Engine Performance Optimization by Permanent Use of Holistic Expert Condition Monitoring System

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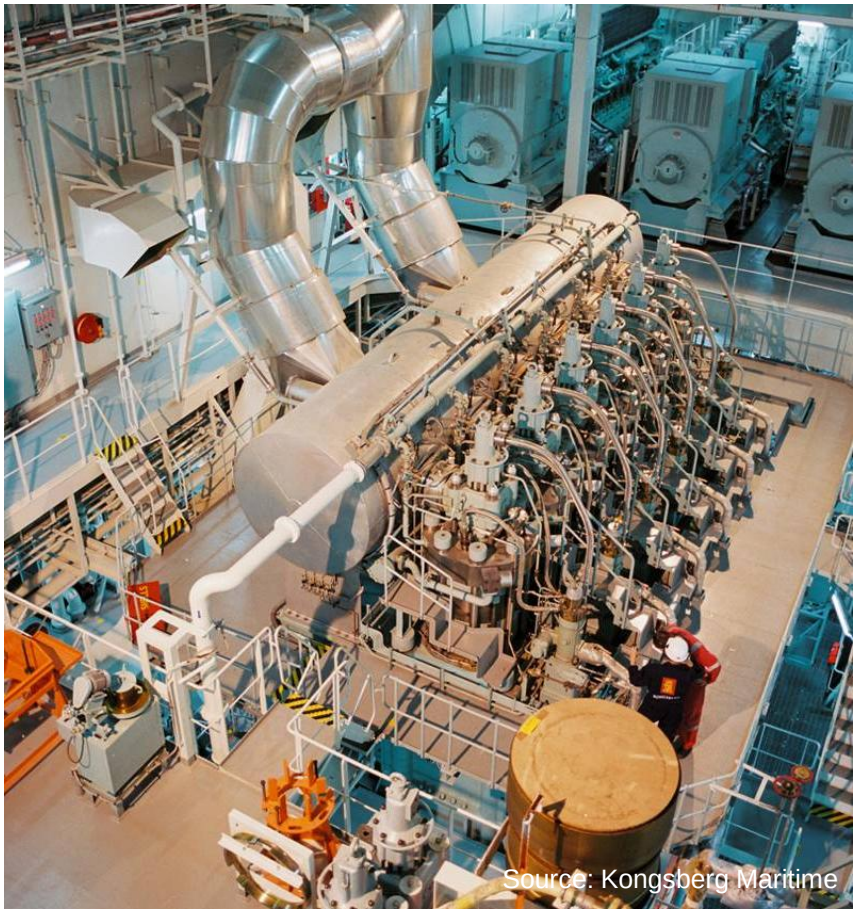
Content of Presentation

- Introduction and Overview
- Requirements for Condition Monitoring Systems
- Concept of AVL EPOS™
- Integration into Kongsberg's Vessel Performance Monitoring
- Field Experiences
- Conclusion and Outlook


Source: Kongsberg Maritime

Who is AVL from Graz / Austria?

World's largest privately owned and independent company

for the development of powertrain systems (combustion engines, hybrid systems, electric drives) as well as simulation and test systems

Founded 1948

4,500 Employees worldwide

45 Representations and affiliates worldwide

AVL covers all Customer Segments

Passenger Cars

2-Wheelers

Racing

Construction

Agriculture

Commercial Vehicle

Locomotive

Marine

Power Plants

Engineering

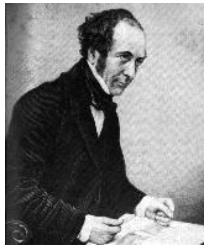
Simulation

Testing

Introduction and Overview

Question out of Book 'Modern System of Naval Architecture':

'how to make her fast before the wind, fast against the wind, fast across the wind, fast when she is deeply loaded, and fast when the sea is smooth, and fast when the sea is rough?'



John Scott Russell, 1865

- statement nowadays still valid for newbuildings and vessels in operation, especially in times of economical crisis
- directly related to efficiency (speed, fuel consumption, emissions)

⇨ key word:

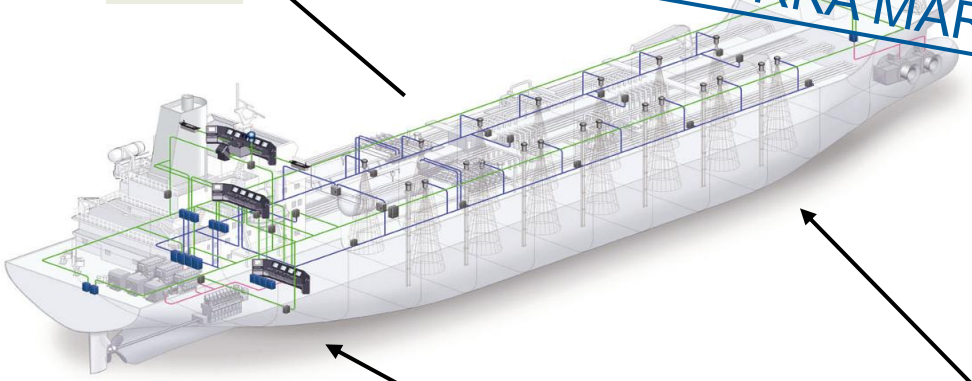
Optimum
Vessel Performance

Introduction and Overview

Kongsberg Vessel Performance System for Merchant Marine Fleet

FLEET MANAGEMENT

Kongsberg K-Chief 600VPS with AVL EPOS™ and MARORKA MAREN inside



KONGSBERG AVL MARORKA

FUEL PERFORMANCE MONITORING

ENGINE PERFORMANCE MONITORING

AVL

MARORKA

ENERGY MANAGEMENT

Introduction and Overview

Goal of Engine Performance Monitoring:

Optimum thermodynamical and mechanical engine behaviour leading to low operating costs and high life cycle quality.

⇨ The view has to be set onto the main and auxiliary engines, in particular to:

- combustion
- fuel supply and injection
- turbocharging
- cooling
- lubrication

… as well for the related auxiliary systems

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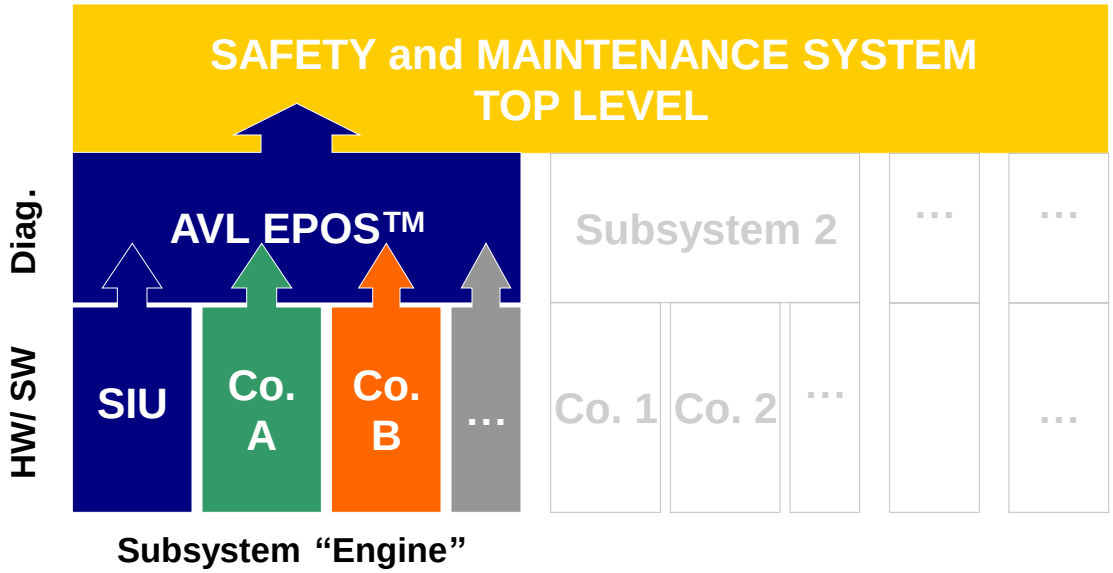
Requirements for Condition Monitoring Systems

- extensive engine expert knowledge in combination with measurement and data evaluation experience as basis for effective and reliable system development evident
- robust system components for long lifetimes under rough operating conditions
- broad interface to alarm and monitoring systems for additional data input
- simple GUI (graphical user interface) for intuitive handling
- effective and operator-configurable data storage
- integration of additional measurement systems possible
- regular and easy data submission to fleet management

Concept of AVL EPOS™ (1)

AVL EPOS™ – the **E**ngine **P**erformance and **O**ptimization **S**ystem

- open diagnosis platform for all kind of IC engines and their auxiliaries
- integrated into Kongsberg Maritime's automation system and vessel performance optimizer for the marine market

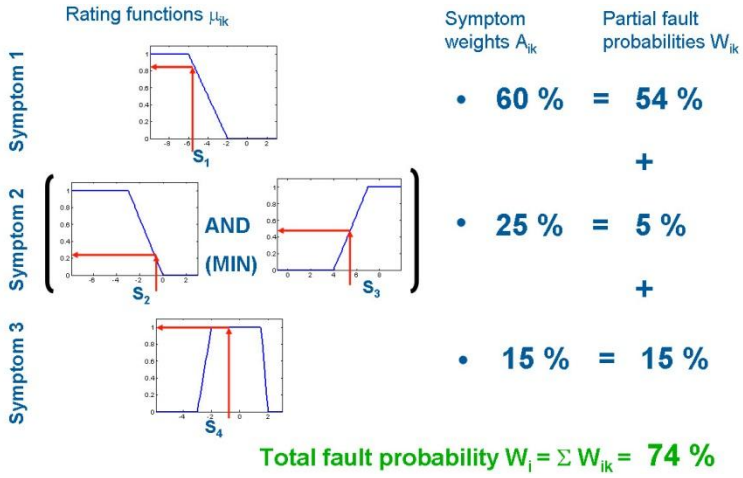


Concept of AVL EPOS™ (2)

Faults

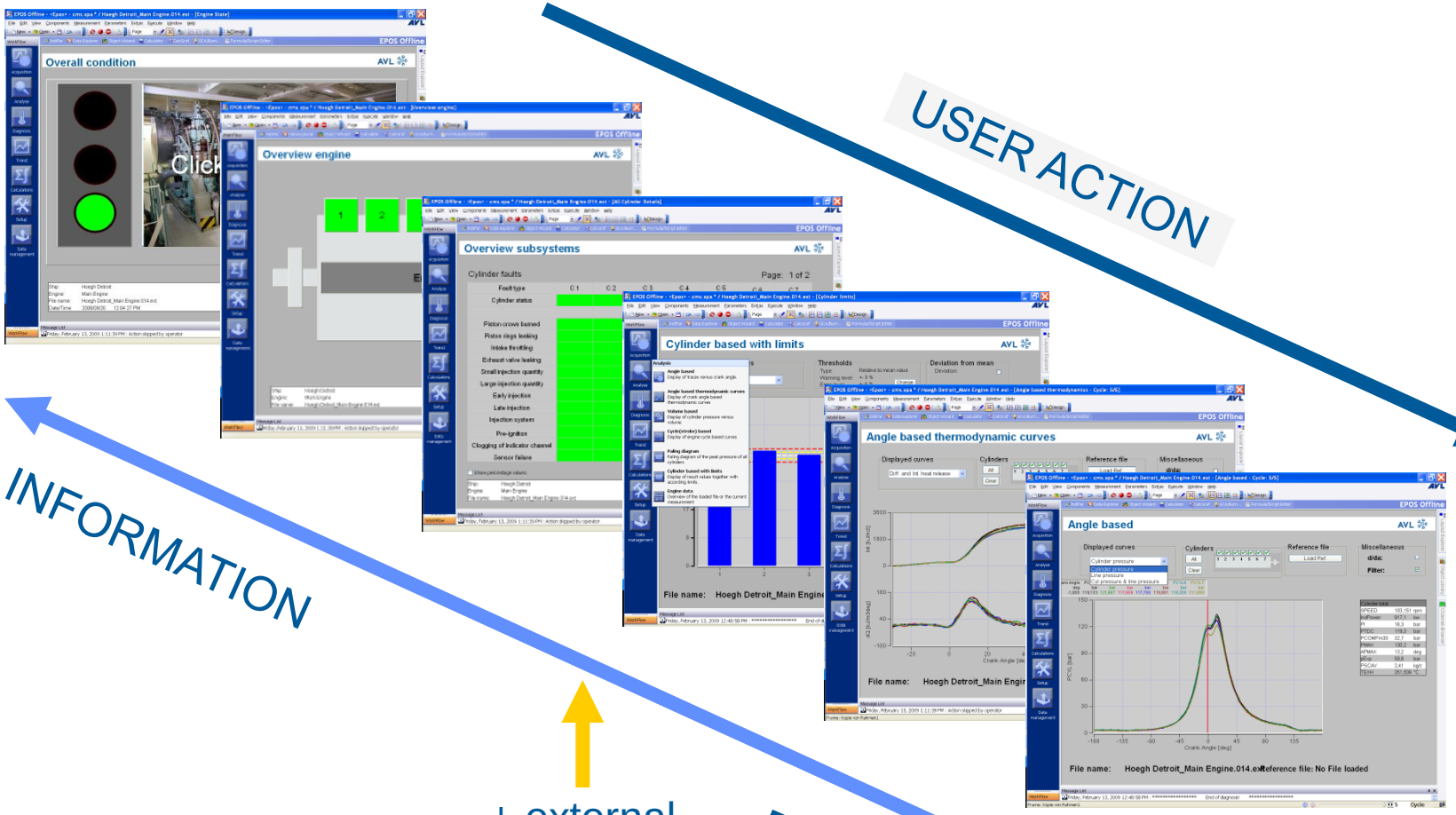
Symptoms

	Fault 1	Fault 2	Fault 3		Fault n
Symptom 1	+	+	-		0
Symptom 2	0	-	0		+
Symptom 3	-	+			
Symptom m	-	+			+



- plausibility check of input signals including sensor modeling
- AVL IndiCom combustion analysis
- extended concept of fault-symptom-pattern, based on field experience
- subsequent algorithms based on upstream data analysis, fuzzy logic and different physical models
- signatures of input signals compared to reference values
- consideration of fault probability and symptom importance
- final status classification of engine, cylinders and subsystems

GUI-Concept of AVL EPOS™



Features of AVL EPOS™

AVL EPOS™ V1.1 includes already

- continuous evaluation and permanent analysis of fuel injection process and combustion process (with AVL $GaPO_4$ cylinder pressure sensors)
- failure detection by expert algorithms of fuel injection system and combustion chamber area
- trend analysis (chronological, characteristic plot vs. engine load or speed) and trend prediction
- integration of external monitoring devices

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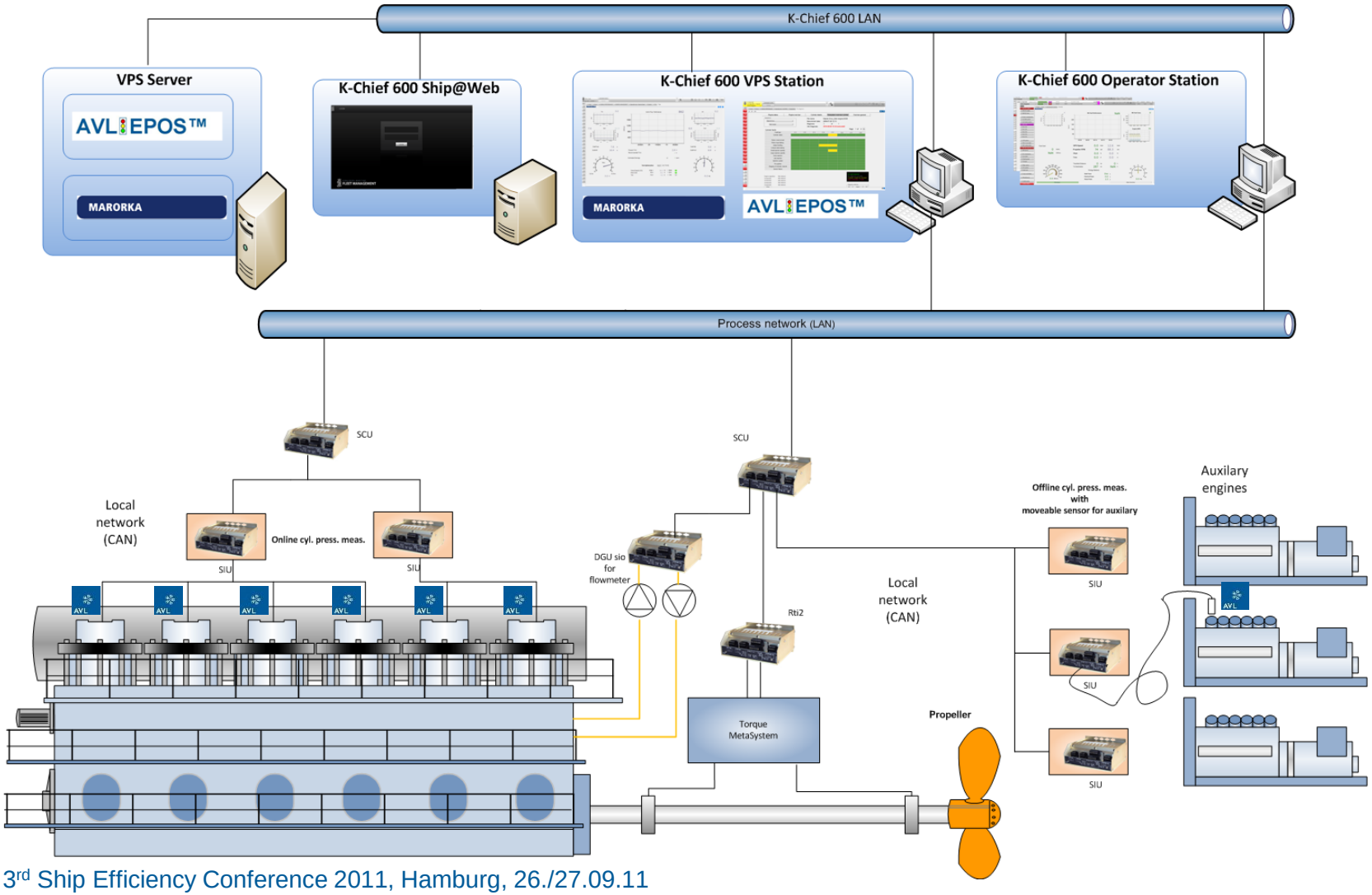
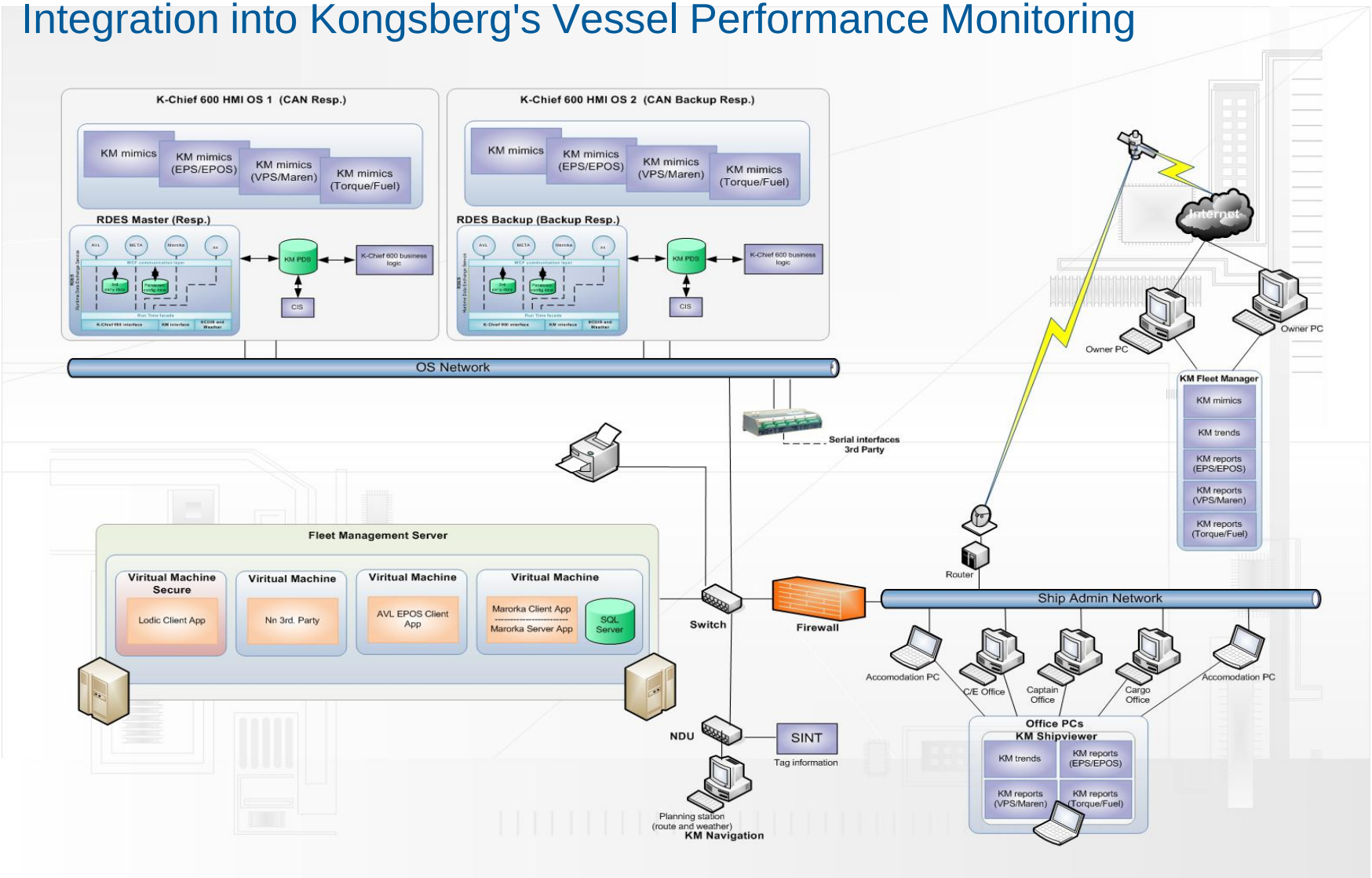
Integration into Kongsberg's Vessel Performance Monitoring

- basis of Kongsberg's VPS is K-Chief 600 automation system, using standard modules communicating by dual redundant process network and configurable for all vessel types
- Kongsberg's VPS provides set of tools for optimized ship operation in a more economical and environmentally beneficial way
- full integration of AVL EPOS™ enabling operator's access to important engine performance data 24/7
- seamless flow of data between both systems organized in the background
- AVL EPOS™ results integrated in KC-600 user interface for easy handling, diving into system for increased information possible
- no interference with integrity of automation system

Integration into Kongsberg's Vessel Performance Monitoring



Integration into Kongsberg's Vessel Performance Monitoring

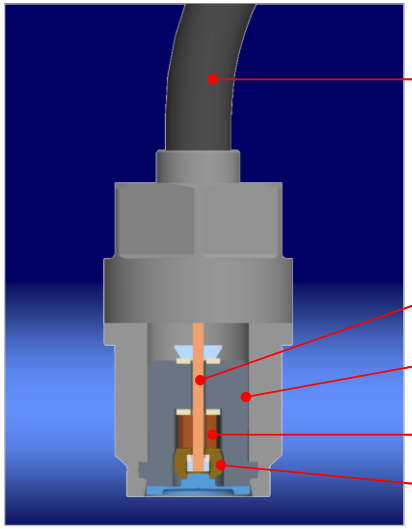


Field Experiences

AVL EPOS™

+ 9 sister vessels

Field Experiences – the Sensor as robust Hardware Core



Integrated FPM Cable

integrated Amplifier (..DA) or Connector for Standardcable (..DI)

Central Pre-tension Element

Double Shell Housing

front- (M14) or shoulder sealed (M14 and M10)

$GaPO_4$ Piezoelements

Leak-proof Conzept (verified)

- extensive positive experiences on HFO-, gas and biofuel engines
  - on 2-strokes as well as on 4-strokes

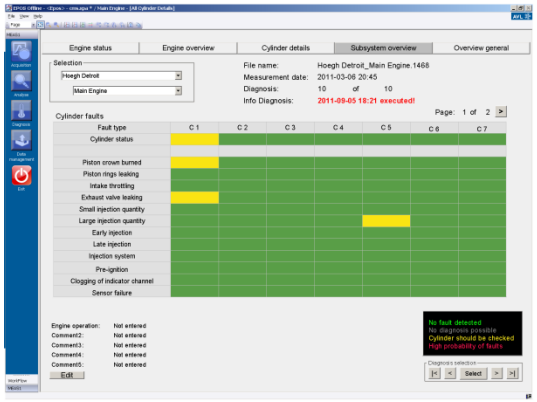
HFO > 15.000 h

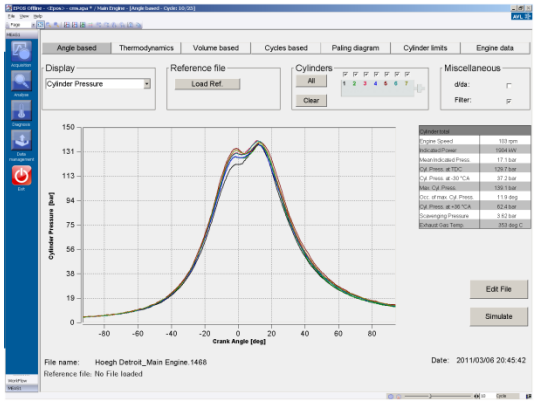
Gas > 15.000 h

Biofuel > 15.000 h

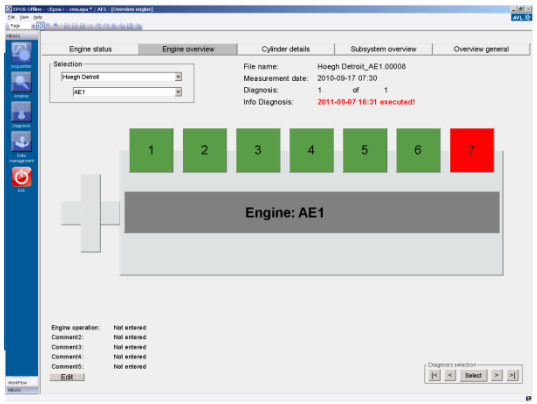
Field Experiences – the Software as proven Expert Tool

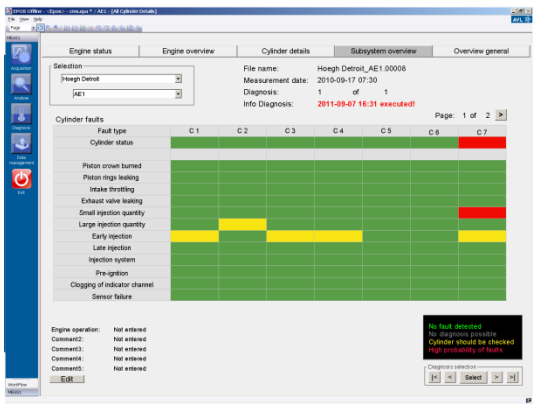
- Example M/E Compression Failure

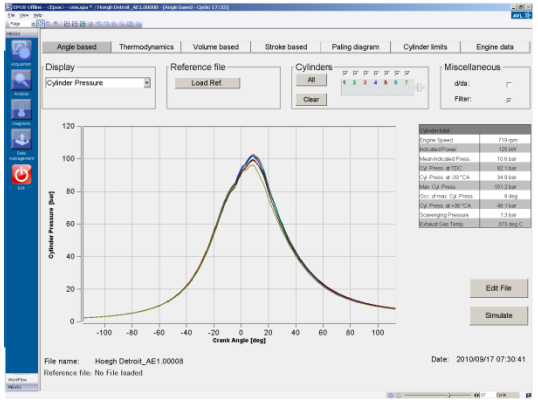




- Example A/E Fuel Injection Pump Failure

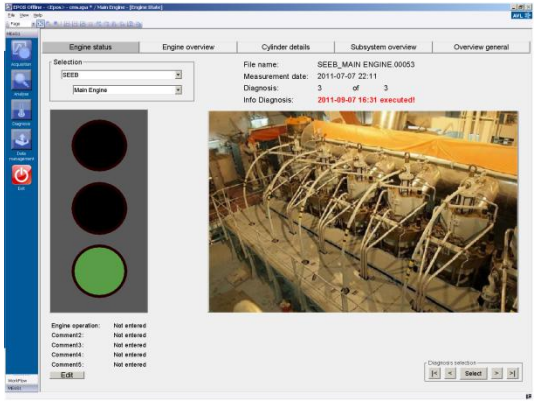


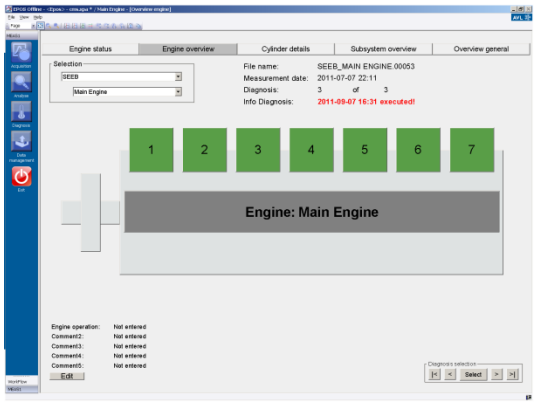


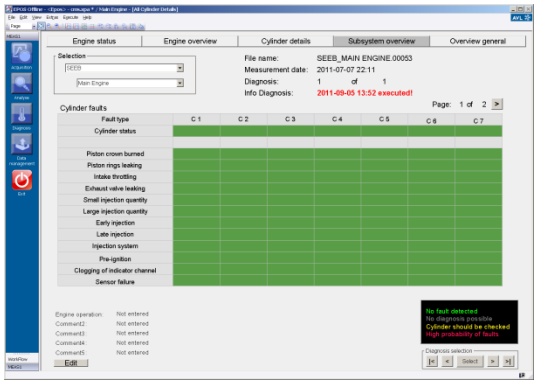


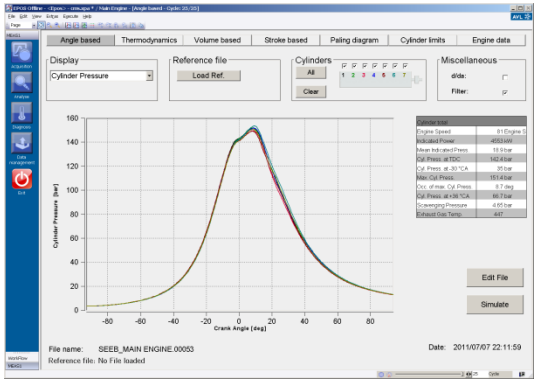
Field Experiences – Installation NITC/Oman Shipping

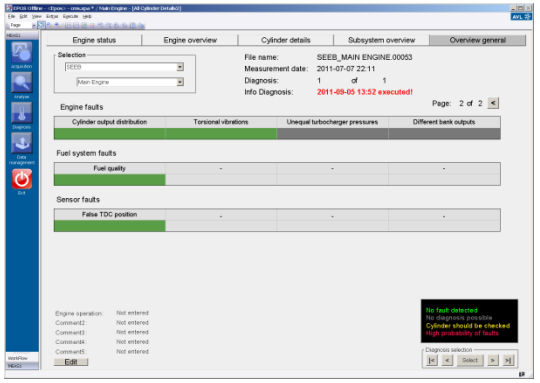
- Example M/T Seeb



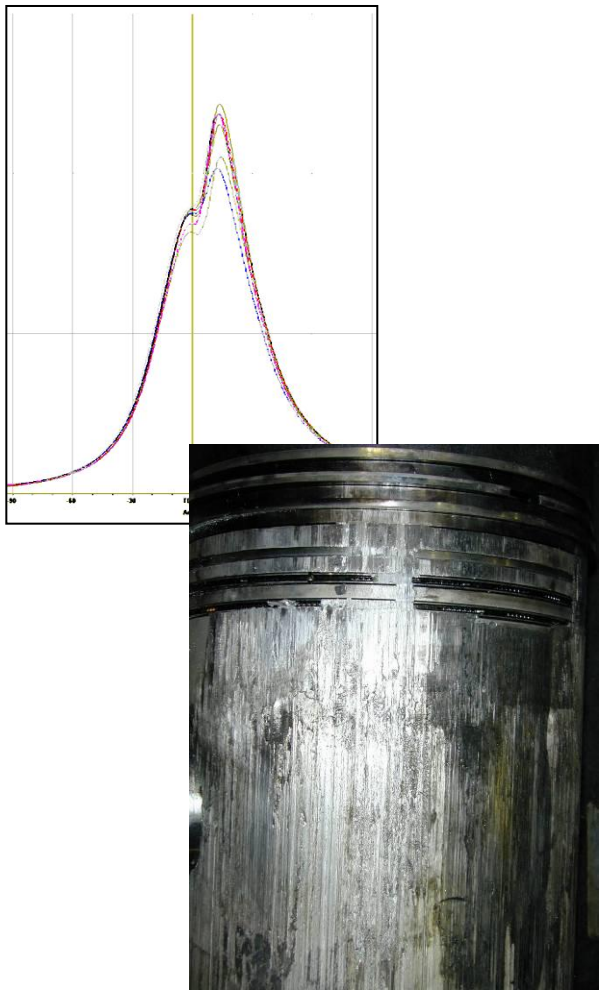








Field Experience – Engine Optimization Impact



- beside early detection of upcoming faults and avoidance of damages also regularly engine operation optimization possible with AVL EPOS™
- unplanned repair works can be changed to planned maintenance works
- experience show optimization potential up to 3 % efficiency (≈ 4 … 6 g/kWh) on usual maintained engines, even higher on poor maintened engines (confirmed by MAN Diesel CIMAC publication)
- consequent use of delivered information about engine status enables savings of up to 100.000 US-$ per year

Conclusion

- CMS for all large-bore engine types and applications
- current version concentrates on combustion and fuel injection expert analysis
- maximum performance reached by integration in KM automation system, stand-alone also available
- trouble-free acting test systems
- vessel operators appreciate independant maker
- consequent system use allows life cycle improvement and savings from optimized engine operation

Outlook

Current development activities:

- thermodynamic and vibration turbocharger monitoring
- online NO_x modelling as well as SO_x and CO_2 calculation
- prediction of engine component behaviour
- improved hardware diagnosis to ensure high signal reliability

Further topics are in the pipeline …