

AVL

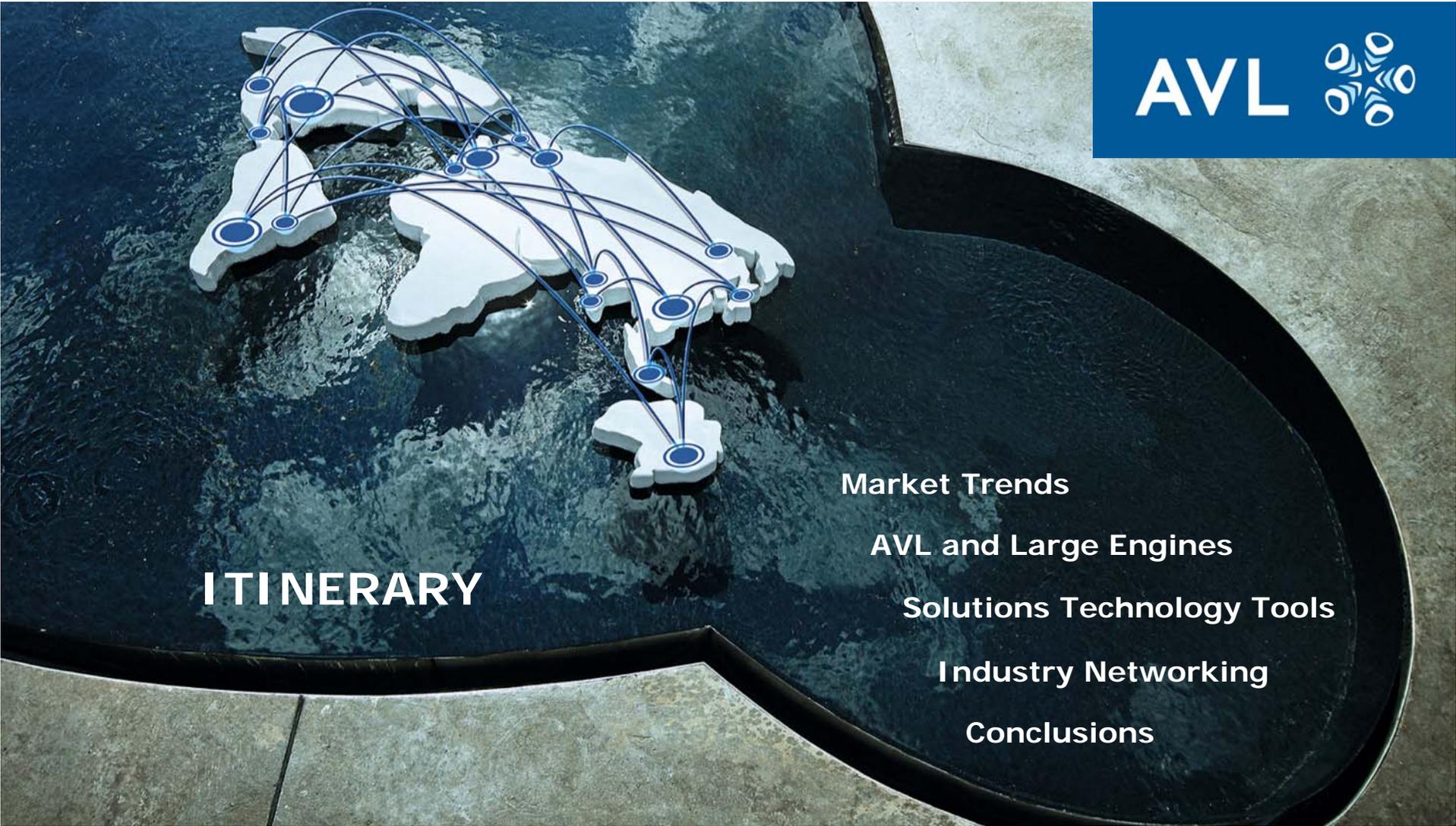


ClassNK

Seminar on Joint Industry Collaboration
Projects at Maritime Energy Test Bed,
3rd November 2015

AVL AND LARGE ENGINE TRENDS

ANDREI LUDU

A 3D map of Europe is shown in white, floating above a dark blue, textured surface that resembles water. The map is overlaid with a network of blue lines and circular nodes, representing a global or regional network. The map is positioned in the upper left quadrant of the slide.

ITINERARY

Market Trends

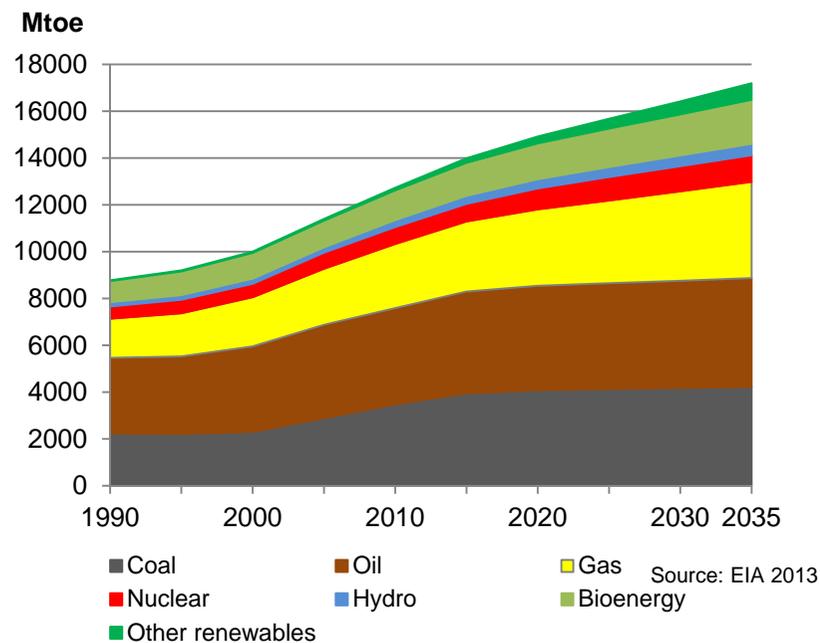
AVL and Large Engines

Solutions Technology Tools

Industry Networking

Conclusions

WORLD PRIMARY ENERGY CONSUMPTION



Source: BP Energy Outlook 2035 (2015)

WORLD PRIMARY ENERGY DEMAND BYFUEL

- World Energy demand increase by 37%
- Oil, Coal & Gas – similar shares
- Renewables – fastest growing, total share still low 8%
- Natural Gas - largest absolute increase
- World population increase 8,7 Billion in 2035 – megatrend
- GDP per Person 75% increase in 2035 - megatrend



MARKET DRIVERS &



AVL SERVICES



Emission and Fuel Legislation



Emission Compliance Development
SCE & MCE Testing



Higher Global Wealth ➡ **Increased Power & Transportation** ➡ **Need for New Engines**



Turn-Key New Engine Design
SCE Design & Procurement



INSTRUMENTATION



Wide Engine Size and Application Scope



Ratings Development
SCE & MCE Testing



Gas Fuel Price and Availability, Fuel Versatility, Gas Into New Large Applications



Dual-Fuel & Gas Conversions
Gas Combustion Development



INSTRUMENTATION



SOFTWARE

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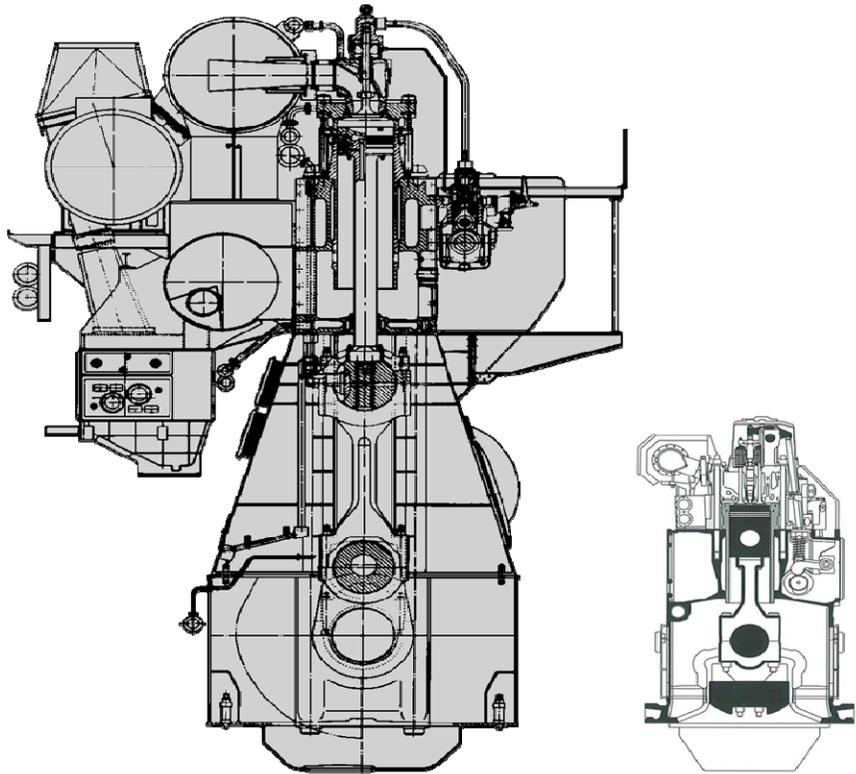
Conclusions



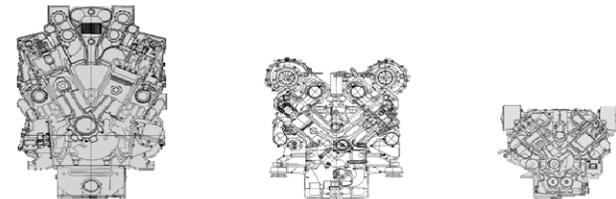
AVL AT A GLANCE



THESE ARE ALL LARGE ENGINES



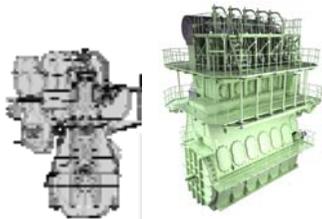
- Wide Engine Size Range
- Diversified Fuels, Diesel and Gas
- Wide Application Range



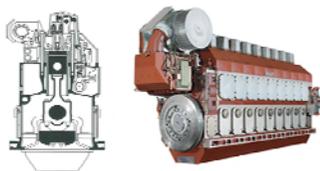
APPLICATION & FUEL DIVERSITY



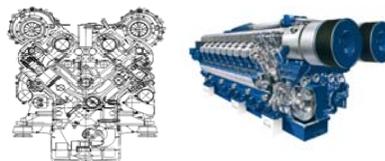
Slow Speed 2-Stroke



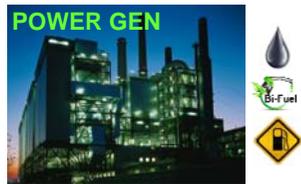
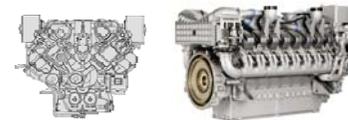
Medium Speed „HFO“



Medium Speed „Non - HFO“



High Speed



Gas Into New Applications !



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COMPLETE NEW ENGINES DESIGN INDUSTRY SOLUTION



From **PRODUCT STRATEGY**

- Engine line-up planning
- Competitive benchmark
- Technology & Rough Engine Architecture

Over **DESIGN & DEVPT PROCESS**

- Design Phases: Concept, Layout, Detail
- Frontloading: Virtual Engine
- Supplier selection

To **ENGINES PROCUREMENT & TESTING**

- Prototype Engine Procurement & Build-up
- MCE Engine Testing Diesel, Gas, Dual-Fuel

LARGE SINGLE CYLINDER ENGINES TOOL & INDUSTRY SOLUTION



SCE DESIGN SOLUTION

- Modular concept
- High Speed, Medium Speed and Large Medium Speed platforms
- Flexible size, Bore x Stroke



Large Medium Speed
Single Cylinder Engine
Platform

DIESEL, HFO, GAS AND DUAL FUEL TESTING

- SCE specialized test beds
- Versatile fuel systems
- Gas mixing station



Large Medium Speed
Single Cylinder Engine
Platform

SCE & TEST BED SOLUTION

- SCE design, procurement, installation
- SCE-dedicated test bed planning, delivery, commissioning



Large High Speed
Single Cylinder Engine
Platform

MCE & SCE TESTING INDUSTRY SOLUTION



MULTI-CYLINDER ENGINE TESTING

- Several test beds
- High Speed engines
- Medium Speed Engines
- Diesel, MDO, GDO, Gas, Dual-Fuel
- Performance & Emissions, Functional Testing, Durability



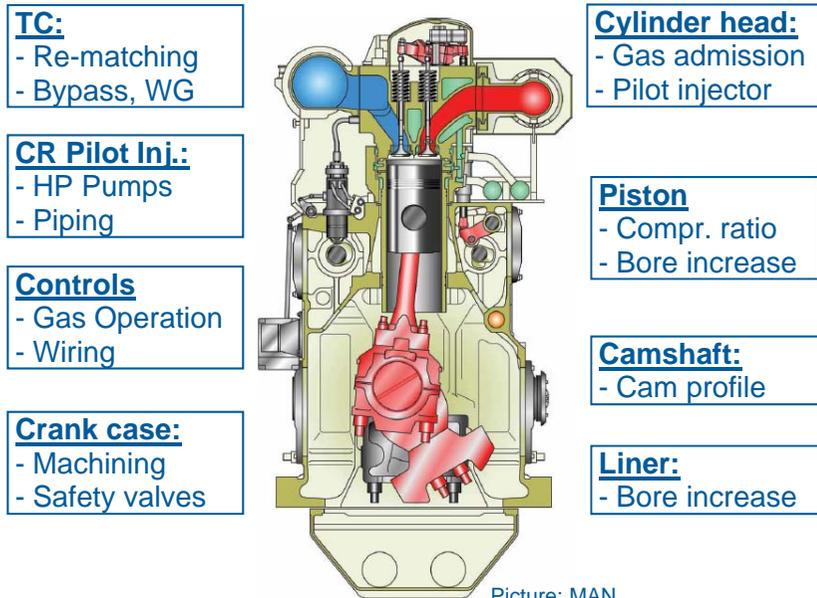
SINGLE CYLINDER ENGINE TESTING

- Several SCE-specialized test beds
- Modular Single Cylinder Engines
- Experimental versatility: Fuel Systems, Turbocharging, High Cylinder Pressure
- High Speed, Medium Speed Engines, Diesel, MDO, GDO, Gas, Dual-Fuel
- Perf. & Emissions, Functional Testing

SOLUTION DUAL-FUEL CONVERSION MEDIUM SPEED ENGINES



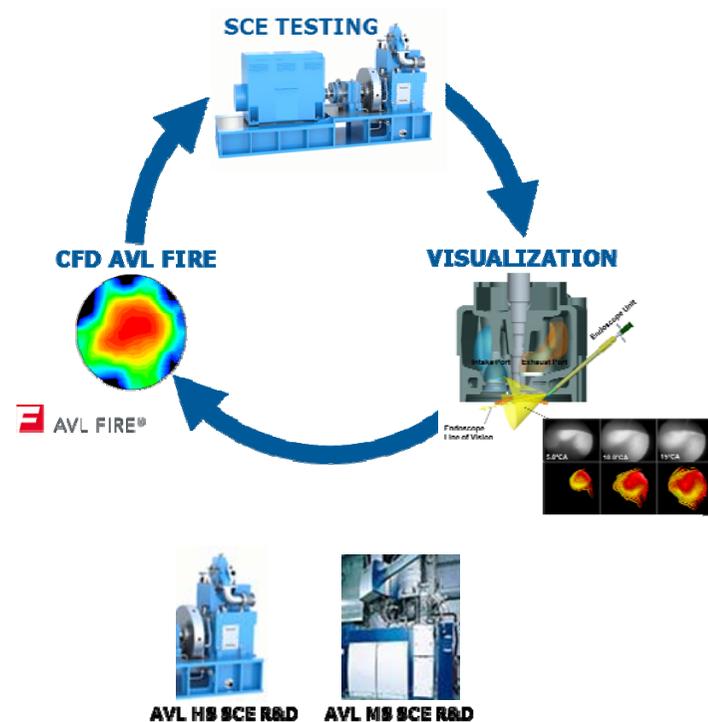
HOLISTIC CHANGES



STARTING POINT DIESEL ENGINE

- Marine, Auxiliary, Power Gen, Locomotive
- IMO2 emissions
- Mechanical injection system (CRS)
- Single stage turbocharging (2 Stage TC)
- Miller IVC
- Fixed valve timing (VVT)

TOOLS AND METHODS SCE TESTING – VISIO – CFD



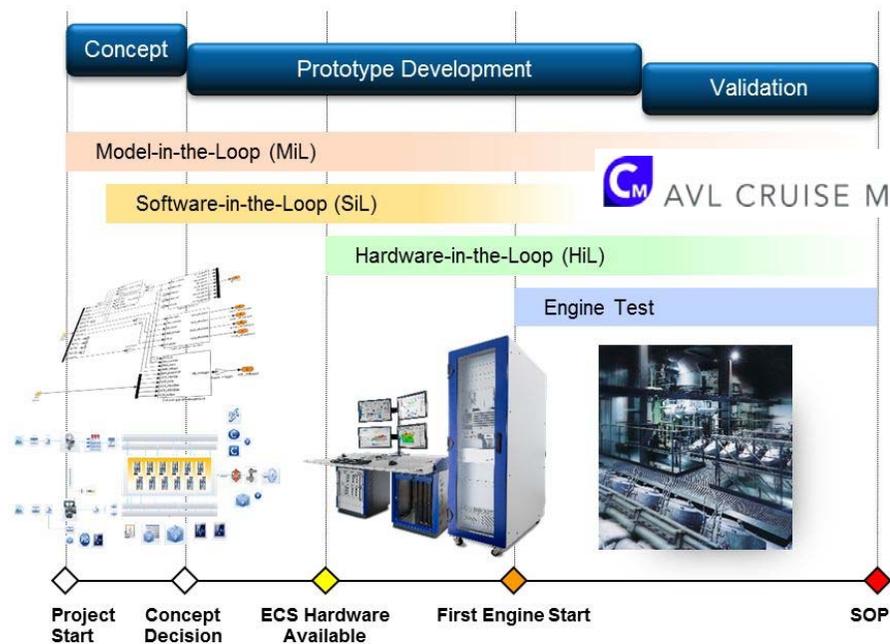
DEEP DIVE

- Understand “special” combustion, e.g. gas substitution, knocking
- Use SCE flexibility and physical access potential for operation and visualisation
- SCE testing and visualisation correlated to CFD and thermodynamics in order to establish model and methods
- Methods, match SCE to realistic MCE operation

SYSTEM SIMULATION SYSTEM INTEGRATION



MODEL-BASED, REAL-TIME

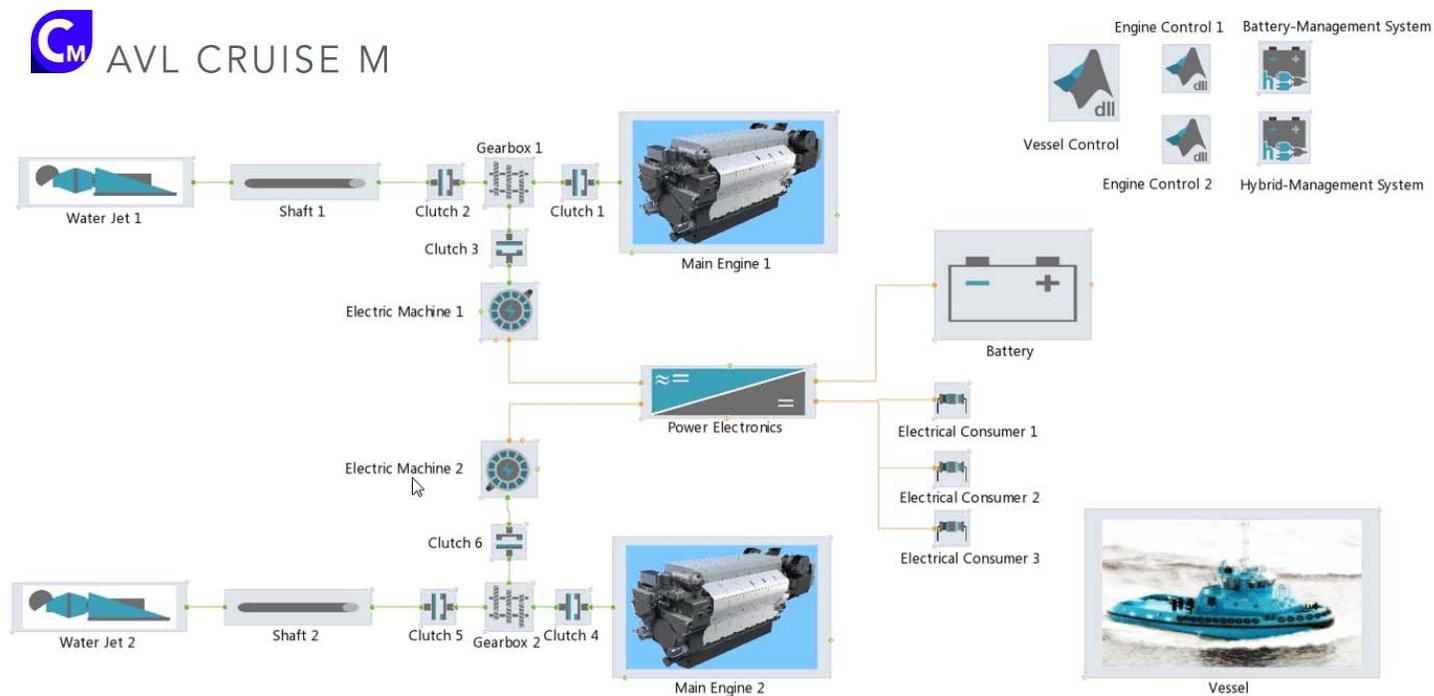


TASKS, APPLICATIONS

- Optimization of System Behavior
- Controls & Software
- Engine & Aftertreatment Calibration
- Electrification & Hybridization
- Virtual Homologation & Model-Based Validation
- Development of Operating Strategies
- Fail-Safe Investigations & Simulation of Worst-Case Scenarios

MULTI-DOMAIN REAL TIME & SYSTEM SIMULATION

EXAMPLE: TUGBOAT



MODEL-BASED CONTROLS & SOFTWARE DEVELOPMENT

WITH HARDWARE-IN-THE-LOOP

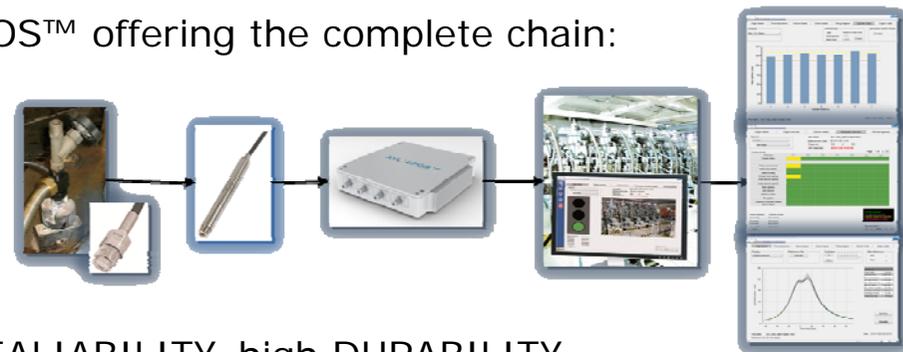


AVL EPOS™ CONDITION MONITORING SOLUTION



FROM SENSOR TO DIAGNOSIS

- Benefit from AVL's long-term engine, measurement and simulation know-how
- AVL EPOS™ offering the complete chain:



- High REALIABILITY, high DURABILITY
- OPEN PLATFORM – Open to other HW and SW
- Class approved NO_x EMISSION MODEL available

AVL EPOS CONDITION MONITORING SOLUTION

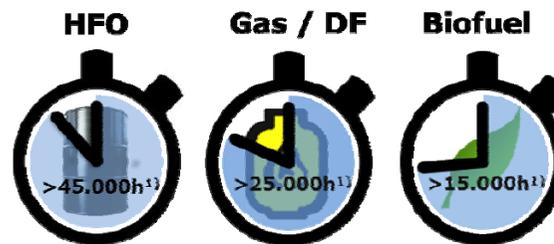


NO_x MODULE

- NO_x emissions calculated from cylinder pressure measurements plus engine operation and fuel data
- IMO certified as NO_x measurement equivalent, MARPOL Annex VI and MEPC.103(49)
- Class approval validated high-accuracy calculation, +/- 3 % compared to measurement



CYLINDER PRESSURE SENSOR REFERENCES

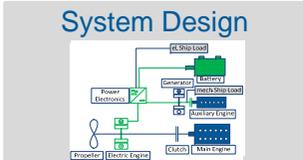


¹⁾Status: August 2015

ELECTRIFICATION AT AVL



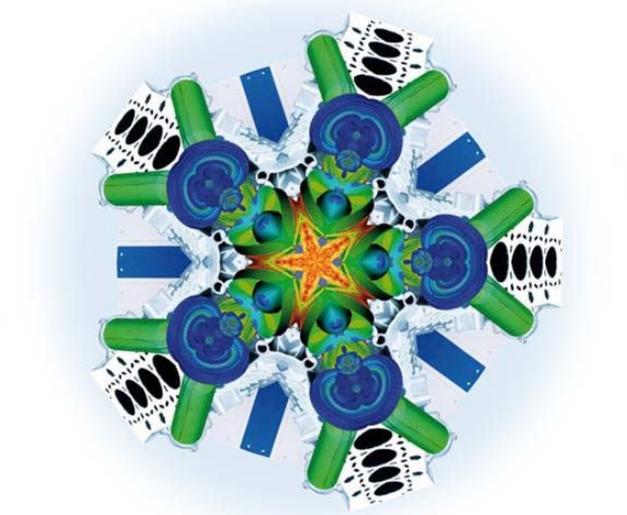
Energy Management



System Simulation

Battery Development

Power Electronics



Battery Management System

EMC Simulation

Vehicle Controls

Transmission Control

APU Development

Transmission Development

Emotor control

Emotor development

APU Controls

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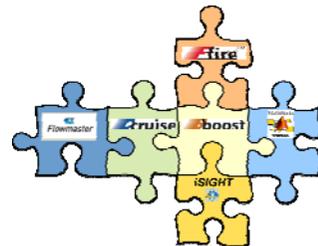
ACADEMIA – INDUSTRY COOPERATION MODEL



SCE & TEST BED



SOFTWARE



COOPERATION MODEL

- R&D Program Marine Industry relevant, e.g. CO2 reduction, ship efficiency; multi-year, experimental & theoretical
- Industry – University Partnership, e.g. OEM, University, AVL
- University: test bed operation, simulation; PhD & post graduate students
- OEM: tasks, engine parts, governance
- AVL: Single Cylinder Engine, Test Bed, Software, Technology, Methodology

AVL LARGE ENGINE TECHDAYS



Review 2014

6th AVL Large Engines
TechDays

„GAS & DUAL FUEL“

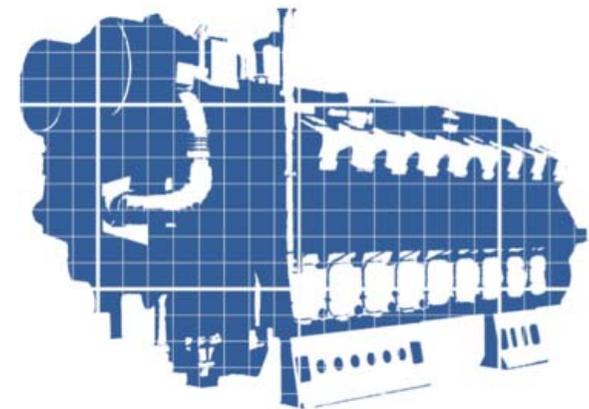
06th-07th May, 2014
Helmut-List-Halle, Graz,
Austria

Presenters



7th AVL Large Engines TechDays

System Integration -
Way to CO₂ Reduction and
Performance Optimization



19th-20th April, 2016
Helmut-List-Halle, Graz, Austria

A 3D map of Europe is shown in white, floating above a dark blue, textured surface that resembles water. The map is connected to various points by a network of thin, blue, glowing lines. Each connection point on the map is marked with a small blue circle containing a white dot. The background is a dark, textured surface, possibly a globe or a large screen, with a curved edge visible on the right side.

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CONCLUSIONS



The Large Engine Market is Driven by the Primary World Energy Demand, the Population and Wealth Growth

Diesel and Gas Fuels will Continue to be the Main Fuels of Choice for Large Engines; Niche Fuel Utilizations will Increase

Technologies in the Focus: System Integration, Controls, Fuel Versatility, Condition Based Monitoring, Variable Systems: Valvetrain, Turbocharging, Compression Ratio, Gas Fuel Systems, Dual-Fuel Combustion, Total HC Abatement, Low Diesel Emission, High PFP Structures, Turbocharging

AVL with Clear Large Engine Focus, Providing Customized Solutions for the Large Engine Industry in Engineering, Instrumentation and Software

AVL as Acknowledged Player and Contributor in the Global Large Engine Industry Network



THANK YOU

Andrei Ludu



www.avl.com