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 CO₂-emission limit

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

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

2-Stroke Marine Industry (Carriers, Tankers)
- Fuel economy at “slow steaming”
- NOₓ-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

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
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
NOx Sensors in Marine Application

Exhaust gas exposure
- Clogging due to high ash content of HFO
- Poisioning 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
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

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

PVS
Physically-assisted Virtual Sensor

Fuel…30M$/yr
Phase I – Emission Control

- **New Emission Control Areas**
  - PVS can be used as a NO\textsubscript{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

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

- **Panamax**
  - 3,000 TEU
  - Dimensions: 250x32x12.5

- **New-Panamax**
  - 12,500 TEU
  - Dimensions: 366x49x15.2

- **Triple-E Class**
  - 18,000 TEU
  - Dimensions: 400x59x15.5

Source: Ashar and Rodrigue, 2012
International Trade

Volume of world merchandise exports (2000 = 100)

Source: Bureau for Economic Policy Analysis
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
Benefits of Engine Optimization

- 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 CO₂
Engine Optimization Case Study

Largest ships: >90MW ...30MCHF/yr
Example: Old Panamax, 38MW

Fuel Savings through Engine Optimization

<table>
<thead>
<tr>
<th></th>
<th>for 2016</th>
<th>~4500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Operating Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Efficiency Increase</td>
<td>%</td>
<td>2..3</td>
</tr>
<tr>
<td>Aprox. Current Fuel Price</td>
<td>$/mt</td>
<td>300.0</td>
</tr>
<tr>
<td>Savings for 2016</td>
<td>k$</td>
<td>70...100</td>
</tr>
</tbody>
</table>
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