
  - Current freight rates
  - Cargo/ballast trip
- Possible fuel savings with HW and SW, or just SW changes
- Use new, optimized parts without parent test





➡ Savings for 72 MW: >**120k$/yr & 1'300 MT CO_2**

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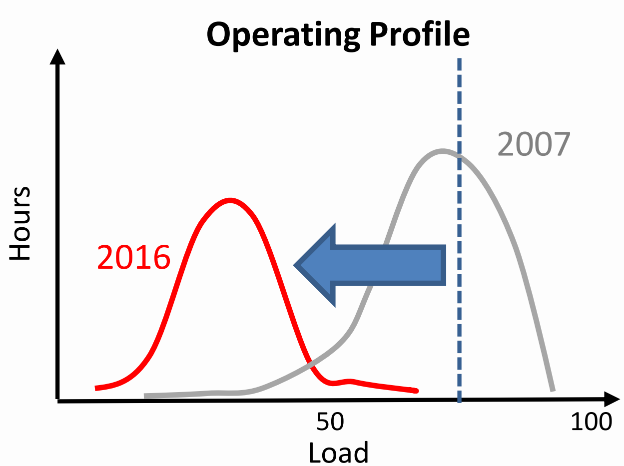
Engine Optimization Case Study

- Largest ships: >90MW …30MCHF/yr
- Example: **Old Panamax**, 38MW



Fuel Savings through Engine Optimization

Total Operating Hours	for 2016	~4500
Expected Efficiency Increase	%	2..3
Aprox. Current Fuel Price	$/mt	300.0
Savings for 2016	**k$**	**70…100**

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Summary

- Significant market potential for PVS
  - Phase I: Emission control
    - Gain access to data and develop credibility
  - Phase II: Vessel optimization
    - Combat engine design uncertainty by allowing engine adaptability
    - Fuel optimization at current market and operating conditions
    - Very strong interest from vessel owners/operators