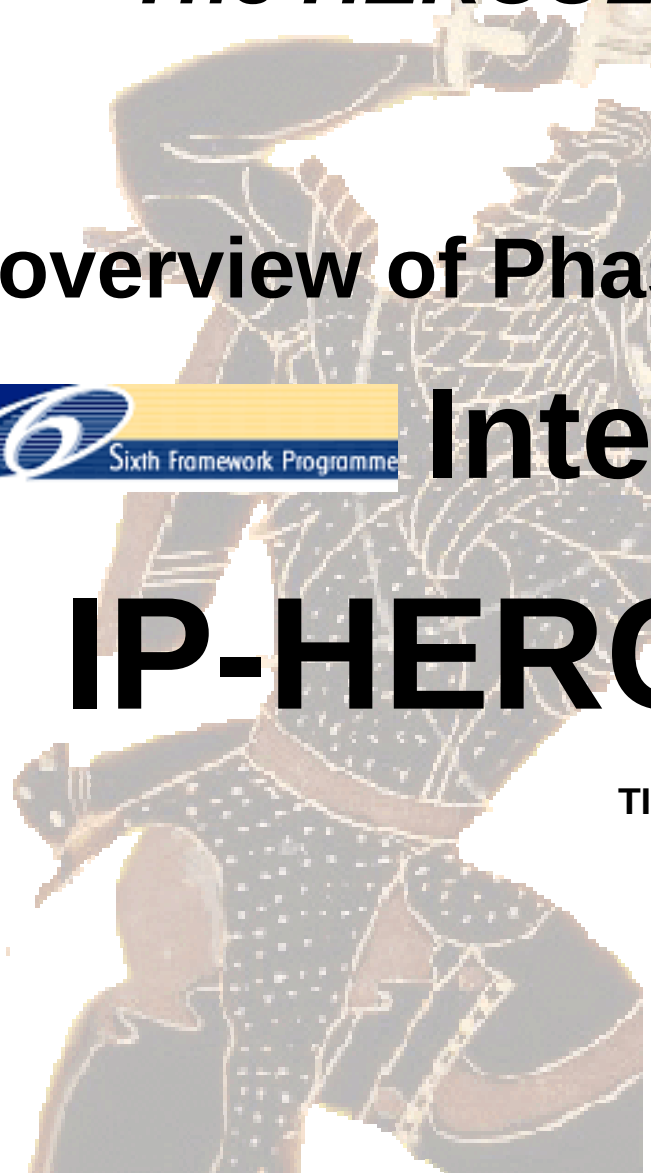
The HERCULES Project



An overview of Phase I (2003-2007) :

The Sixth Framework Programme Integrated Project

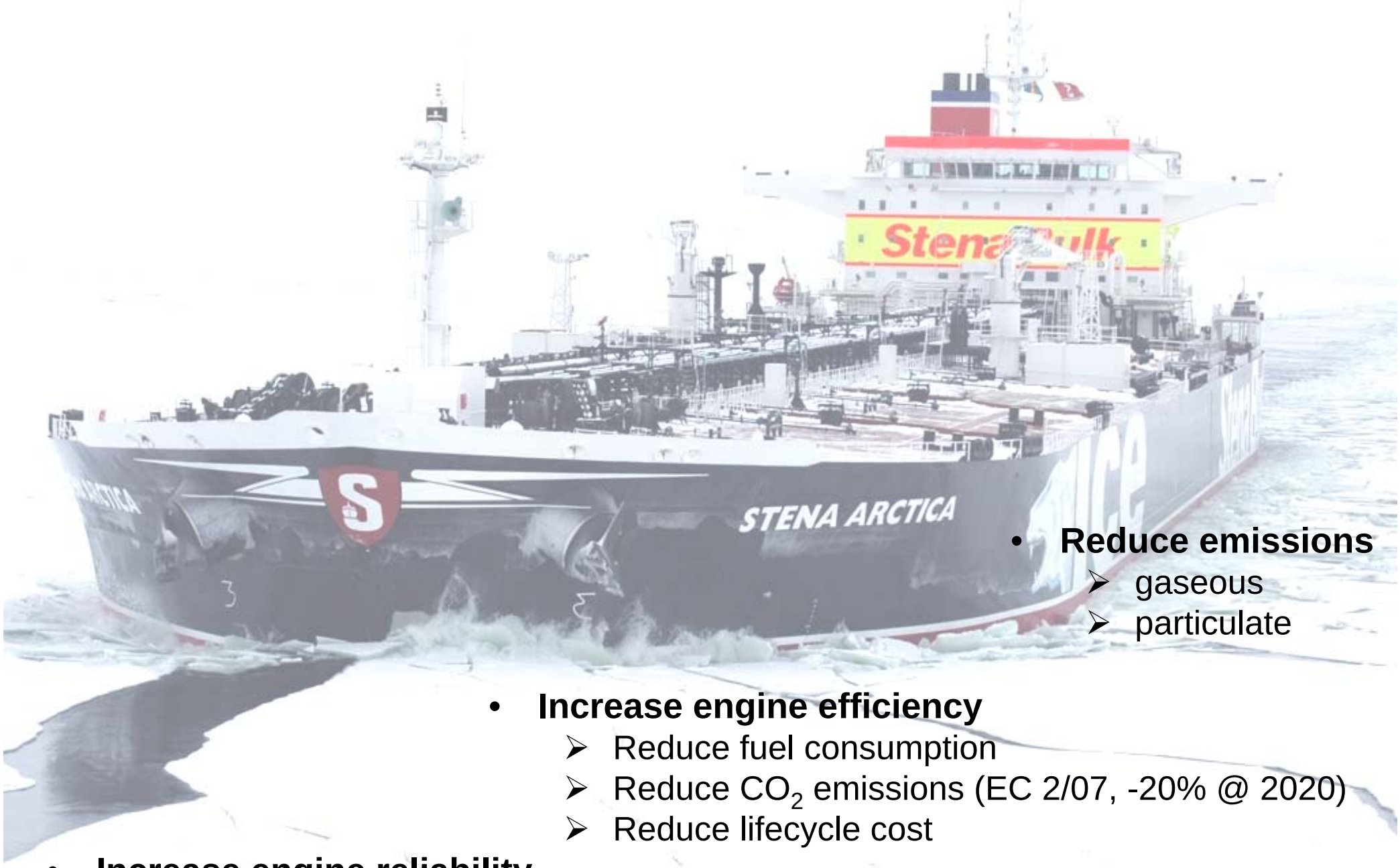
IP-HERCULES

TIP3-CT-2003-506676

Presented by
Prof. Nikolaos P. Kyrtatos
Project Coordinator

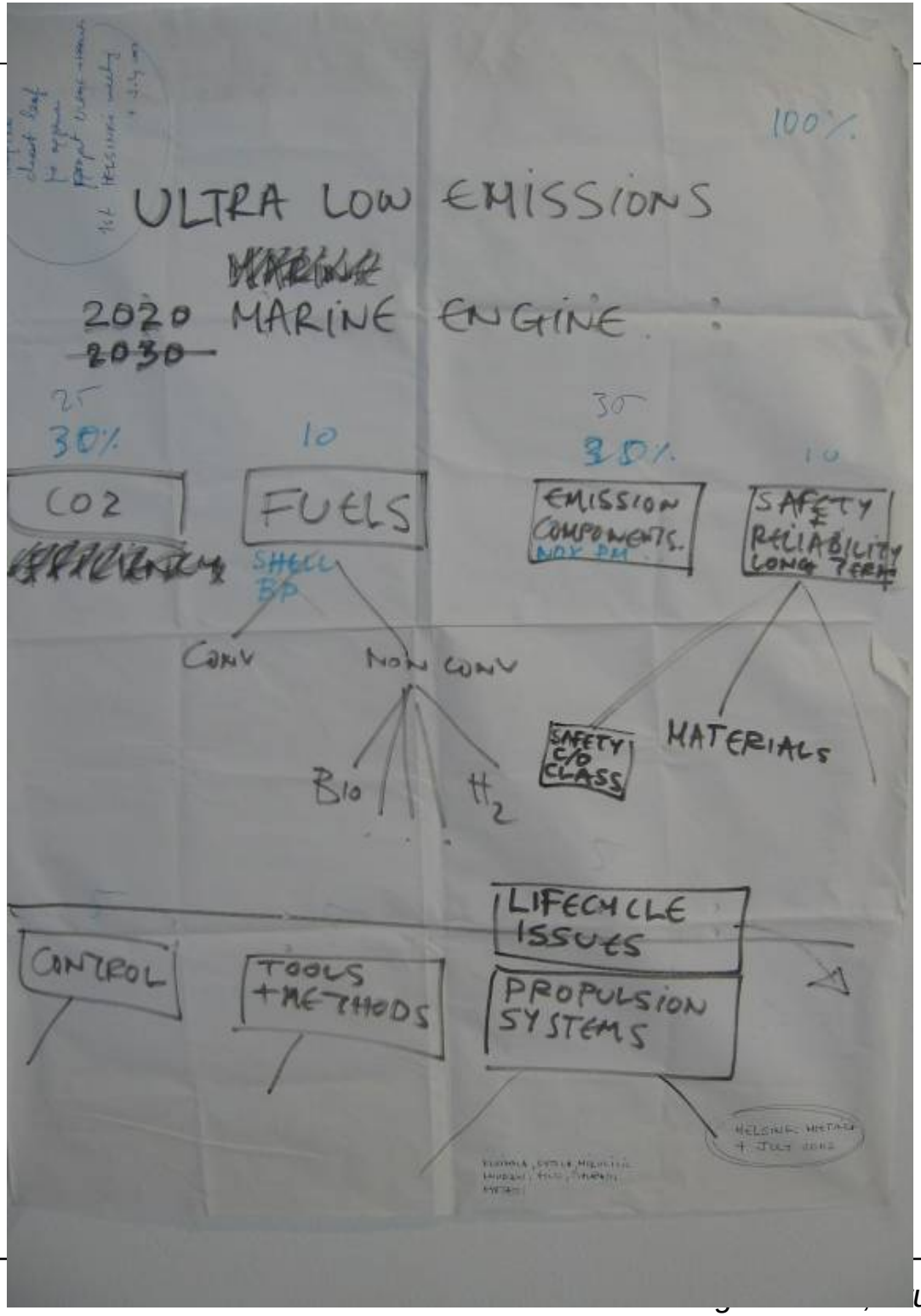
HERCULES is developing **new technologies** for marine diesel engines:

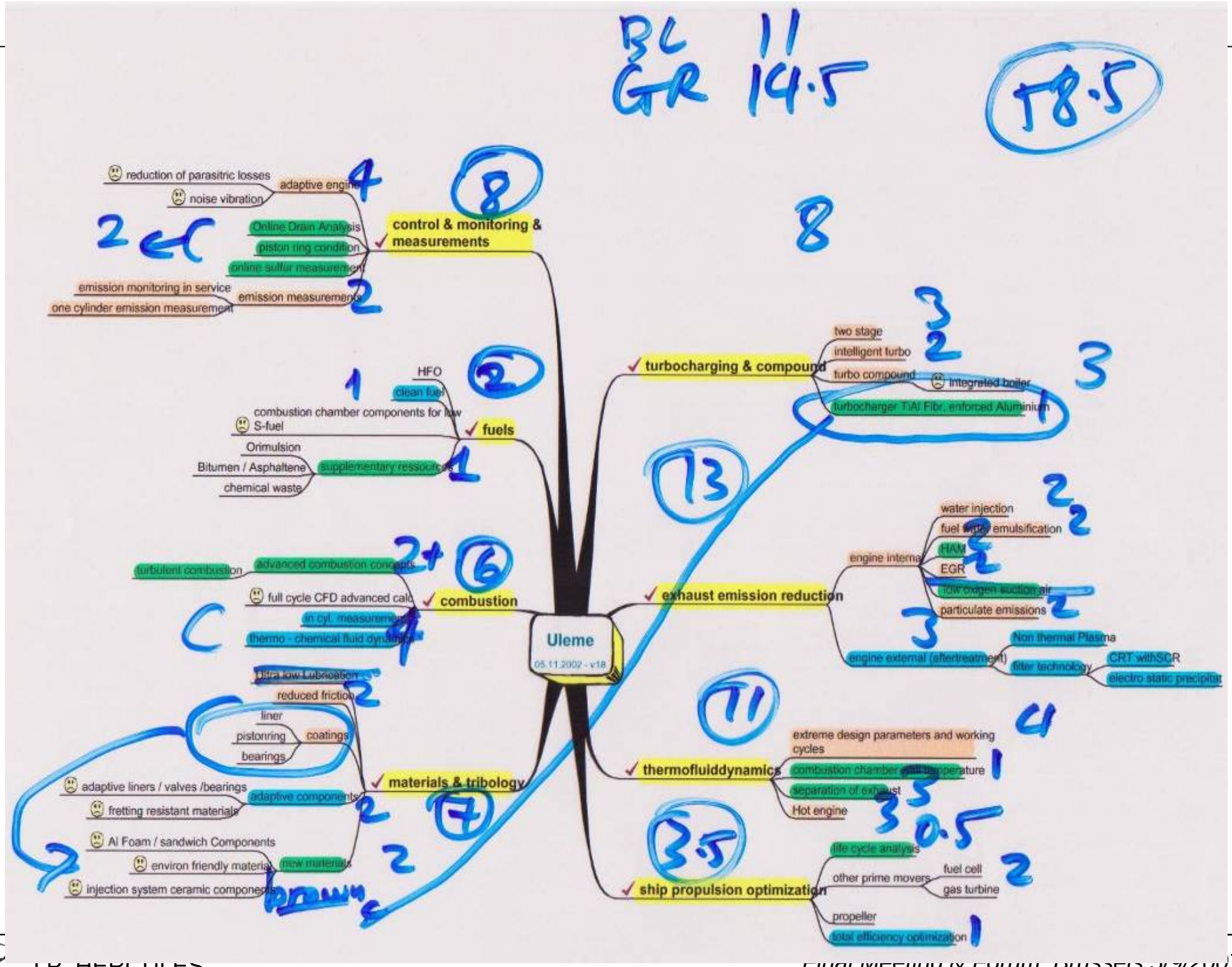
(used by 99% of world fleet; 50,000 ships ± 1200 ships/yr)

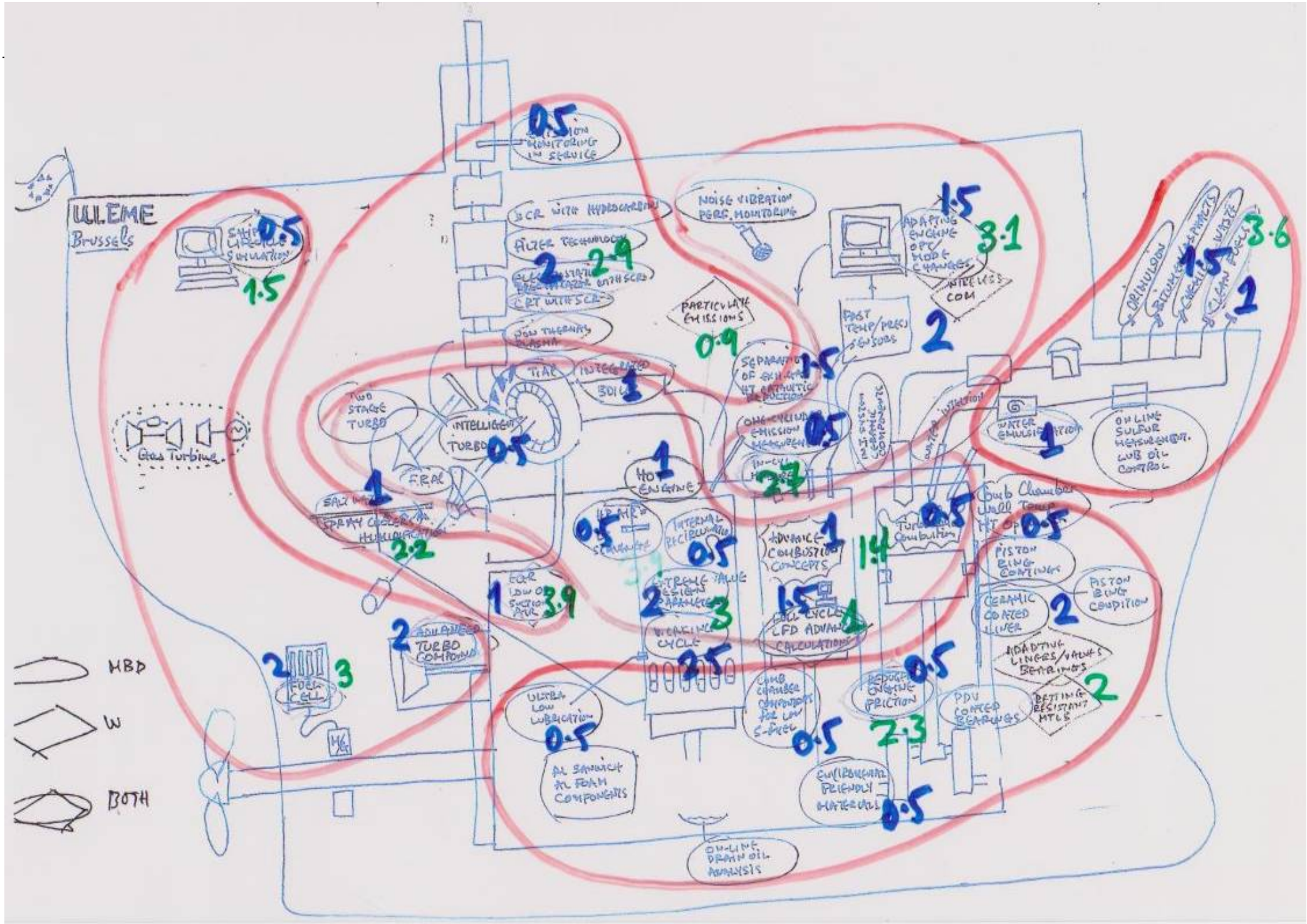


- **Reduce emissions**
  - gaseous
  - particulate
- **Increase engine efficiency**
  - Reduce fuel consumption
  - Reduce CO_2 emissions (EC 2/07, -20% @ 2020)
  - Reduce lifecycle cost
- **Increase engine reliability**

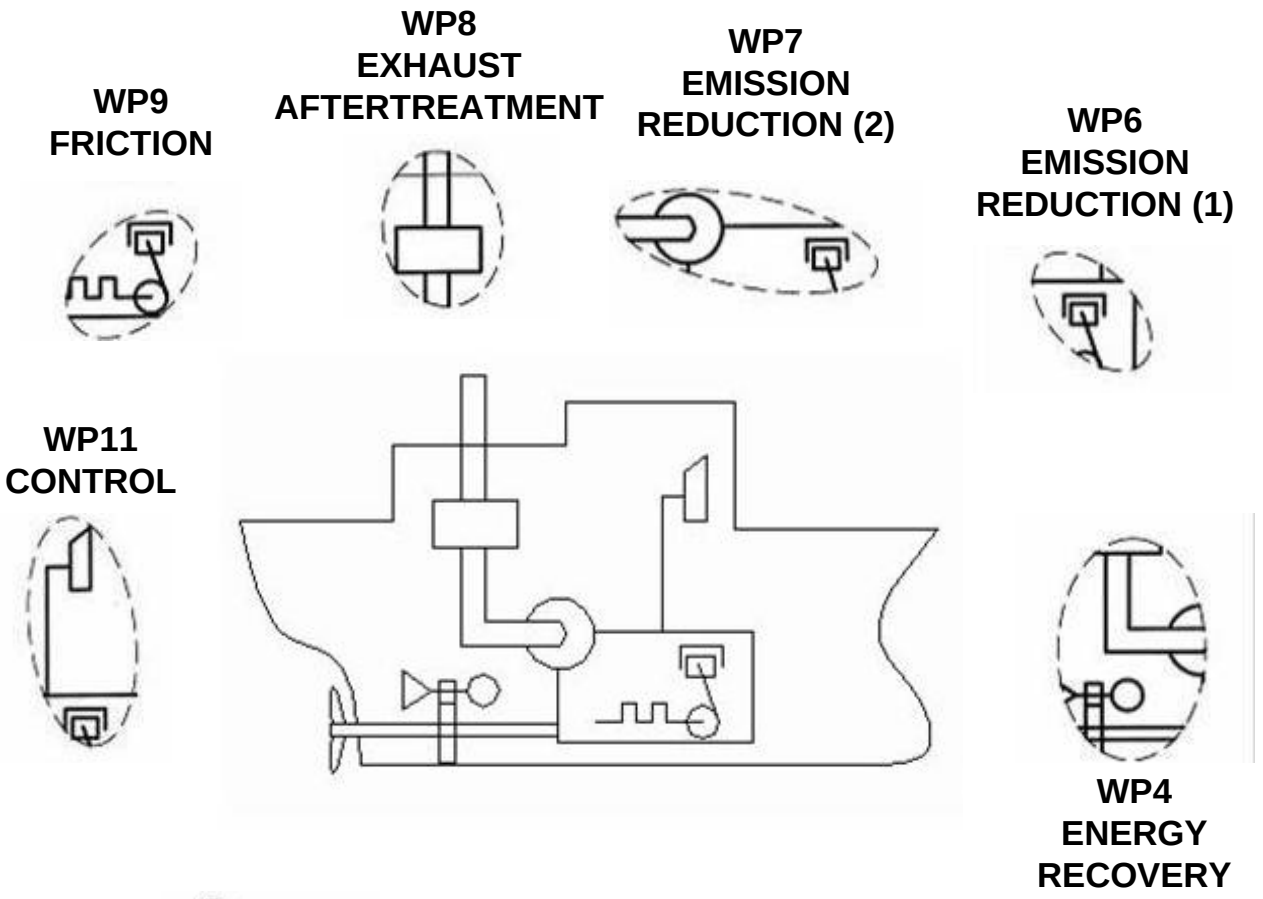
First
MAN – WARTSILA
joint Meeting:
Helsinki, 4th July 2002




Uleme
05.11.2002 - v18
control & monitoring & measurements
reduction of parasitric losses
noise vibration
adaptive engine
Online Drain Analysis
piston ring condition
online sulfur measurement
emission monitoring in service
one cylinder emission measurement
emission measurements
fuels
HFO
clean fuel
combustion chamber components for low S-fuel
Orimulsion
Bitumen / Asphaltene
chemical waste
supplementary ressources
combustion
turbulent combustion
advanced combustion concepts
full cycle CFD advanced calc
in cyl. measurement
thermo - chemical fluid dynamics
materials & tribology
Ultra low Lubricating
reduced friction
liner
pistonring
bearings
coatings
adaptive liners / valves /bearings
fretting resistant materials
adaptive components
Al Foam / sandwich Components
environ friendly material
injection system ceramic components
new materials
turbocharging & compound
two stage
intelligent turbo
turbo compound
Integrated boiler
turbocharger TiAl Fibr. enforced Aluminium
exhaust emission reduction
engine interna
water injection
fuel water emulsification
HAM
EGR
low oxigen suction air
particulate emissions
engine external (aftertreatment)
Non thermal Plasma
filter technology
CRT withSCR
electro static precipitat
thermofluiddynamics
extreme design parameters and working cycles
combustion chamber wall temperature
separation of exhaust
Hot engine
ship propulsion optimization
life cycle analysis
other prime movers
fuel cell
gas turbine
propeller
total efficiency optimization


ULEME
Brussels
Gas Turbine
HBD
W
BOTH
SCR WITH HYDROCARBONS
FILTER TECHNOLOGY
PT WITH SCR
NOISE VIBRATION PERF. MONITORING
PARTICULATE EMISSIONS
ADAPTING ENGINE OPT. MODE CHANGES
INTELLIGENT COM
FAST TEMP/PRESS SENSORS
OPTIMULSION
WATER EMULSIFICATION
ON LINE SULFUR MEASUREMENT LUB OIL CONTROL
TWO STAGE TURBO
INTELLIGENT TURBO
FRAC
SPRAY COOLER
HUMIDIFICATION
HP ENGINE
INTERNAL RECIRCULATION
ADVANCE COMBUSTION CONCEPTS
Sub Chamber Wall Temp
PISTON RING COATINGS
PISTON RING CONDITION
CERAMIC COATED LINER
ADAPTING LINERS/VALVES BEARINGS
BEARING RESISTANT MTLS
FOR LOW SULFUR FUEL
ADVANCED TURBO COMPOUND
FUEL CELL
HYBRID CYCLE
CFD ADVANCED CALCULATIONS
REDUCE ENGINE FRICTION
PDV COATED BEARINGS
ULTRA LOW LUBRICATION
AL SAMARIUM AL FOAM COMPONENTS
ENVIRONMENTAL FRIENDLY MATERIALS
ON-LINE DRAIN OIL ANALYSIS

Overview of I.P. HERCULES Workpackages



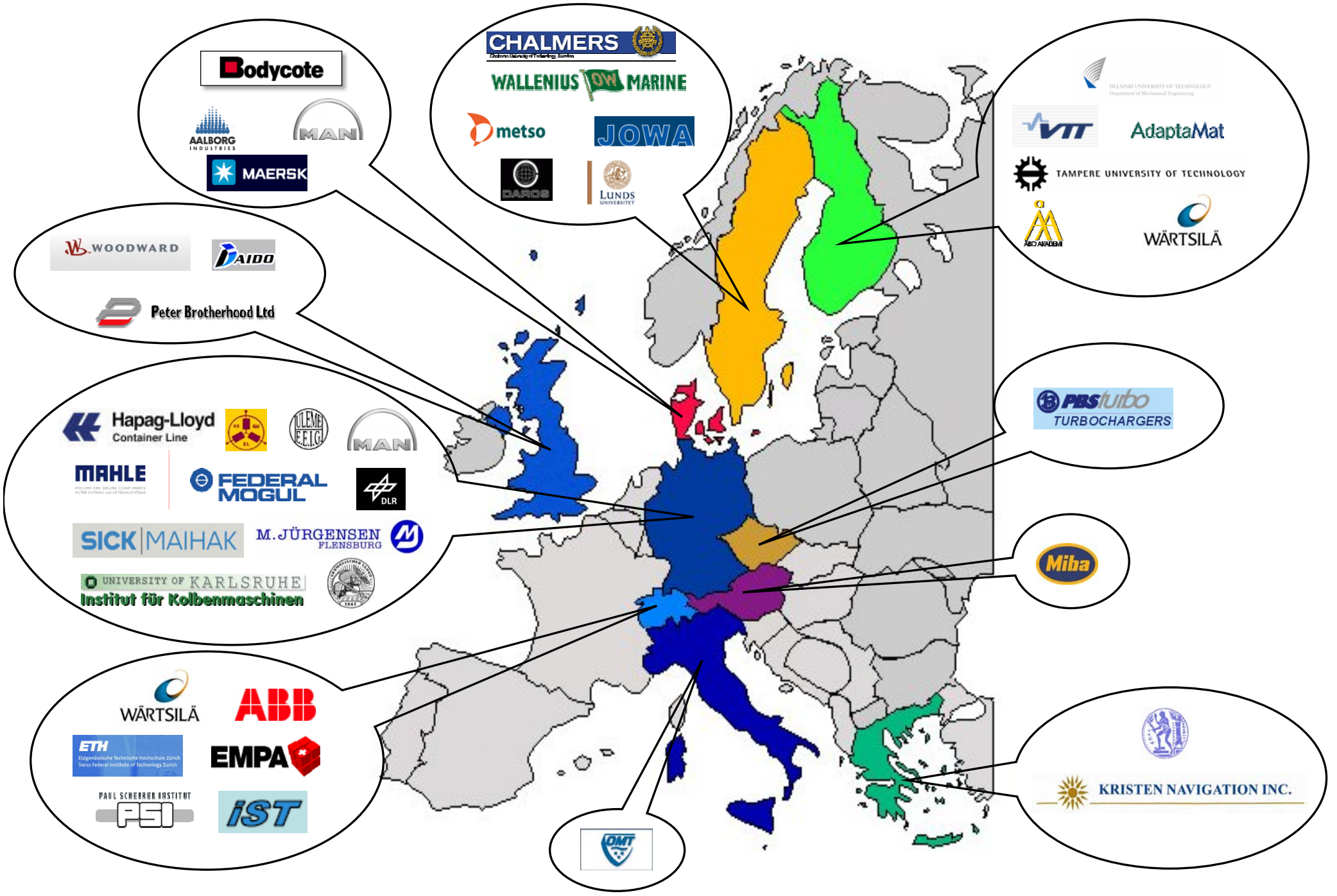
STRUCTURE OF THE WORK

54 Subprojects

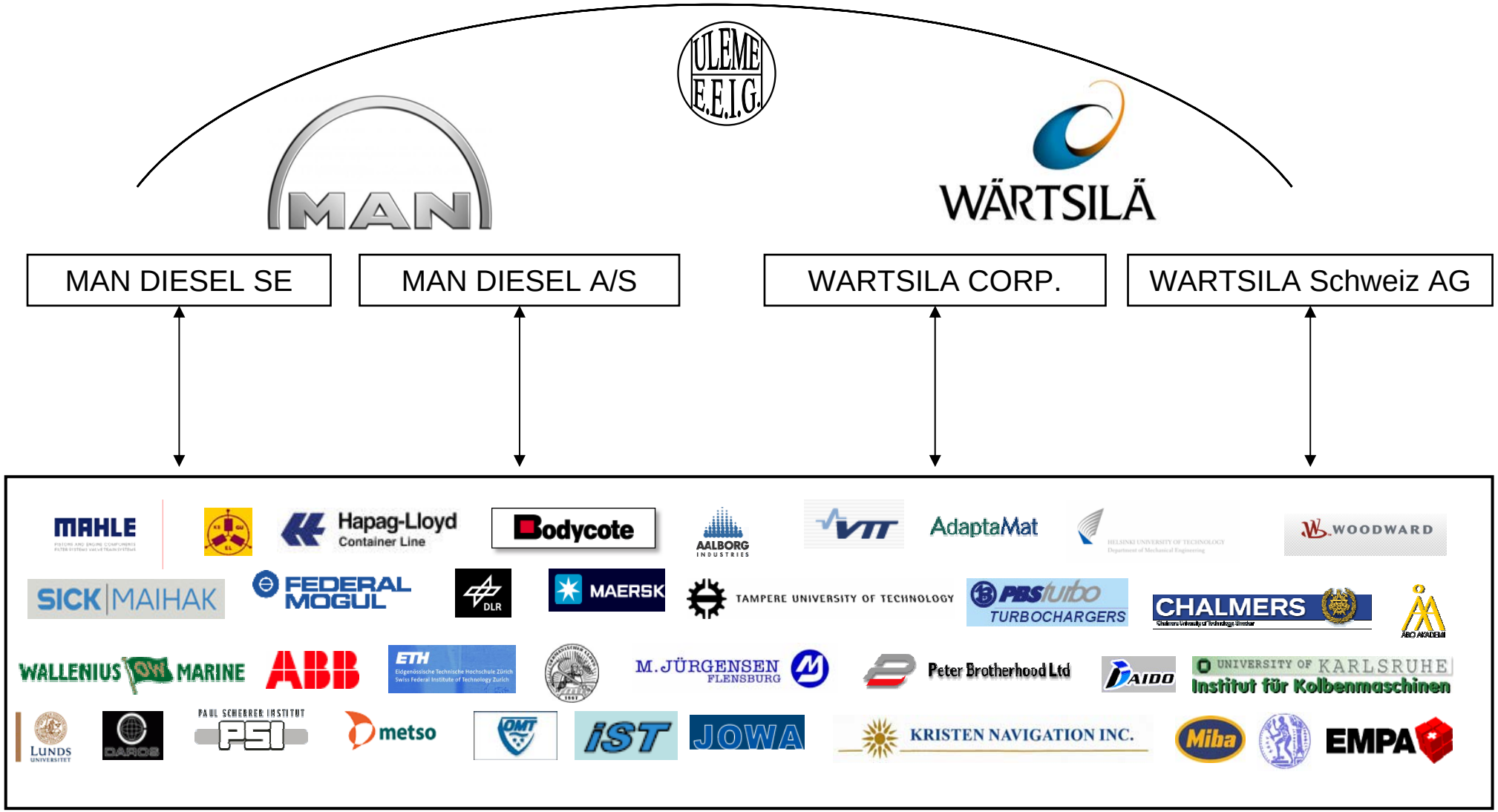
↳ **18 Tasks**

↳ **9 Workpackages**

I.P. HERCULES – Consortium

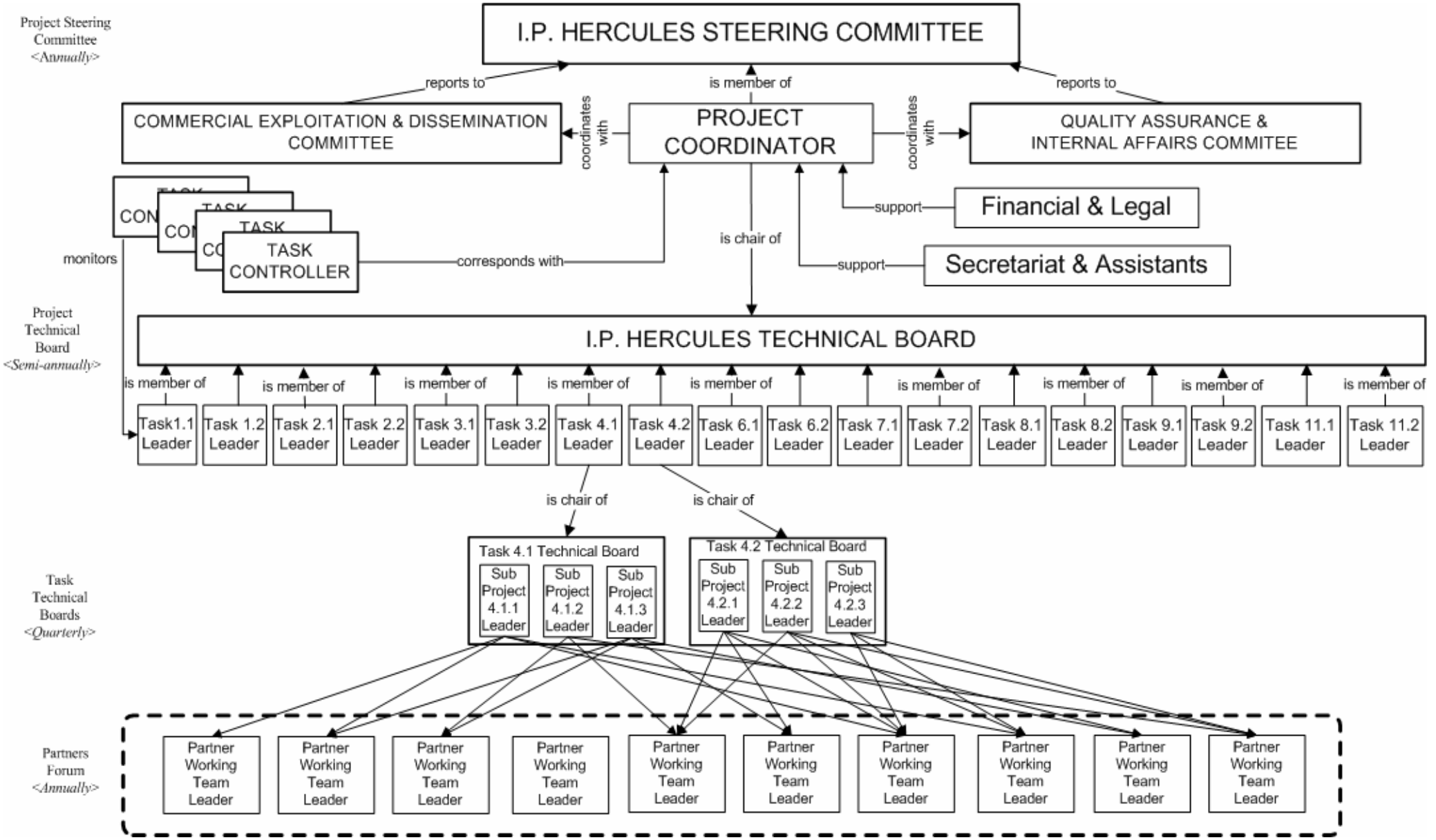


I.P. HERCULES – Consortium

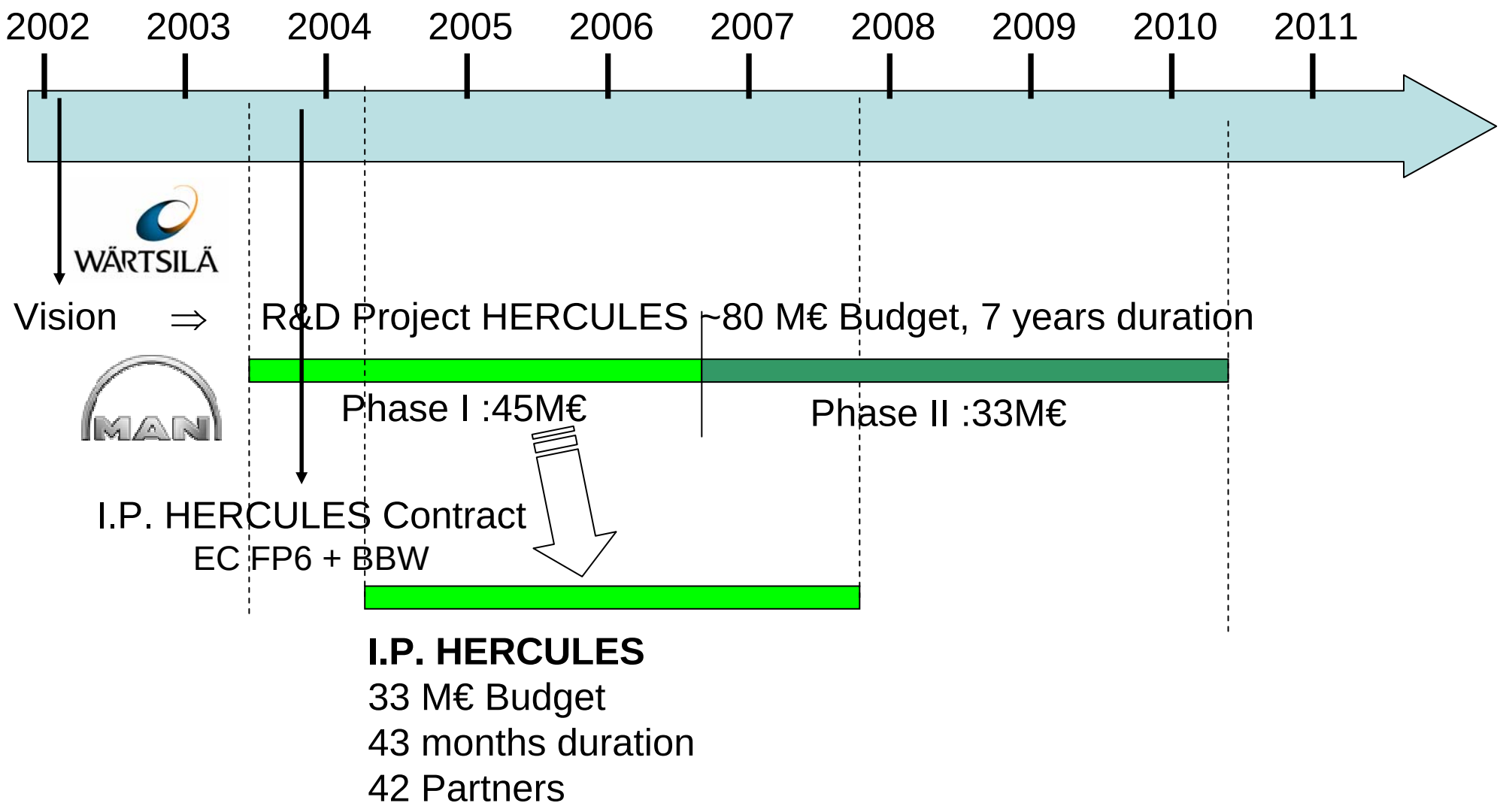


60% *Industrial partners,* **19**% *Universities*, **12**% *Research organisations*, **9**% *Users / Ship Operator companies*

I.P. HERCULES Management Structure



Project HERCULES



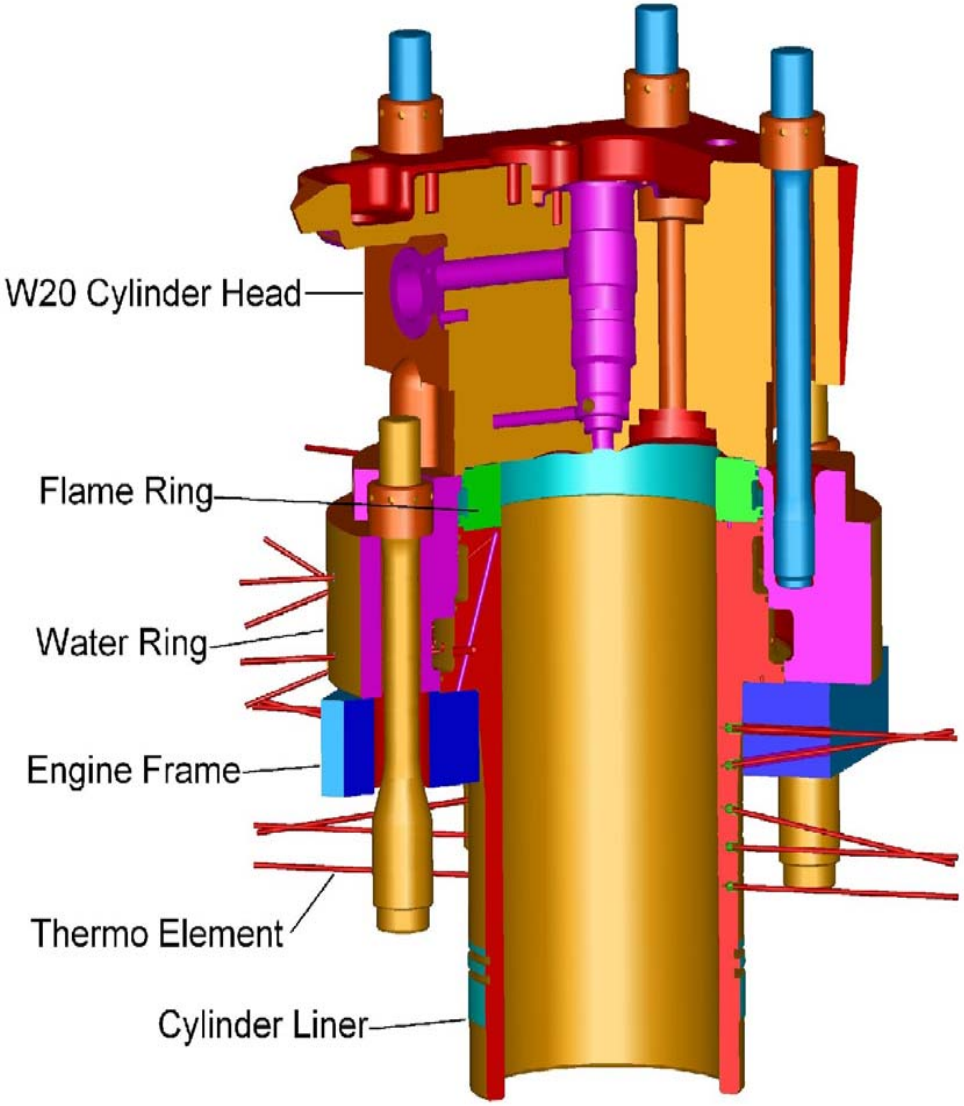
I.P. HERCULES
33 M€ Budget
43 months duration
42 Partners

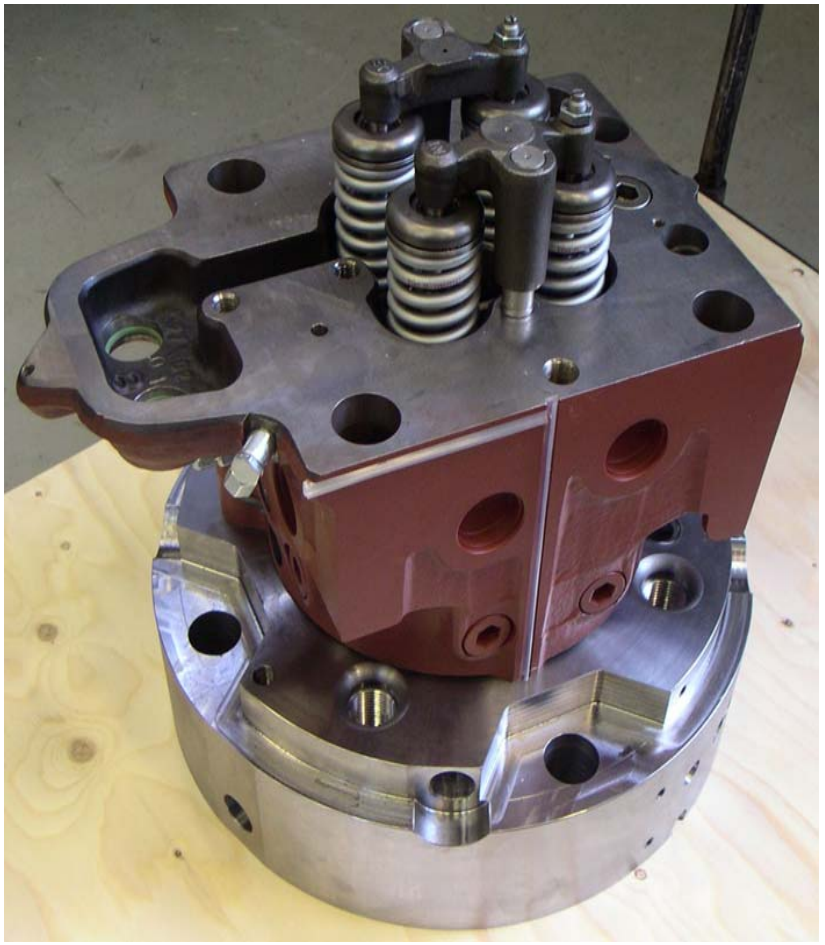
I.P. HERCULES General Objectives & Achievements

I.P. HERCULES Objective	**Year 2007 Targets**	**Year 2007 Achievements**	Comments
Specific Fuel Consumption	**- 1%**	**-1.4%**	WP3, WP4
NOx emission	**-20%**	**-50%**	WP7 (EGR) WP6 (Direct Water Injection) WP6 (Wetpac Humidification) WP3 (2-stage T/C)
Other emission components	**-5%**	**-20%, HC -40%, PM -90%, SOx**	WP7 (EGR) WP8 (Wet scrubber) WP8 (Wet scrubber)
Reliability *(Present TBO 18,000 hrs)*	**+10%**	**Up to 8,000 hrs testing**	WP9 (liner, rings)
Time to market *(Presently 60 months)*	**-10%**	**Within 42 months**	WP9 (MR sensor "*TriboSen*")

- Concept design
- Preliminary design
- Detailed design
- Construction Planning
- Prototype
- Prototype testing (Results)

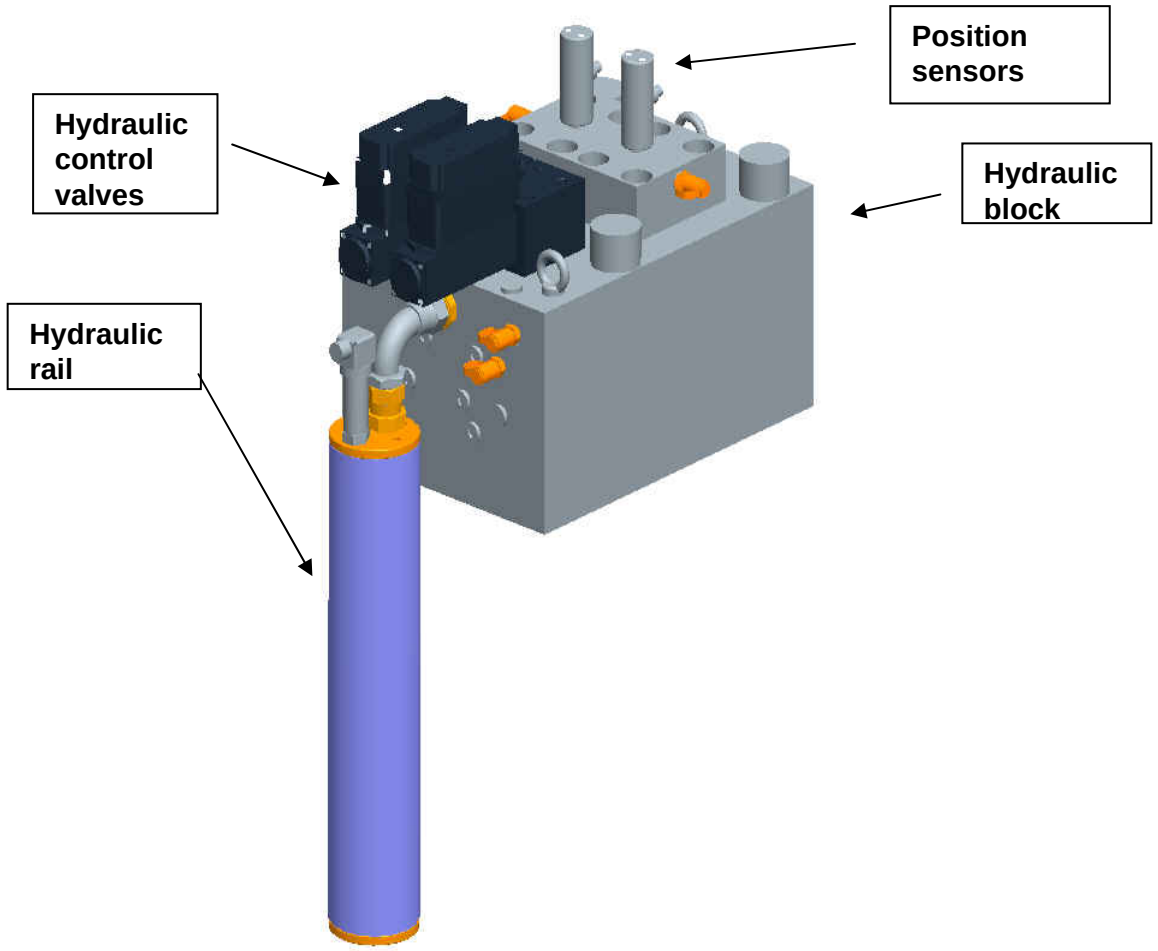
TASK 1.1: Mechanics of engine with extreme design parameters

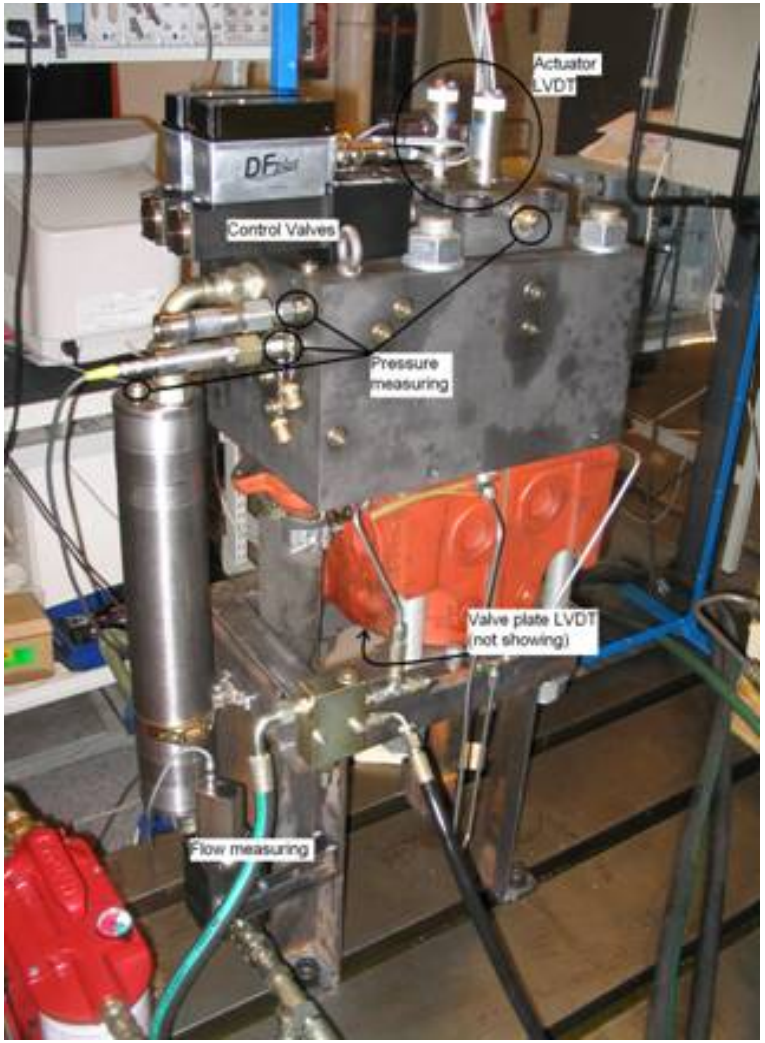


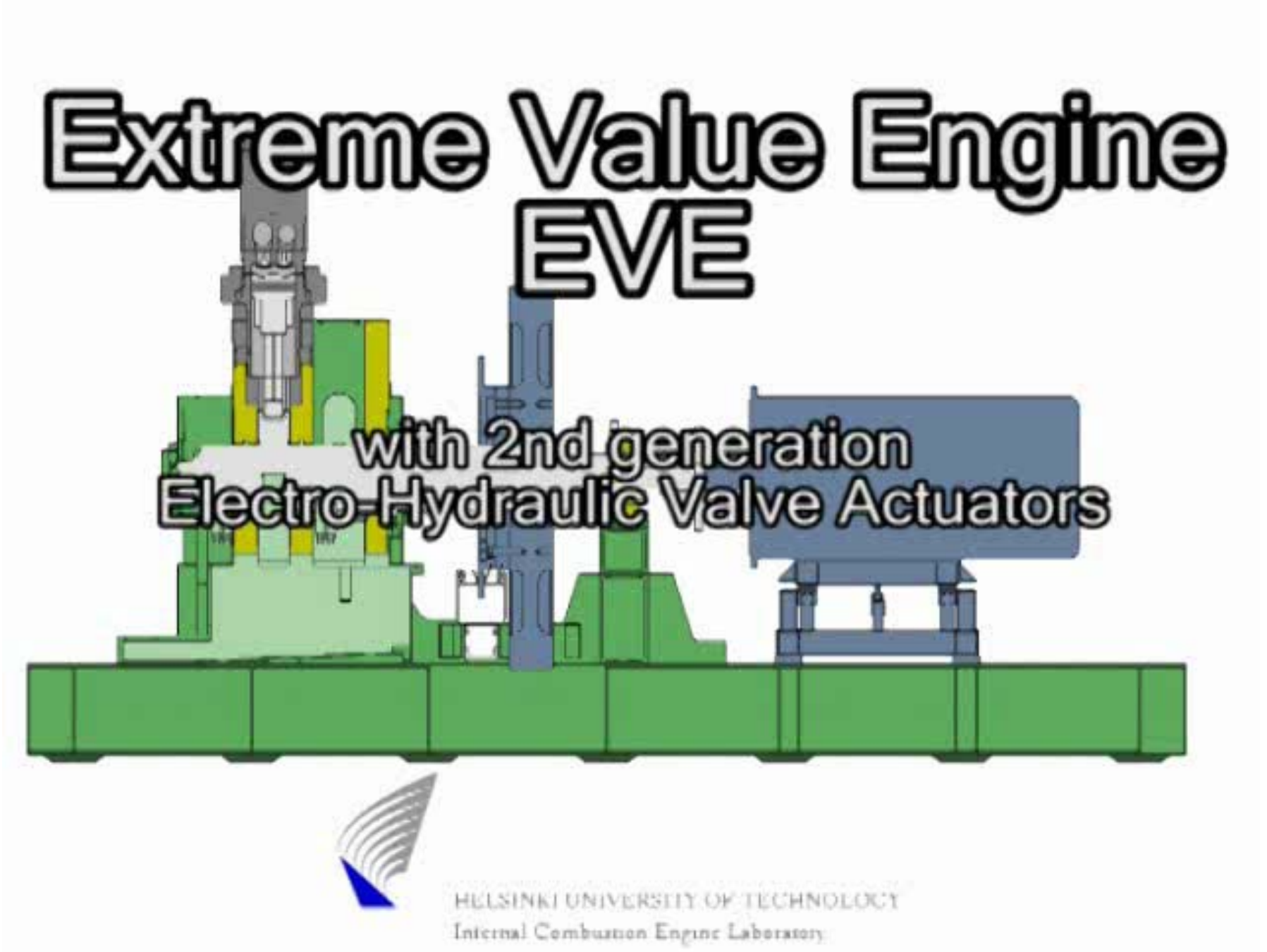


The EVE cylinder head and liner assembly

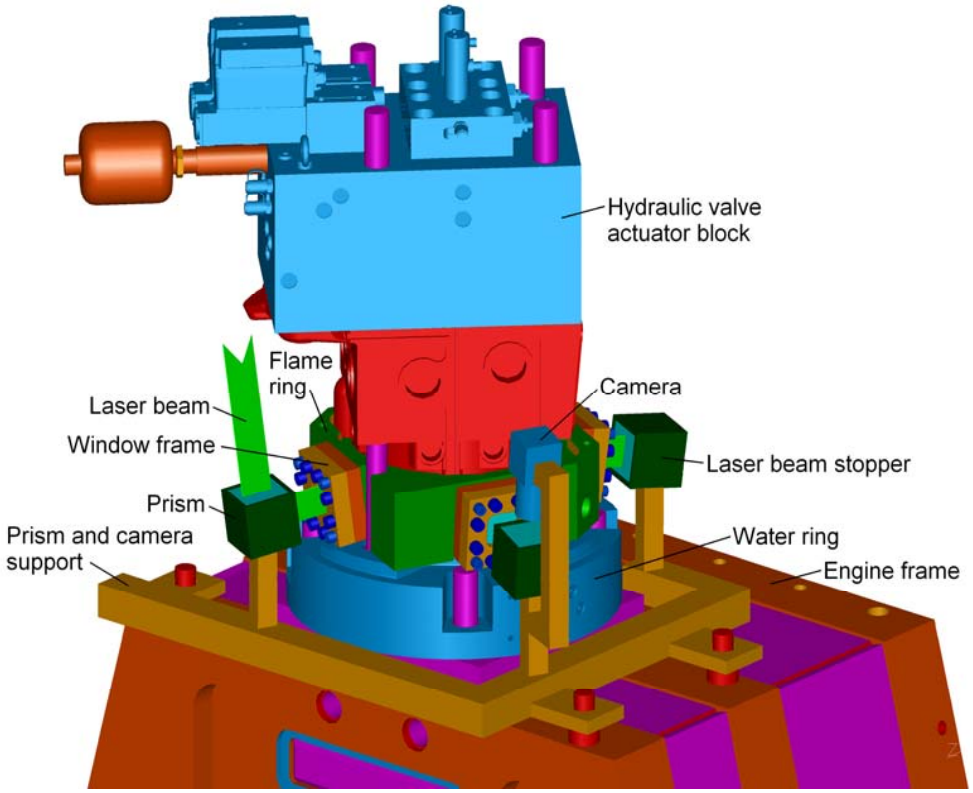
EVE's hydraulic valve actuating system

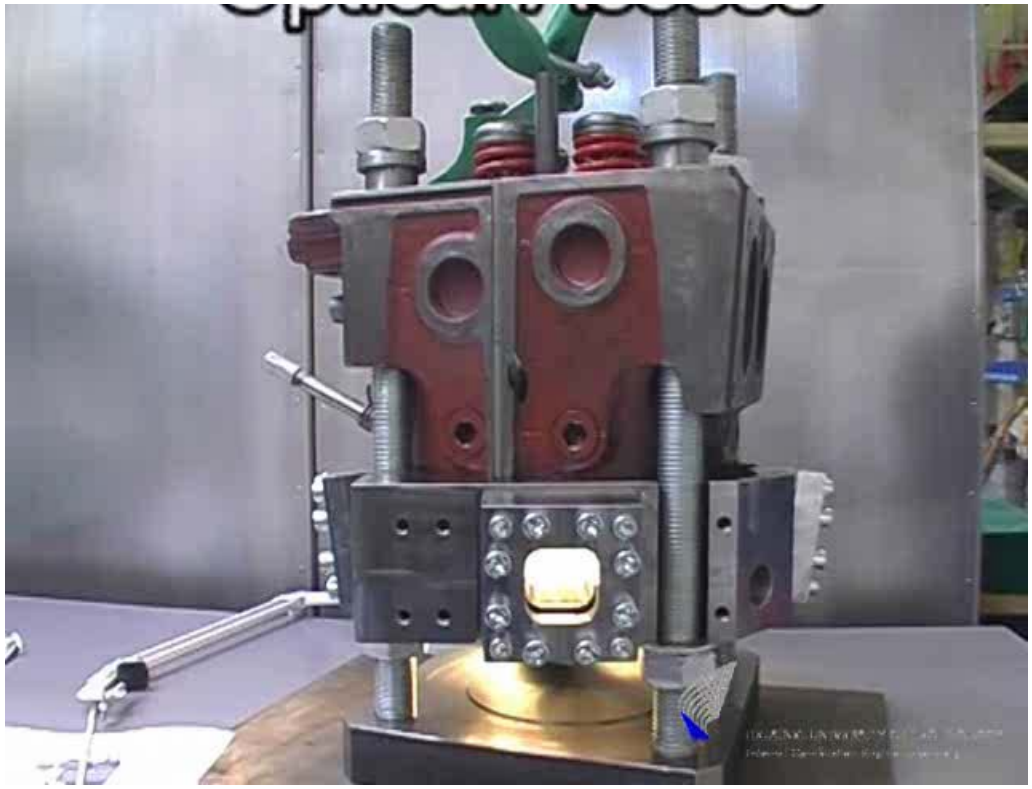





Extreme Value Engine
EVE
with 2nd generation
Electro-Hydraulic Valve Actuators
HELSINKI UNIVERSITY OF TECHNOLOGY
Internal Combustion Engine Laboratory

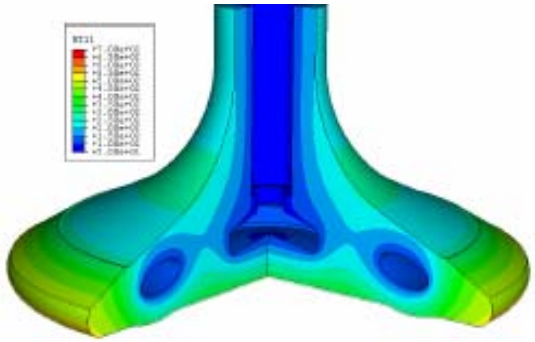
EVE: Access through flame ring





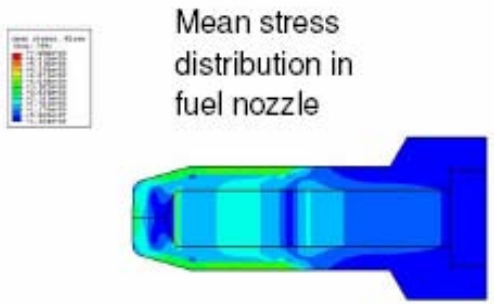
TASK 1.2: Thermodynamics of engine with extreme design parameters

Prototype components 2-stroke engine



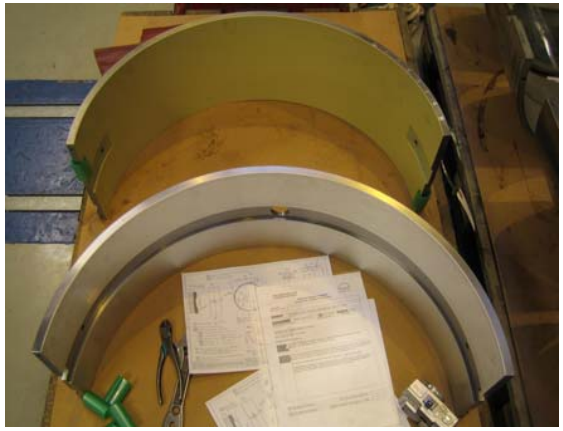
Temperature distribution in cooled spindle

Liquid cooled exhaust valve spindle



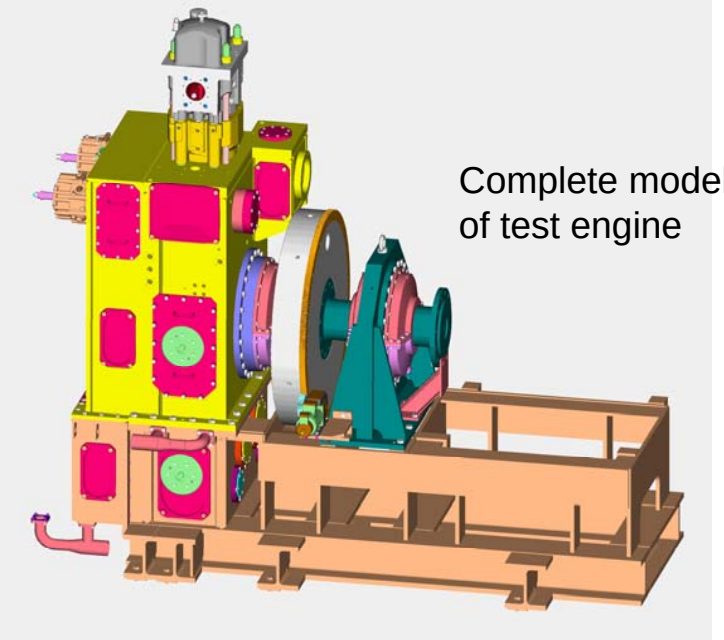
Compound fuel valve nozzle

New top piston ring

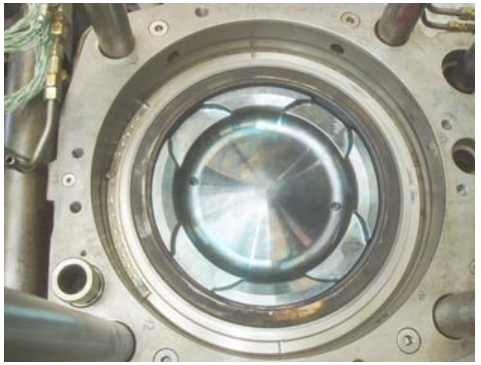


New main bearing

New 4-stroke test engine

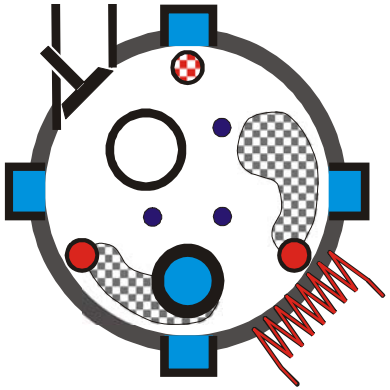


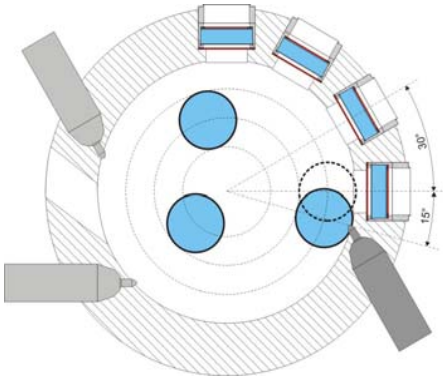
Complete model of test engine



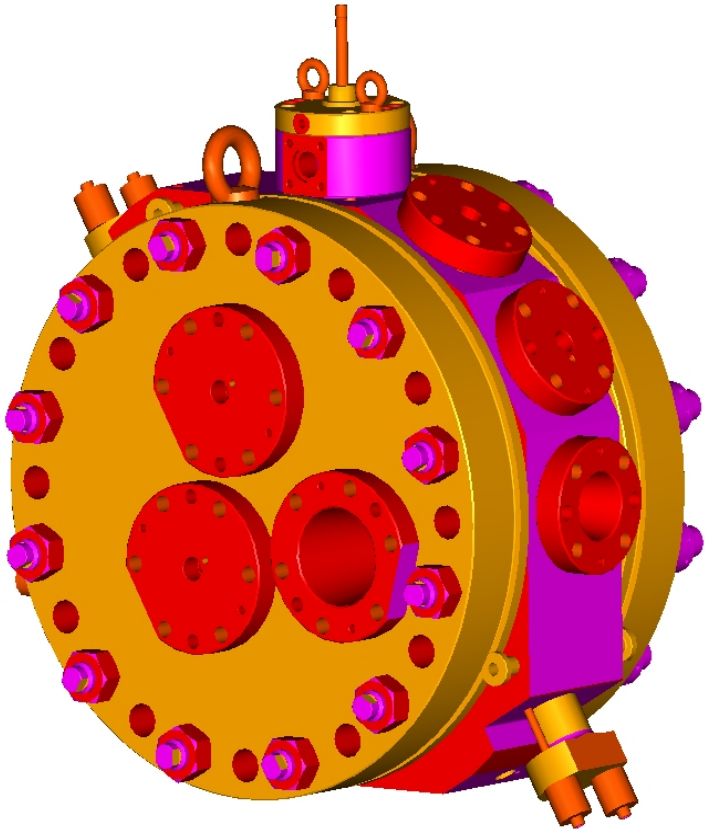
New piston bowl

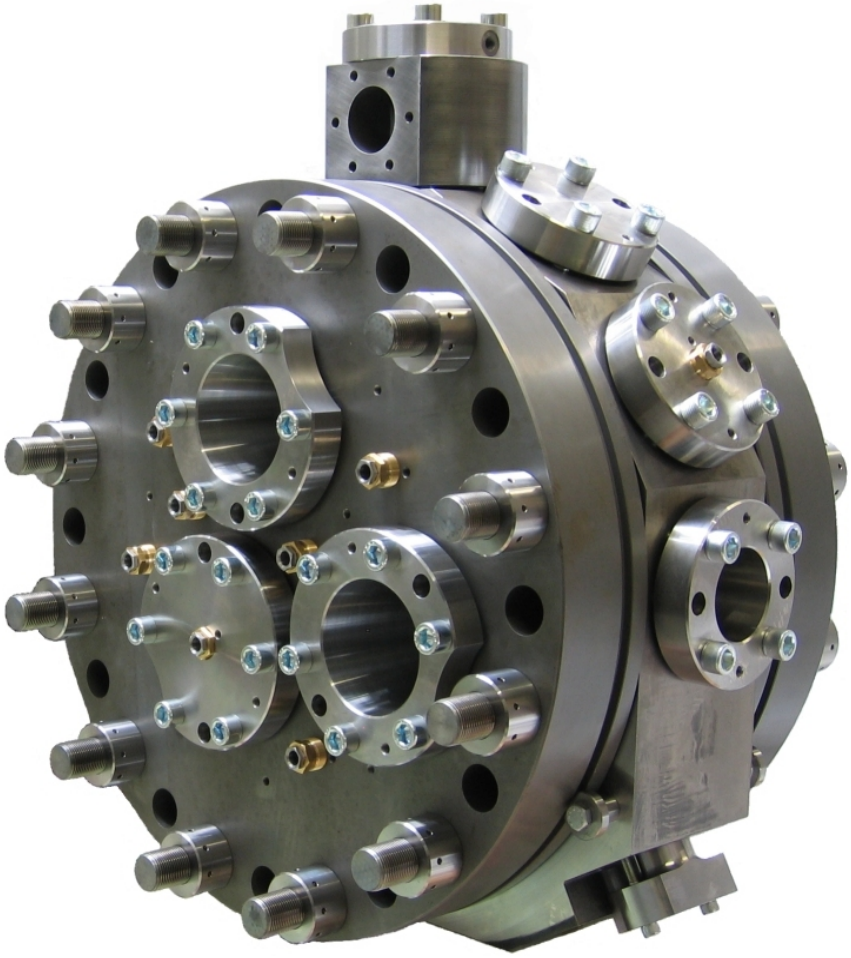
TASK 2.1: Combustion process simulation





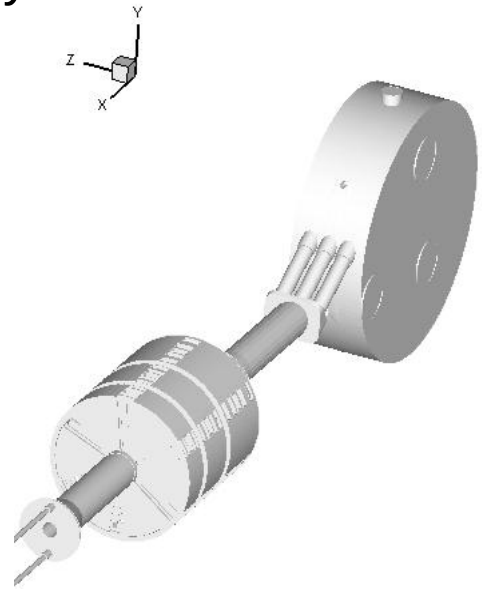
Spray / Combustion Chamber

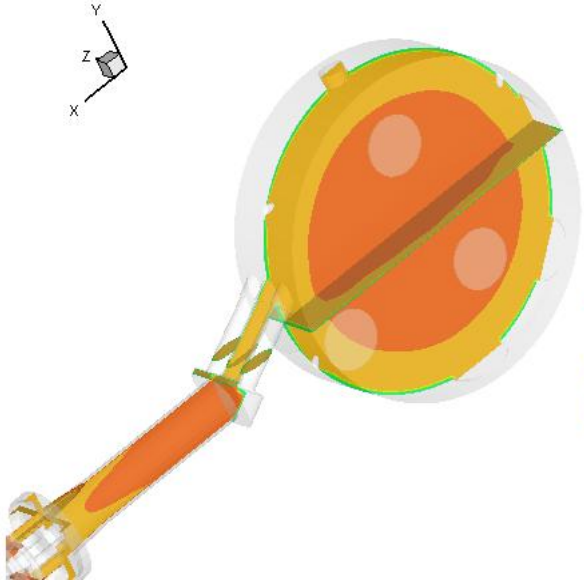


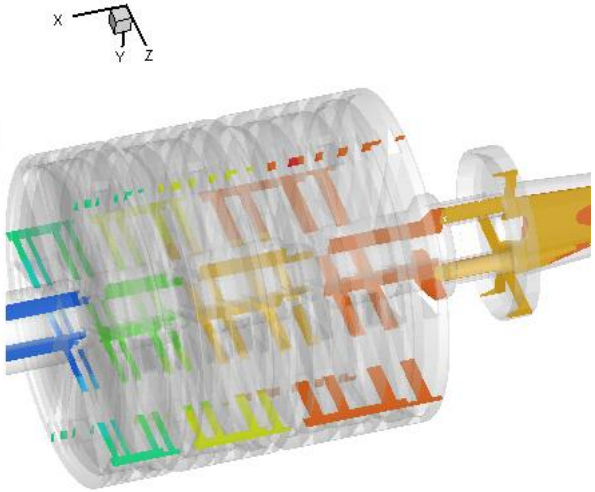


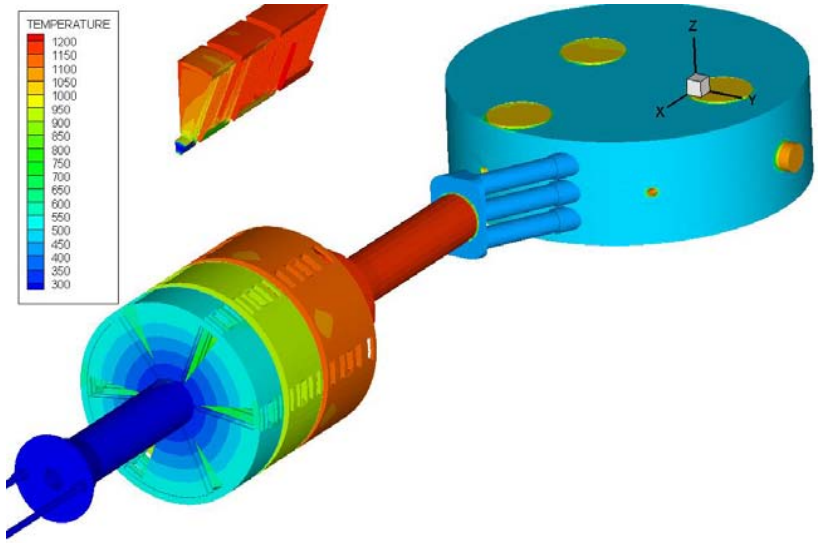
TASK 2.1: Combustion process simulation

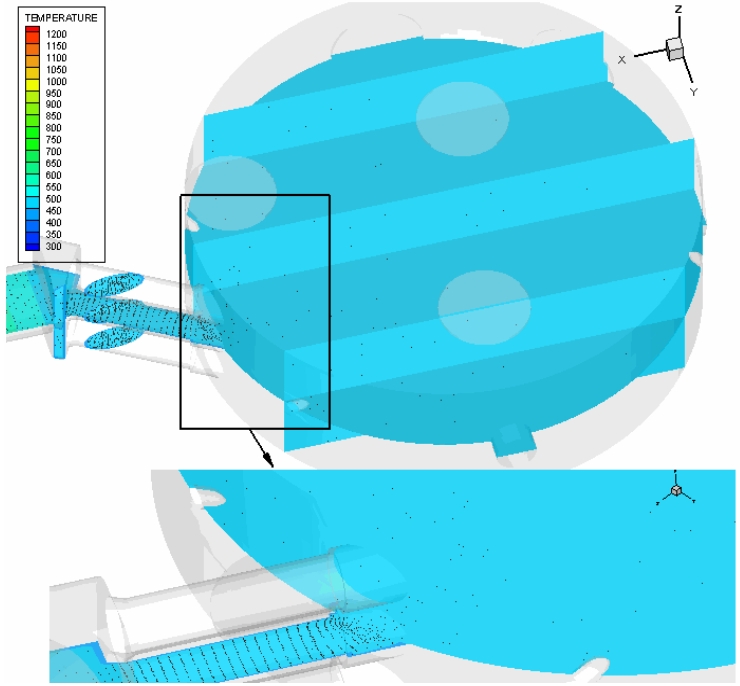
Spray combustion chamber simulation



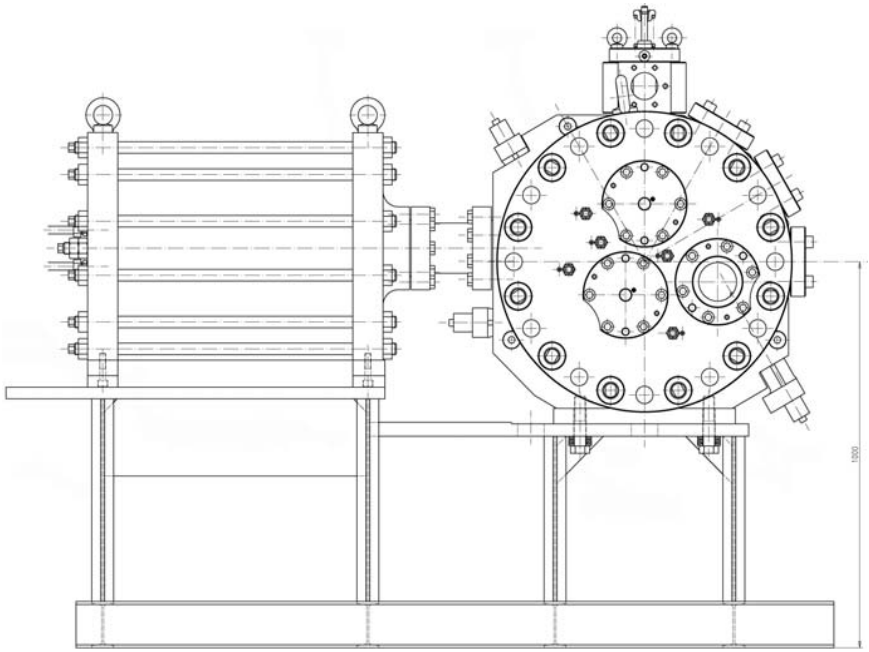




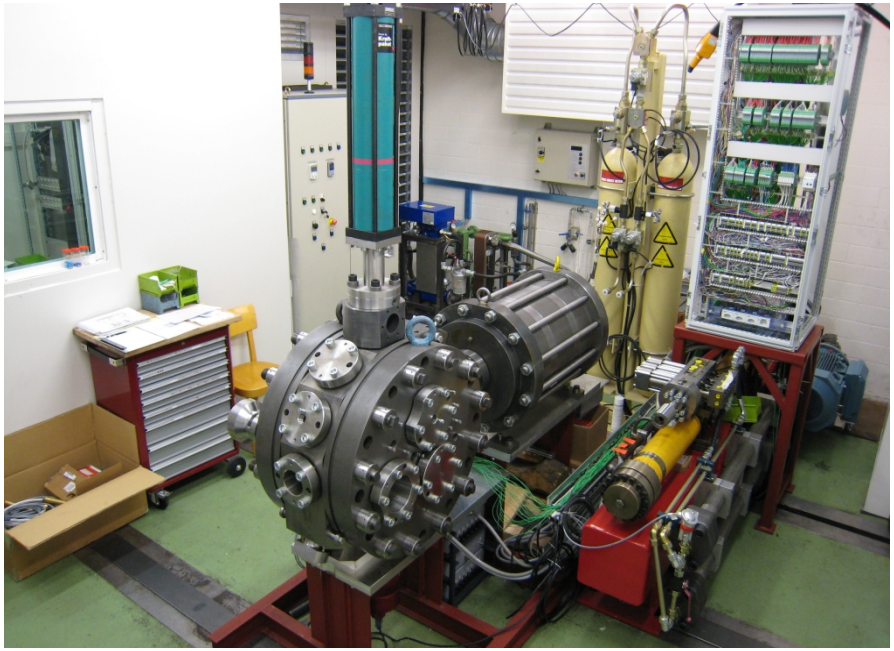


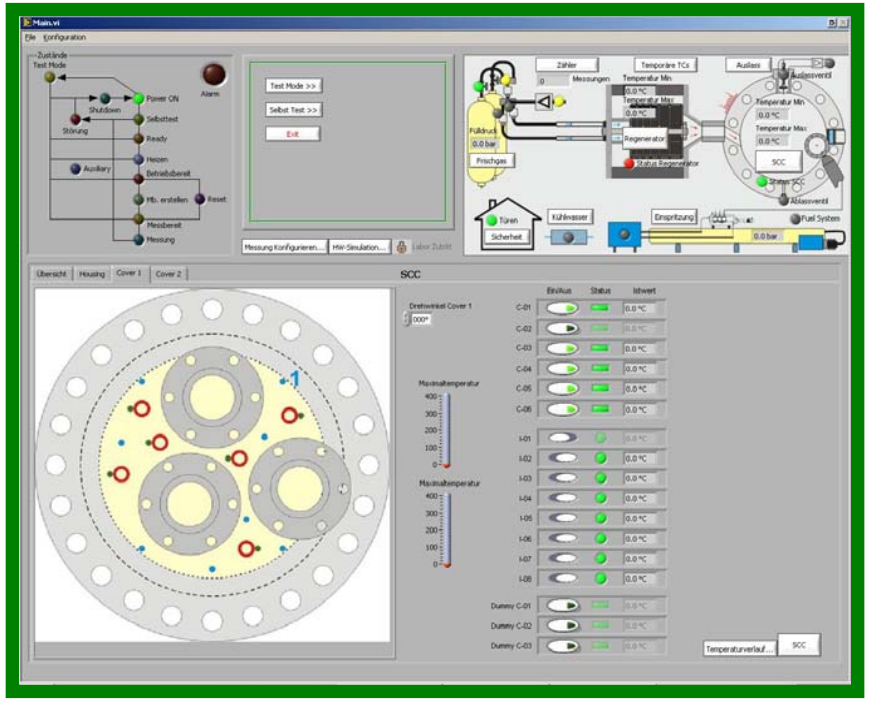


TASK 2.1: Combustion process simulation



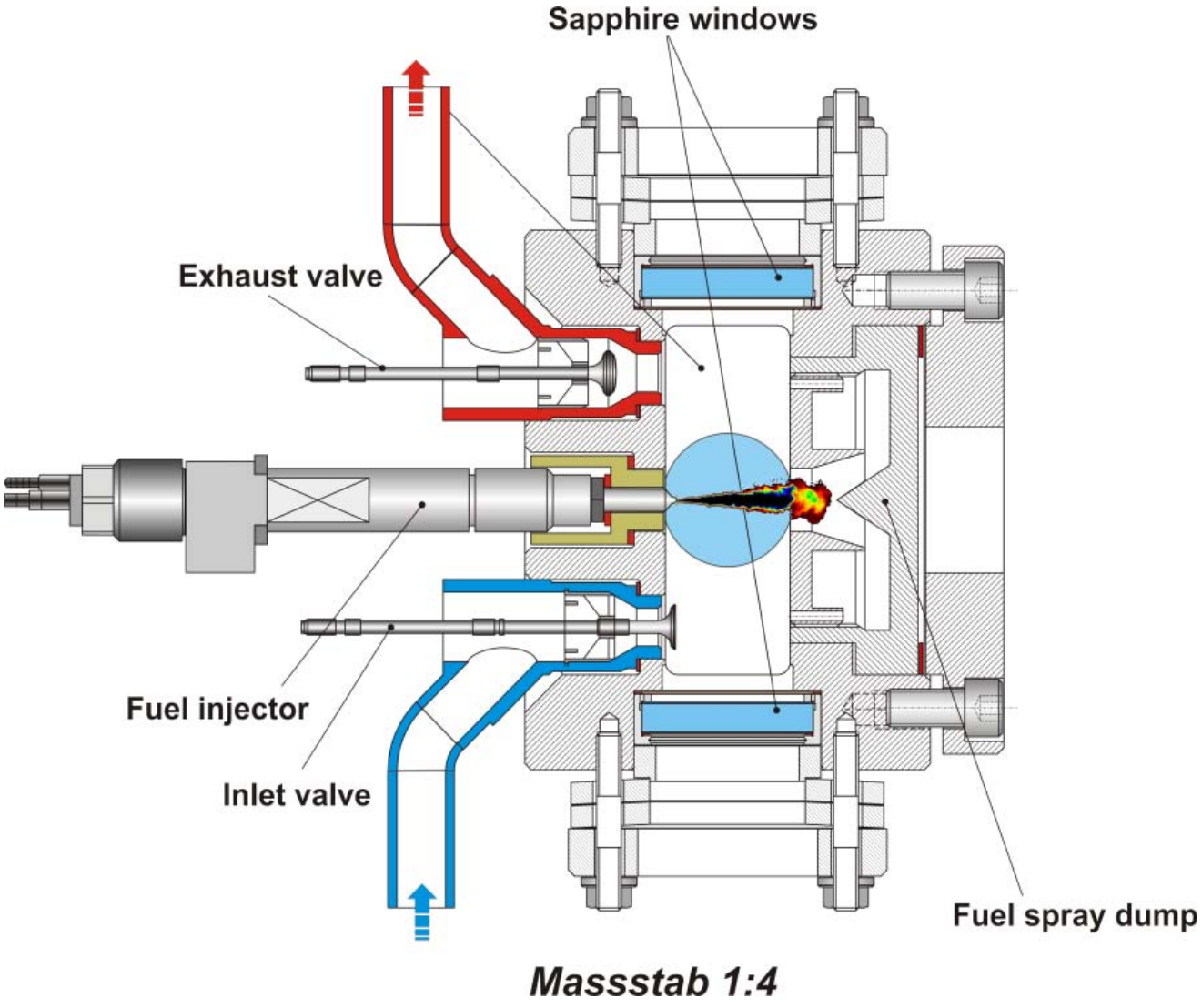
CIMAC 2007 Congress: BP award !

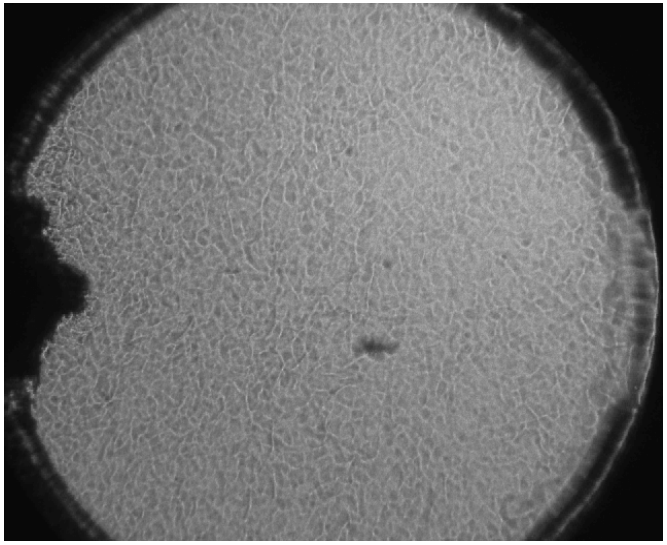




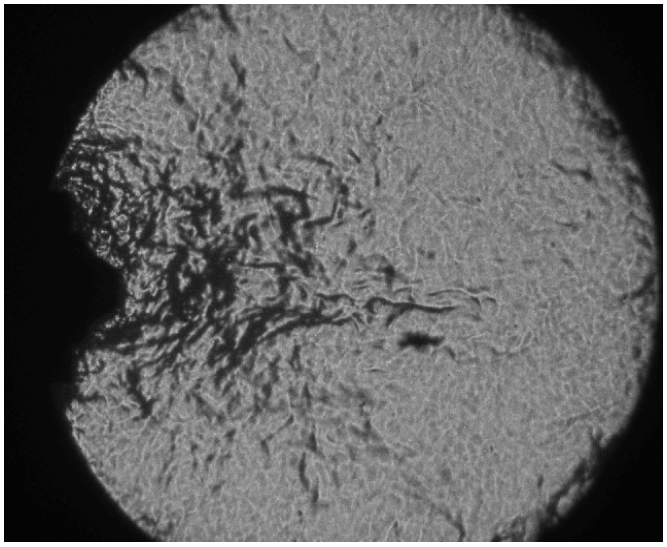
TASK 2.1: Combustion process simulation

Spray visualization using simultaneous Schlieren/Shadowgaphy measurements





Shadowgraph

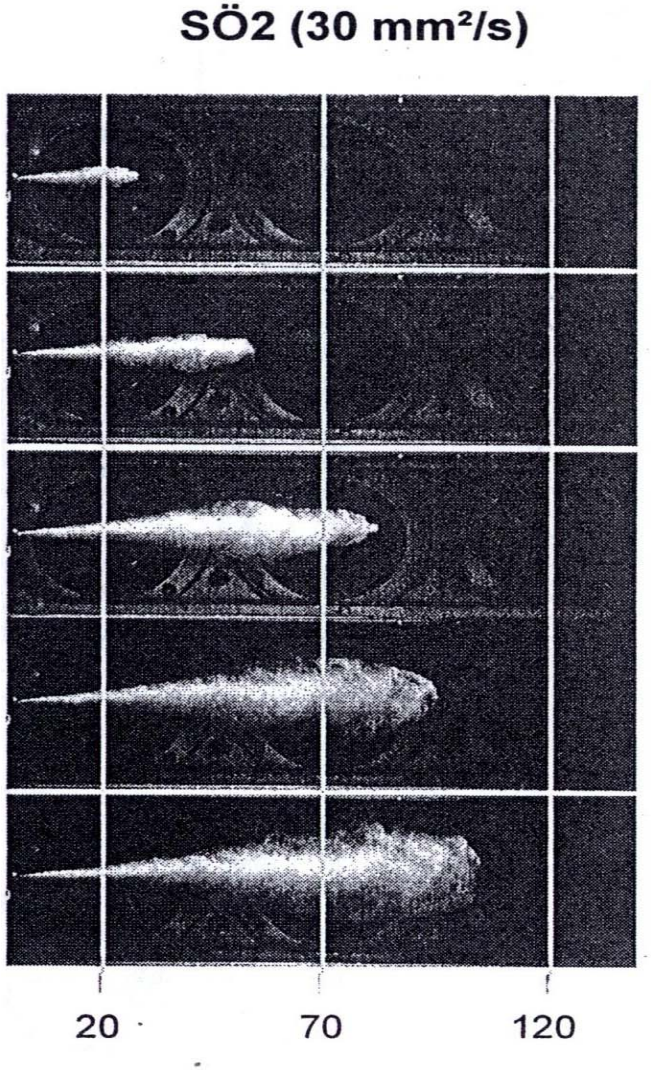


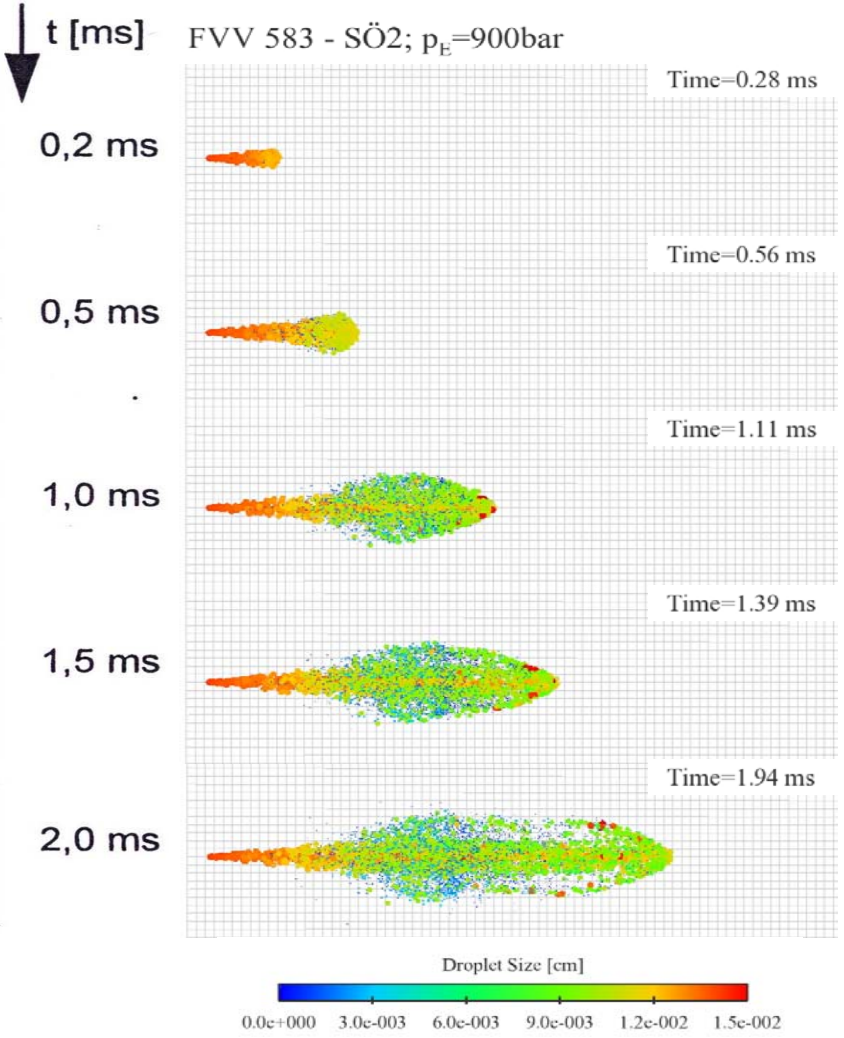
Schlieren

TASK 2.2: Emission formation simulation

Exp. investigation of fuel spray geometry with high speed camera (50.000 frames/sec)

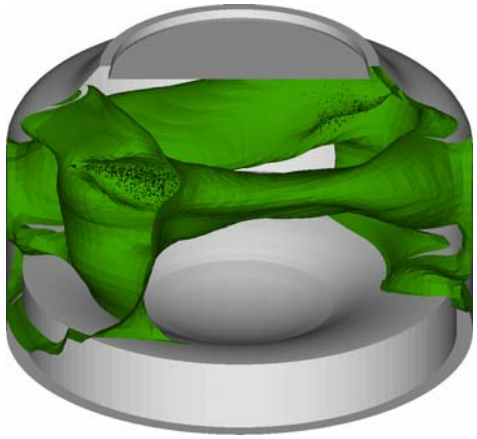
Fuel Model Validation with Bomb Experiments



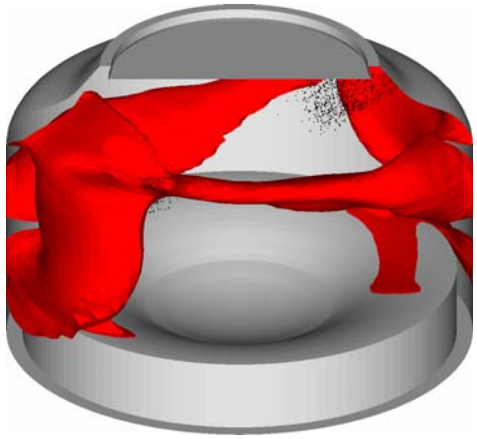


TASK 2.2: Emission formation simulation

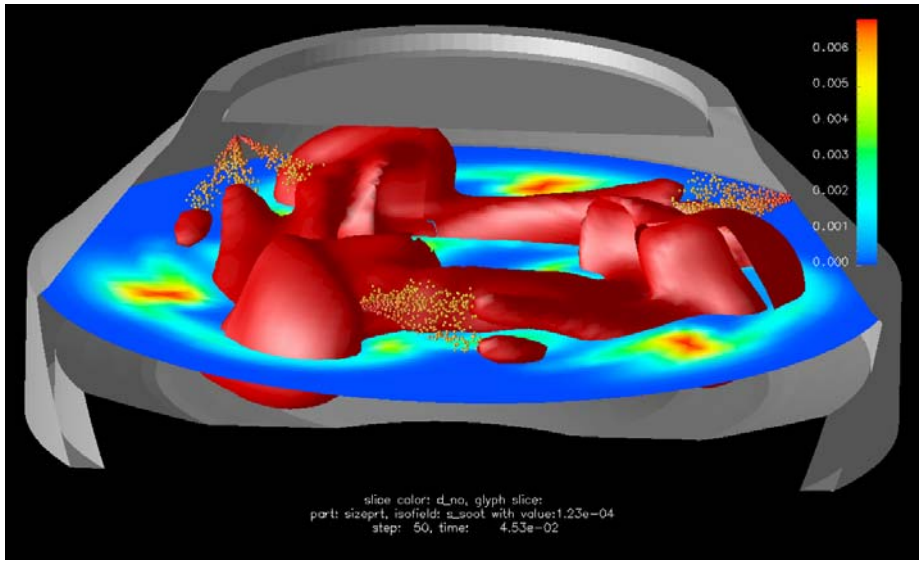
Isosurface representation of predicted soot for 4T50ME-X two-stroke engine

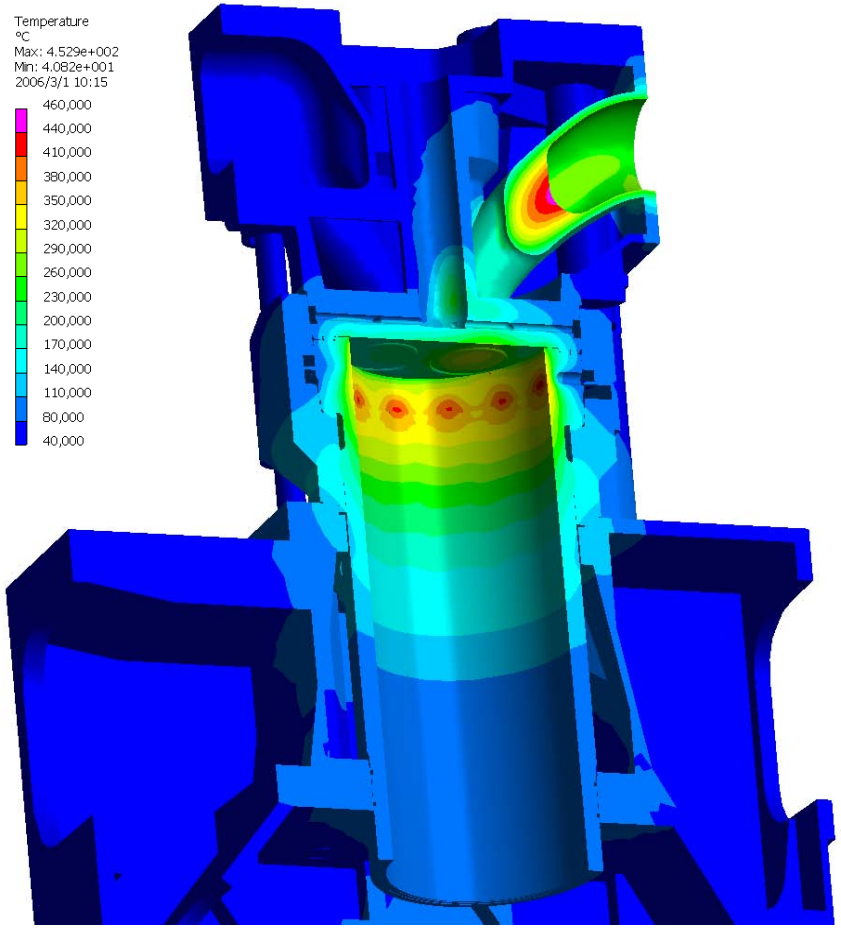


Original Kiva soot model



New flamelet soot model

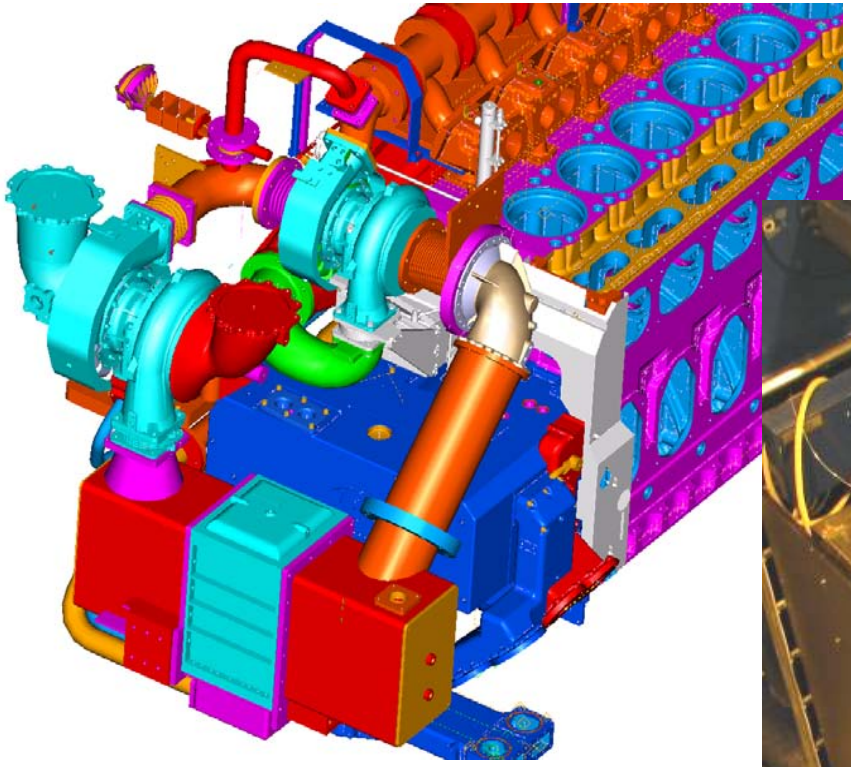




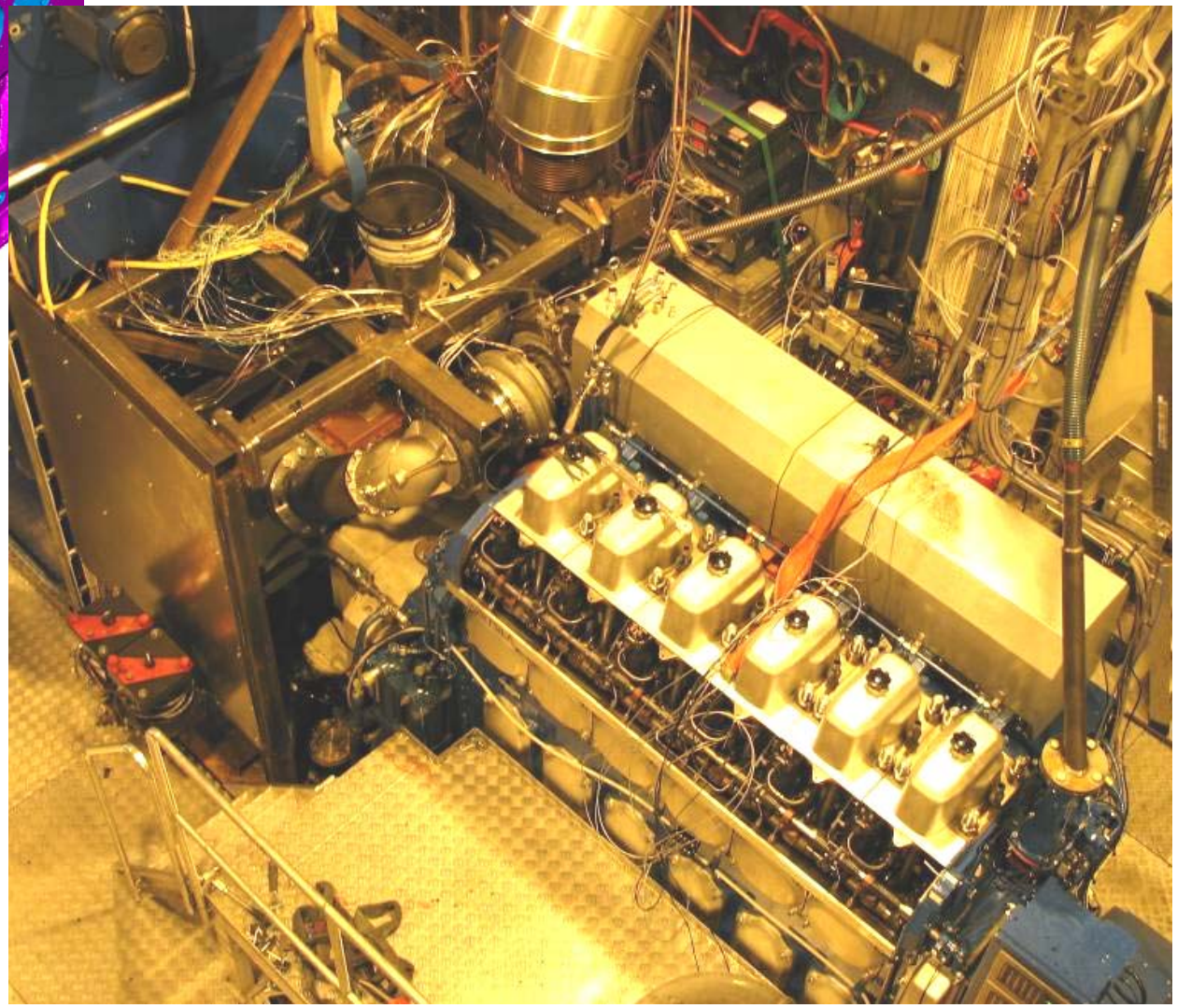
Predicted wall temperatures in the combustion chamber of 32/44 four stroke engine

TASK 3.1: Variable turbocharging

Two-stage turbocharged 4-stroke engine

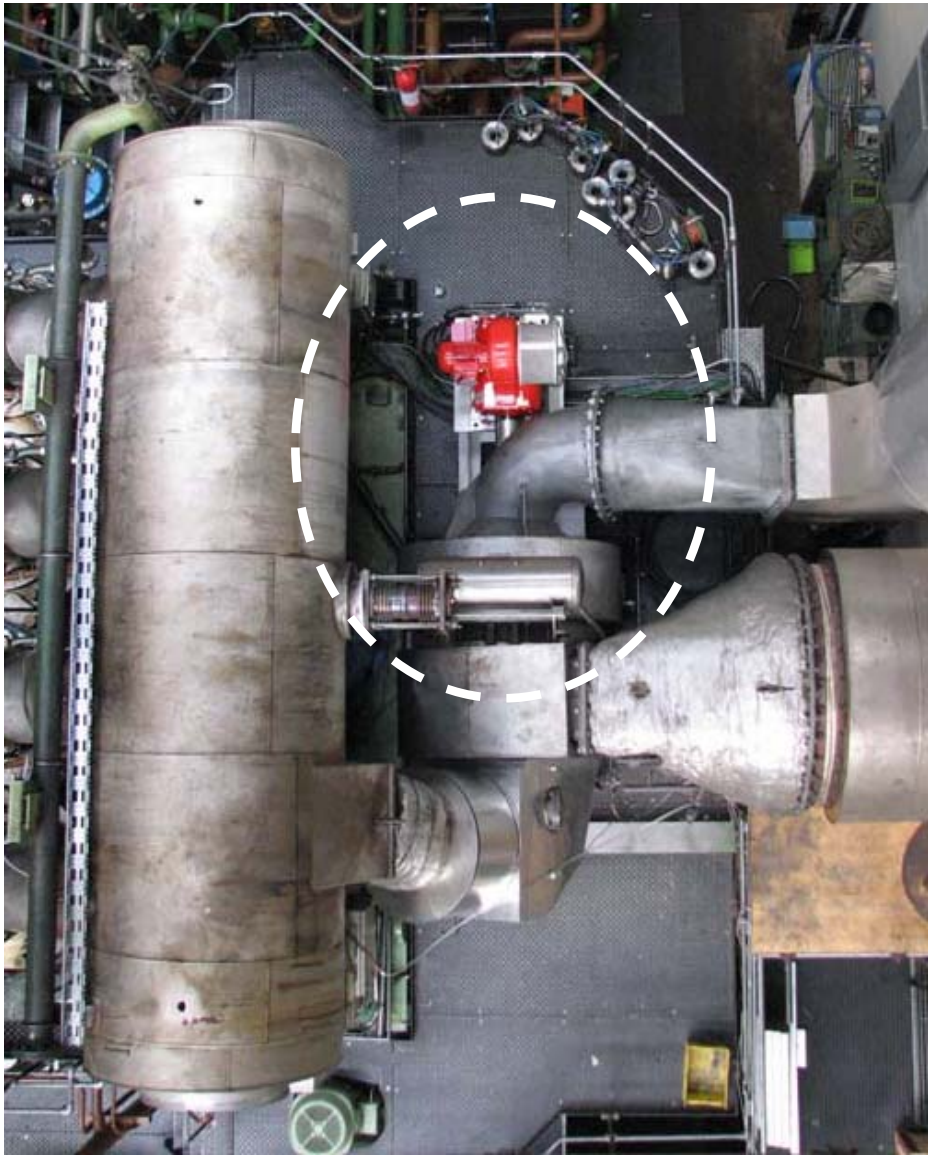


CIMAC 2007 Congress: Best paper award !



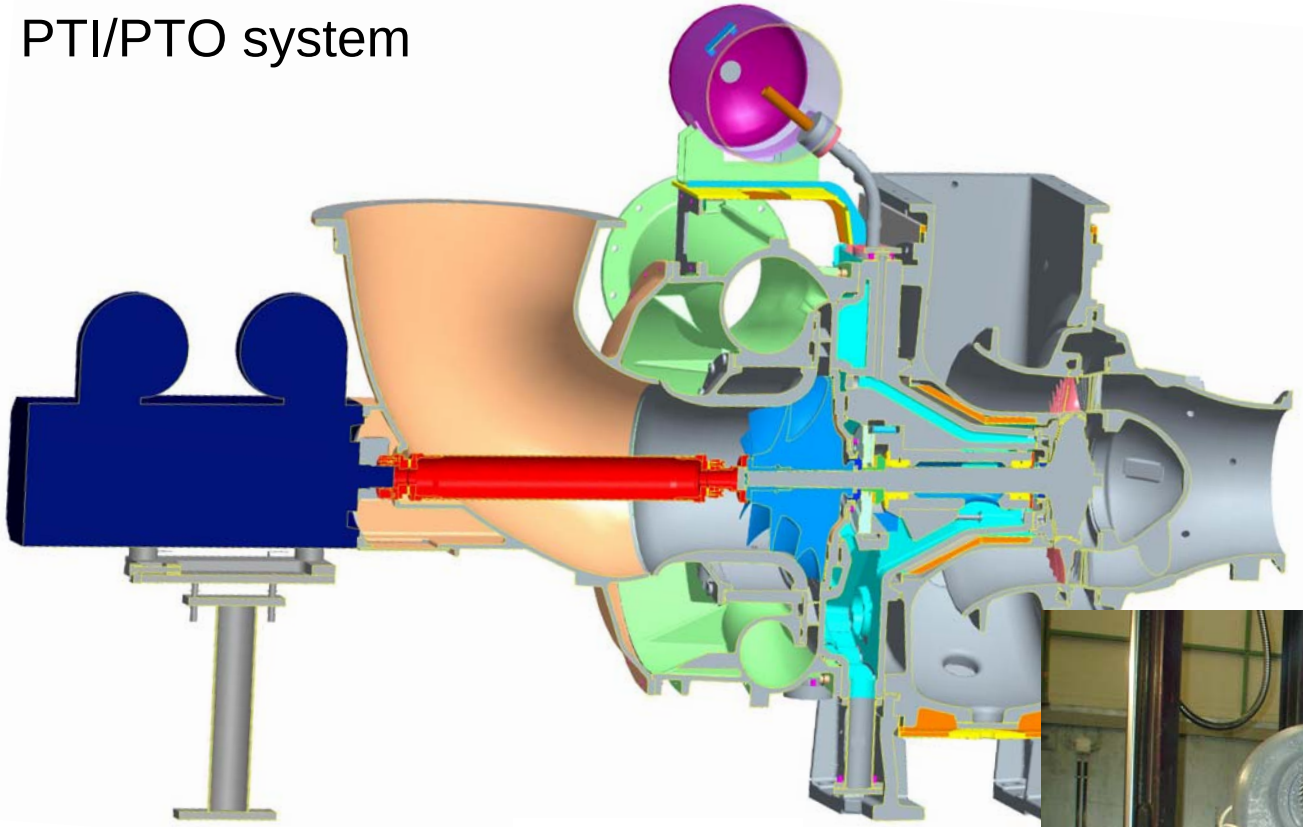
PTI: compressor wheel
with coupling parts

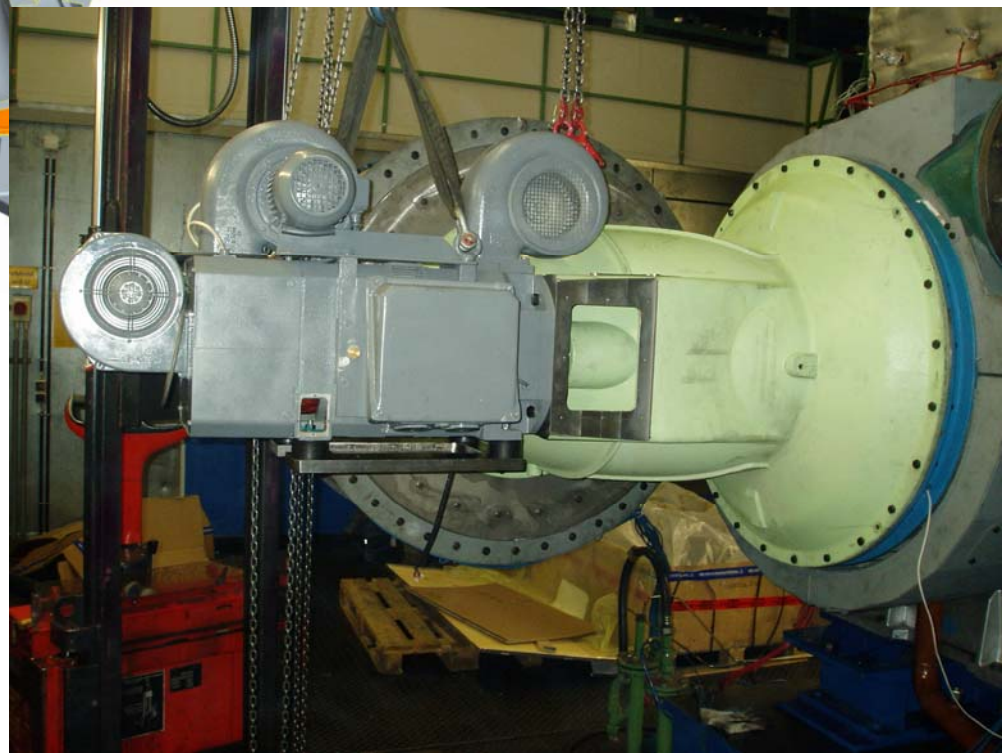
PTI Test cell setup



TASK 3.2: Intelligent turbocharging

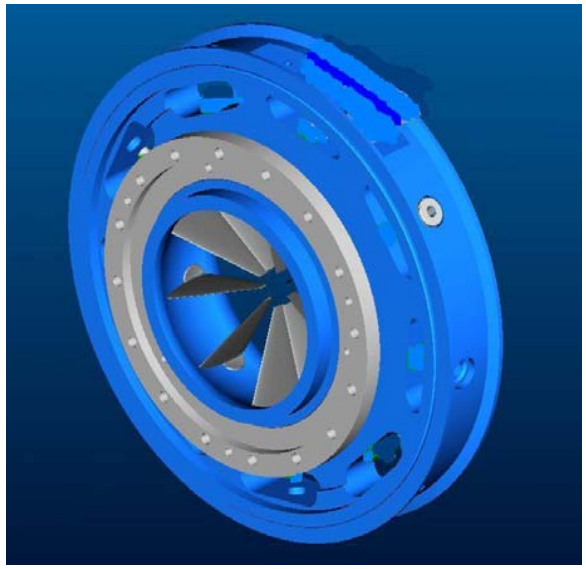
PTI/PTO system



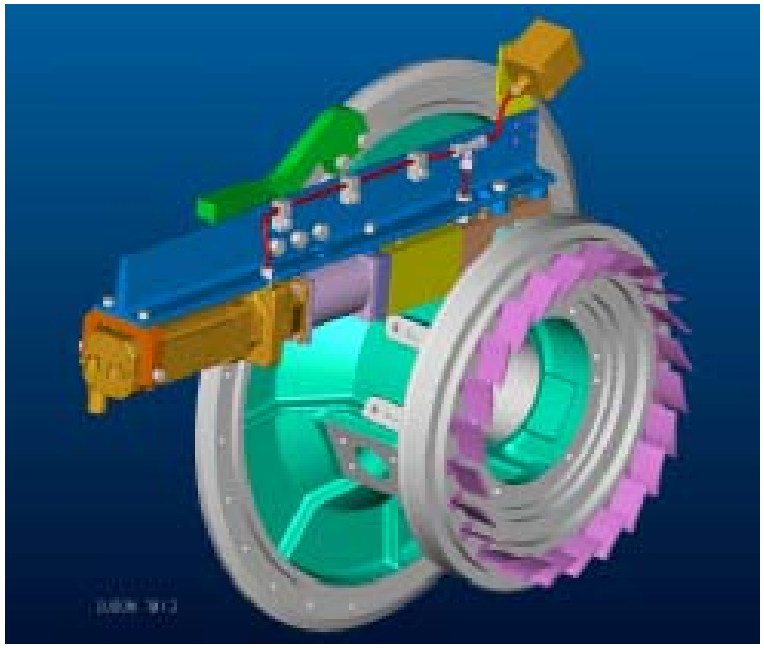


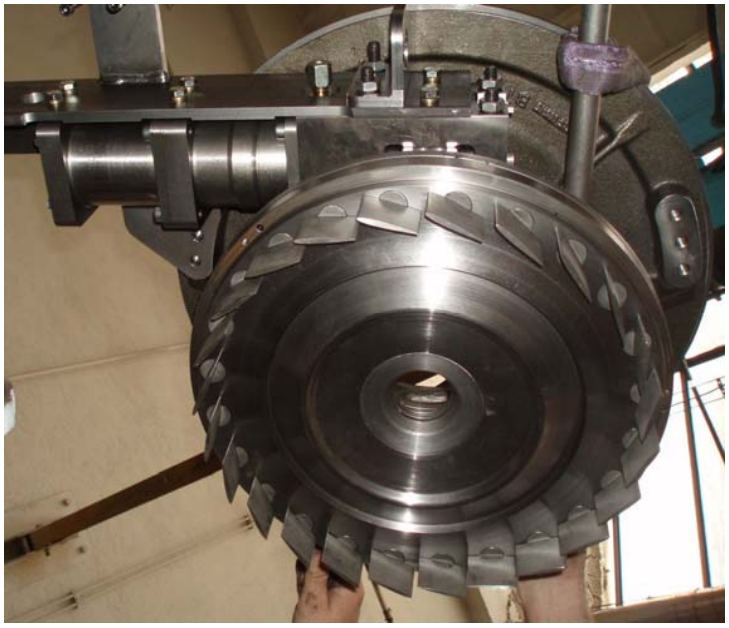
TASK 3.2: Intelligent turbocharging

Variable Compressor Inlet Guide Vanes (VIGV)

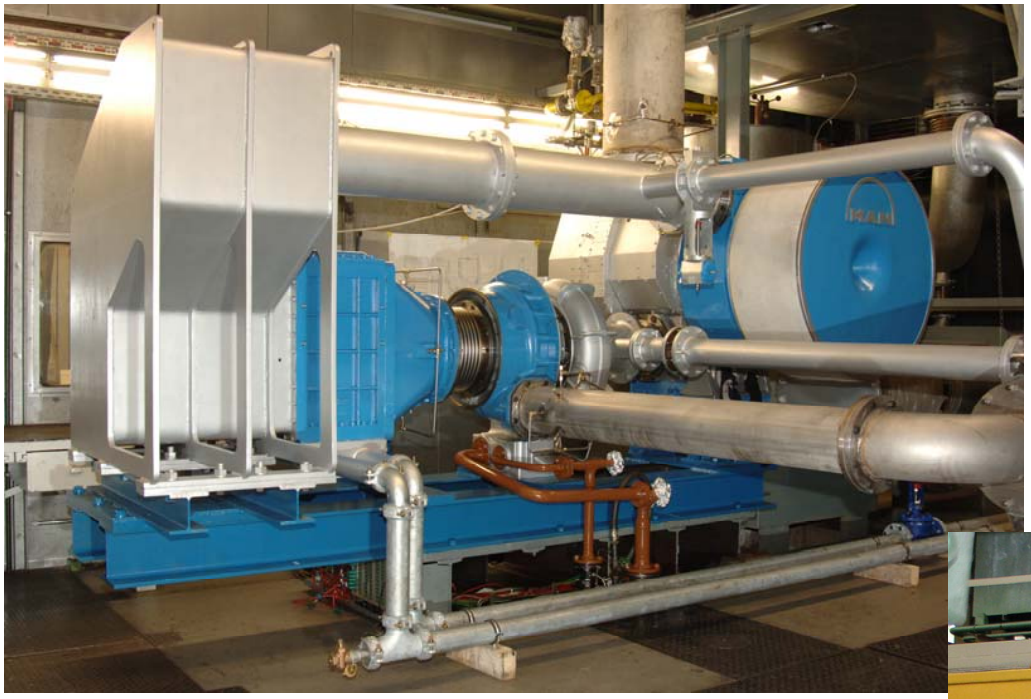


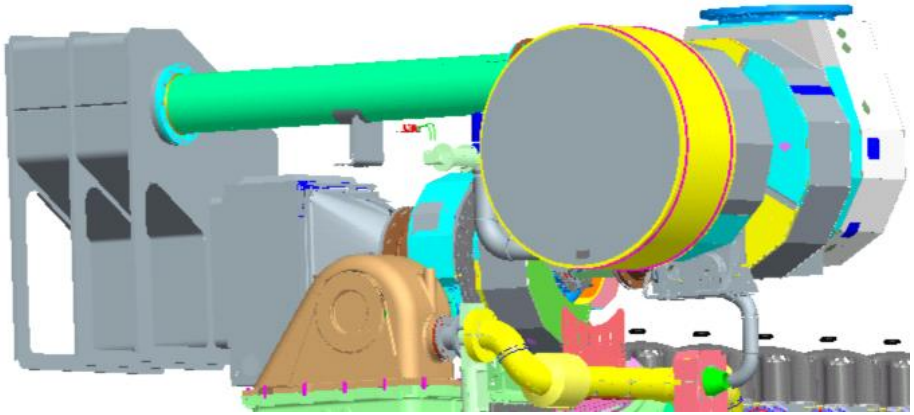
Variable Turbine Area VTA

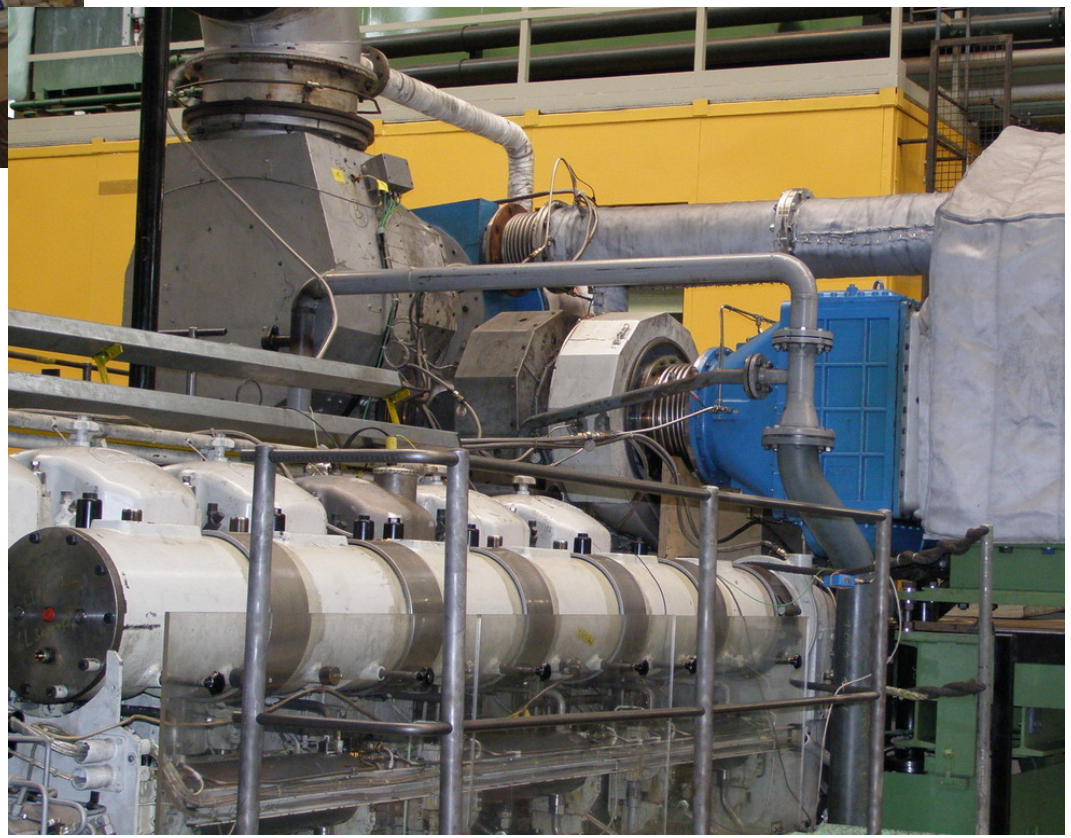




TASK 3.2: Intelligent turbocharging

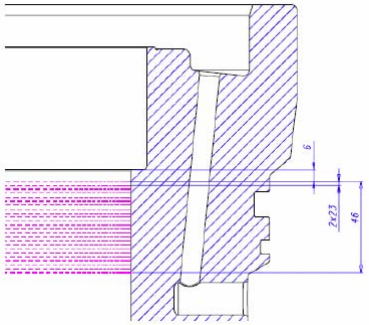




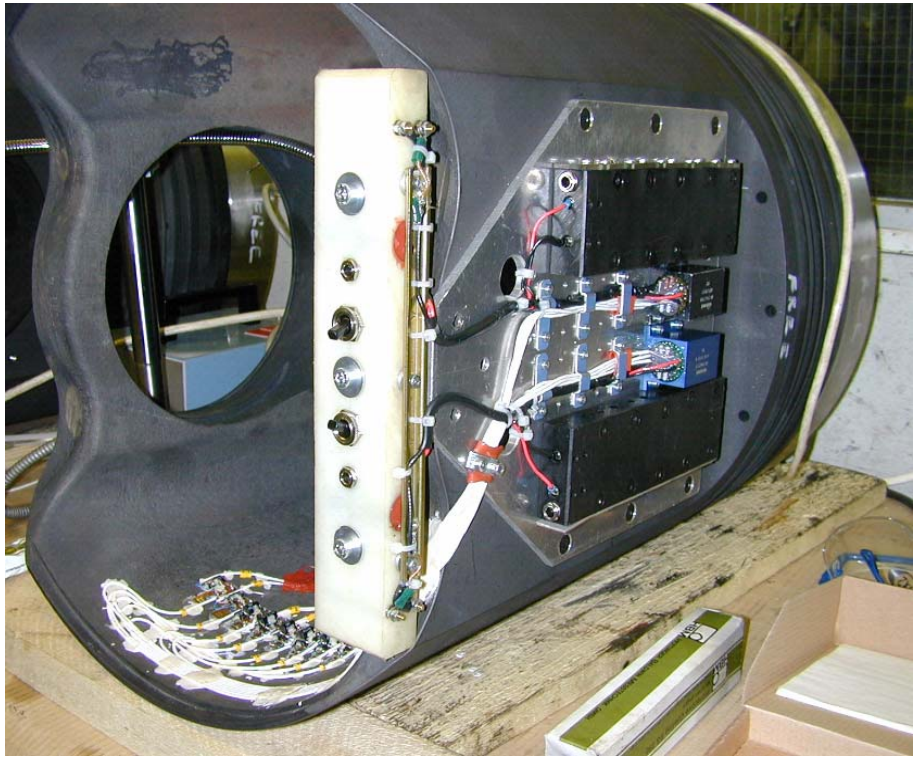


Two-stage intelligent turbocharger

TASK 4.1: Combined Cycle



Laser structuring a W32 cylinder liner



Hot engine piston prototype.

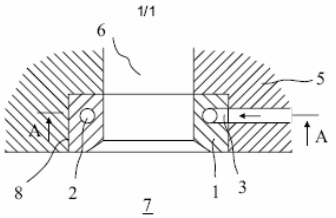
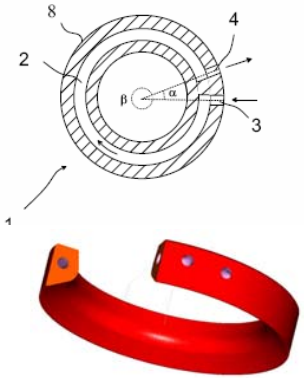
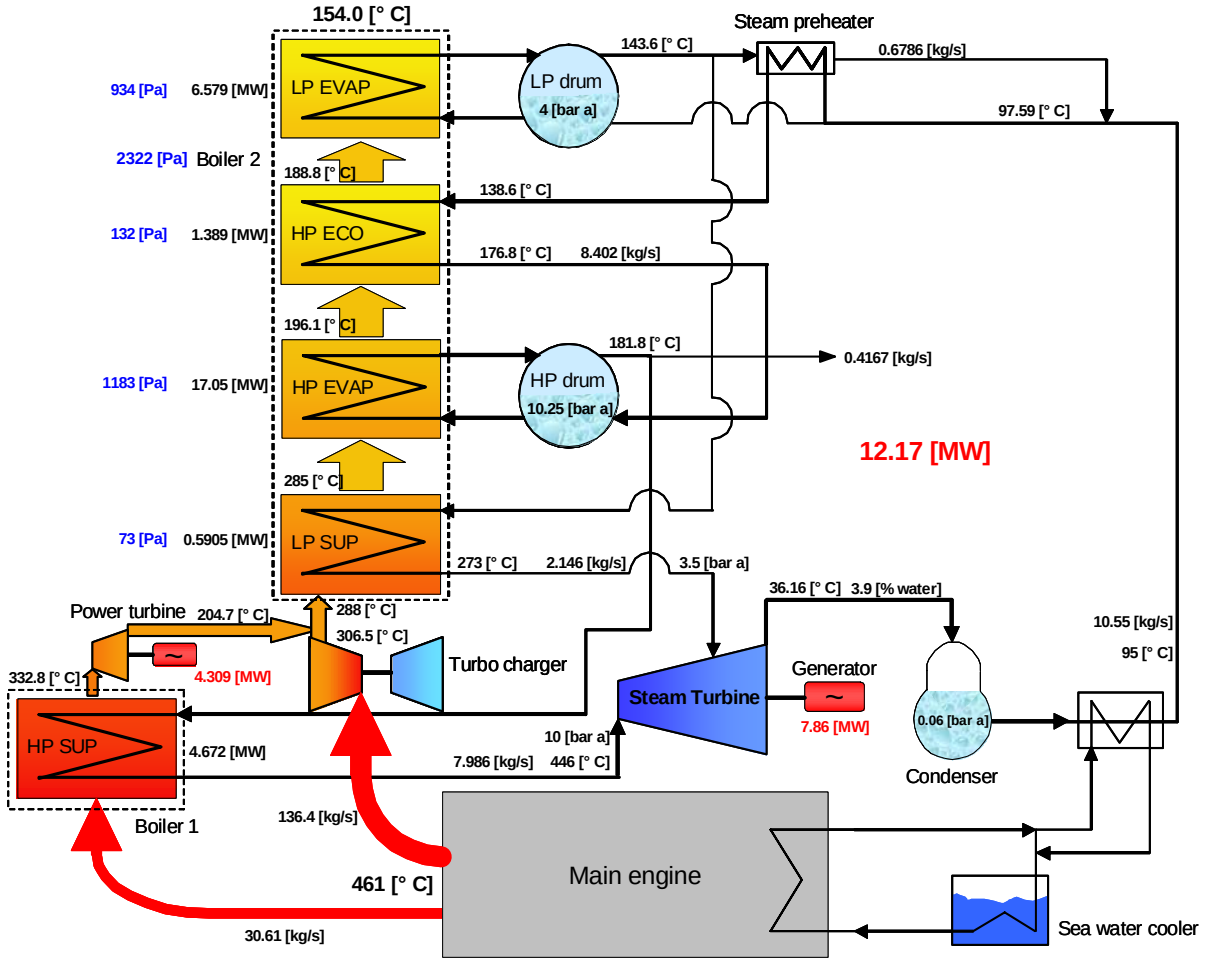


Fig. 1



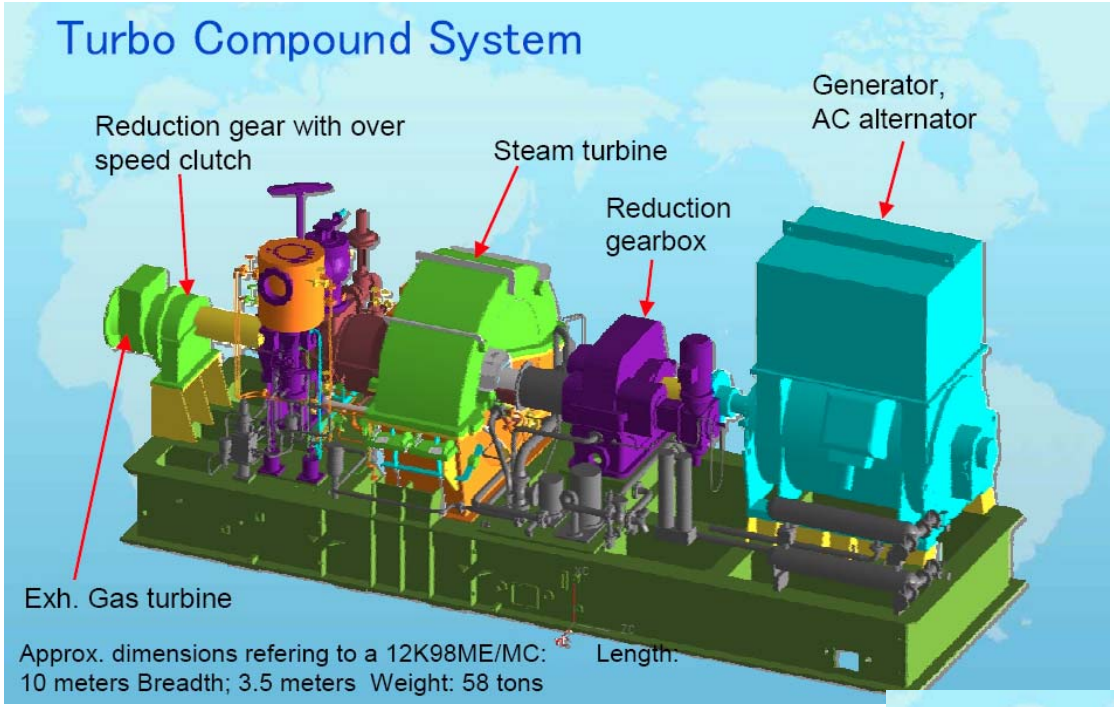
Prototype seat rings assembled in cylinder head

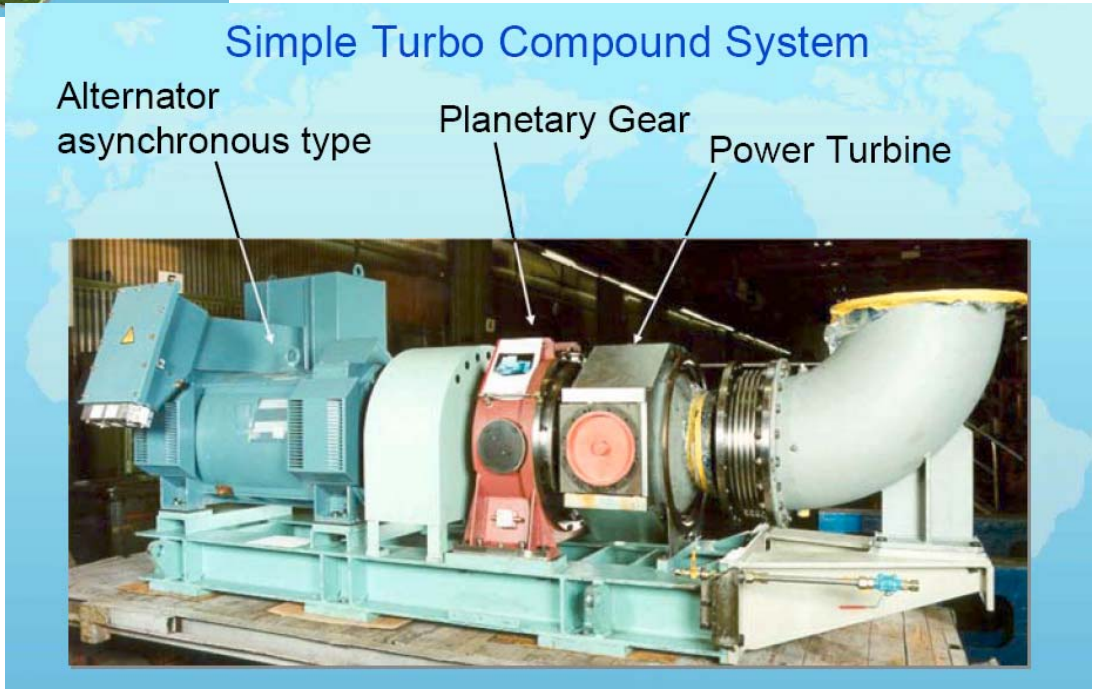
Optimised combined cycle concept



Fore and aft end bypass from the exhaust receiver to the scavenging air receiver

TASK 4.2: Hot Engine

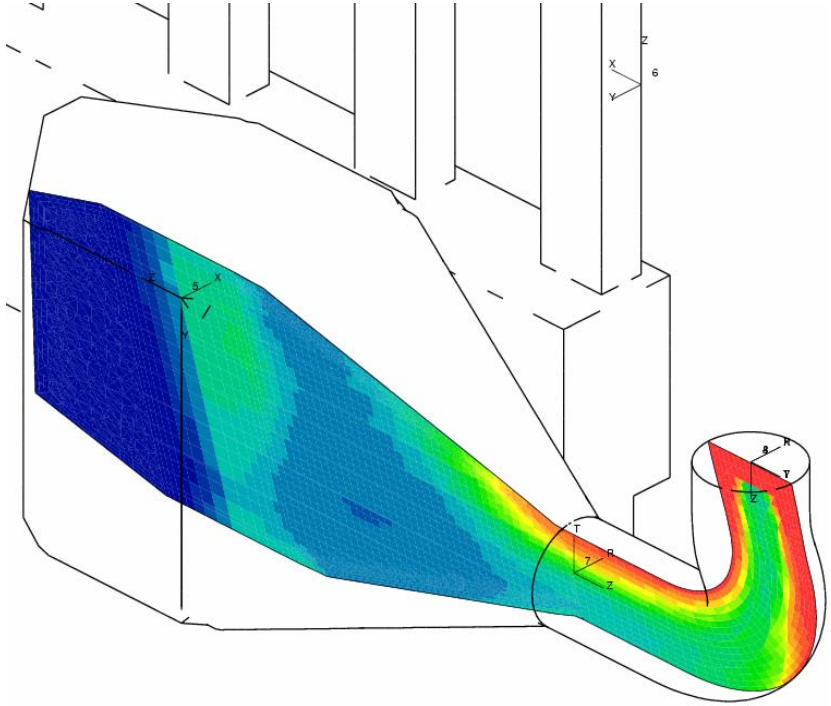


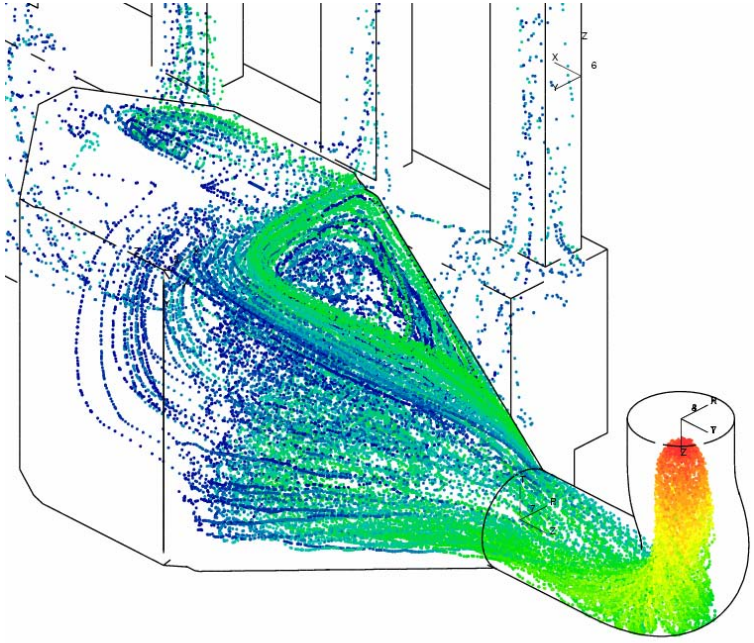


Wetpac H humidification system

Example results

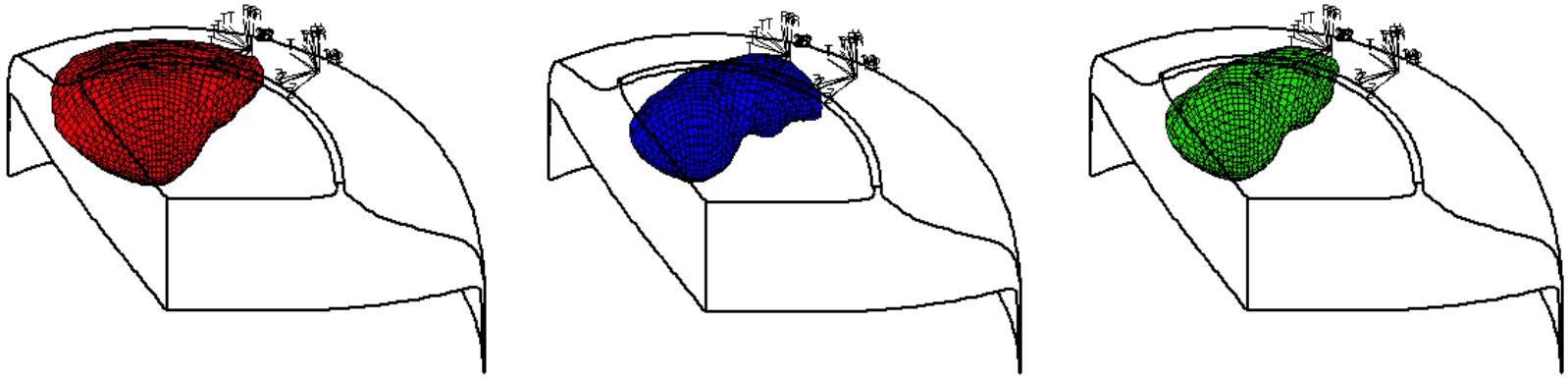
- Droplet distribution
- Temperature distribution



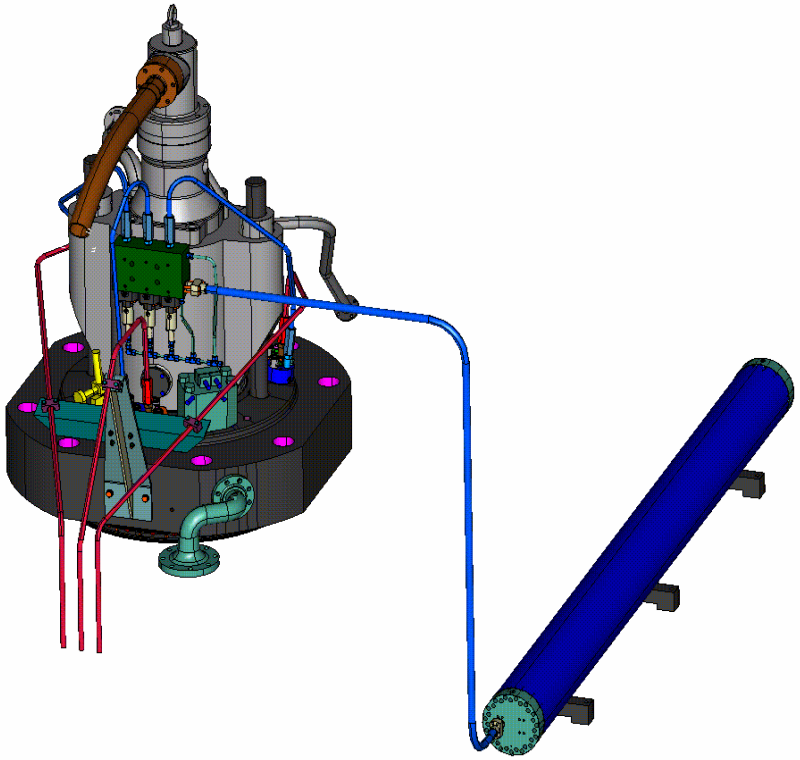


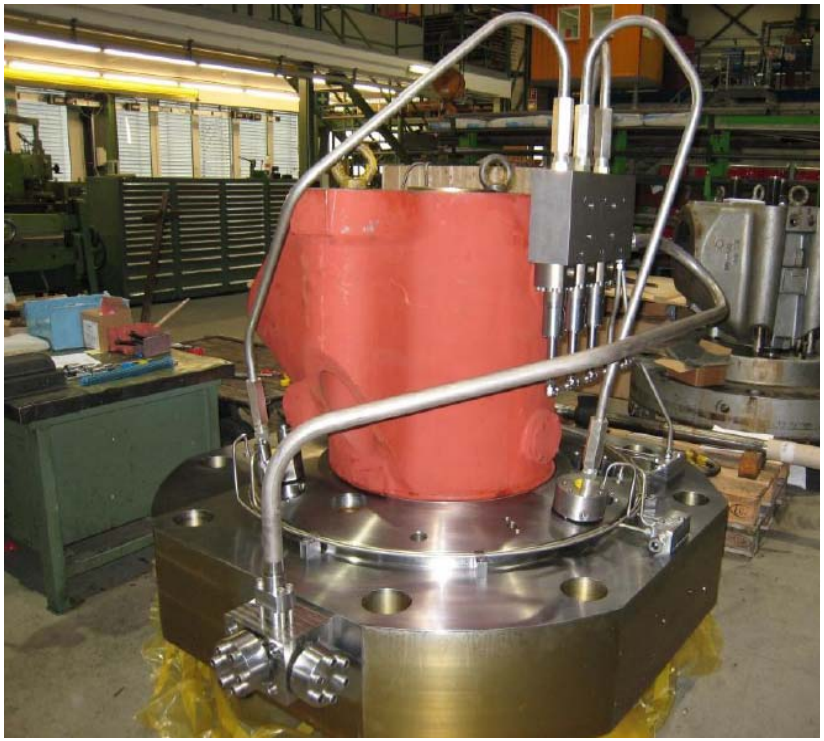
TASK 6.1: Water injection techniques

Direct Water Injection (DWI) system

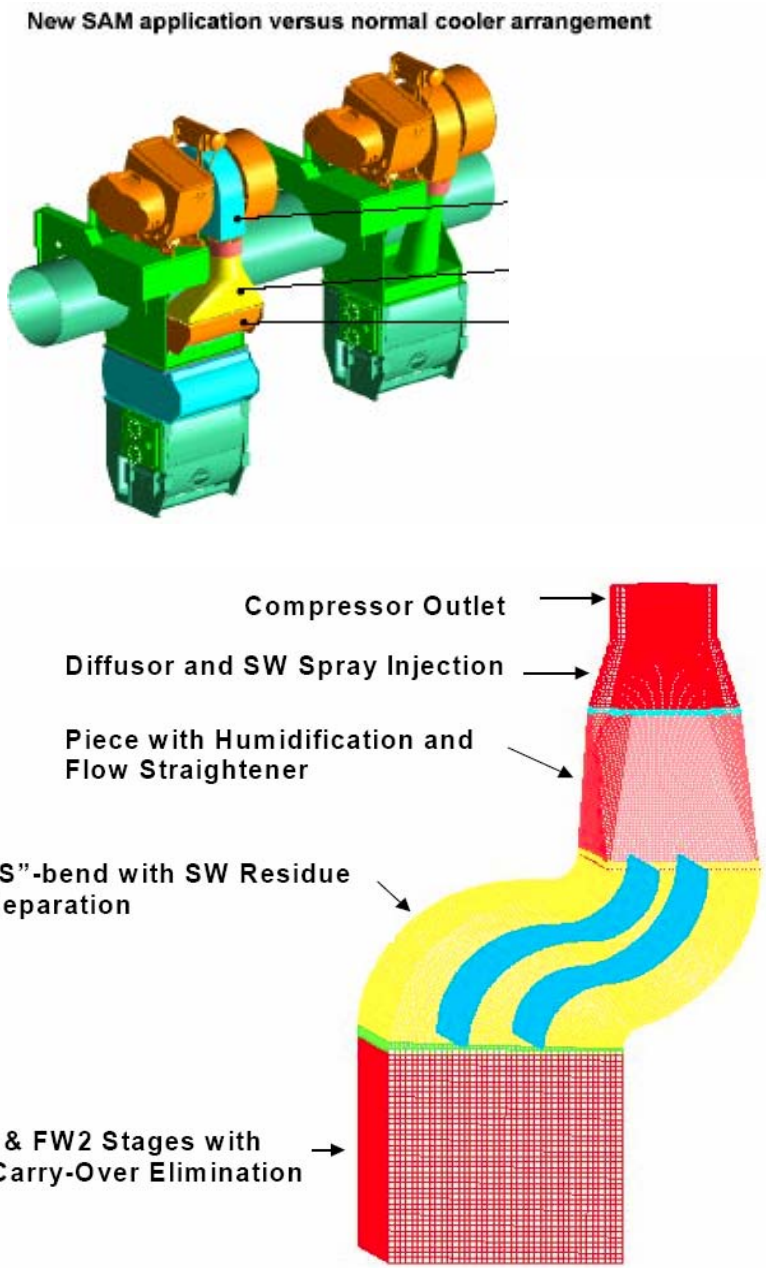


Comprehensive simulation studies for DWI system optimisation

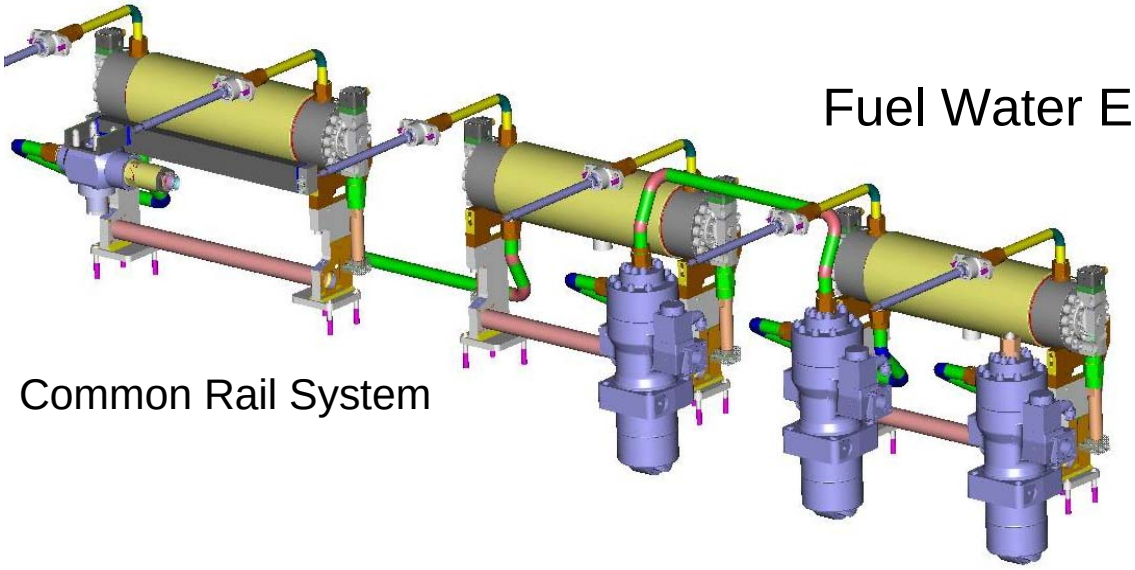




Scavenging Air Moistening (SAM) system for NOx reduction



TASK 6.2: Humidification Methods



Common Rail System

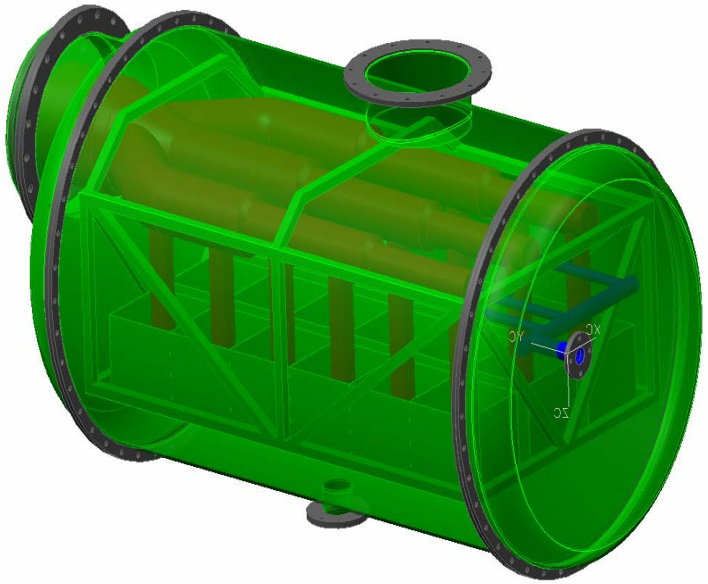
Fuel Water Emulsion (FWE) system

CR prototype for
FWE operation

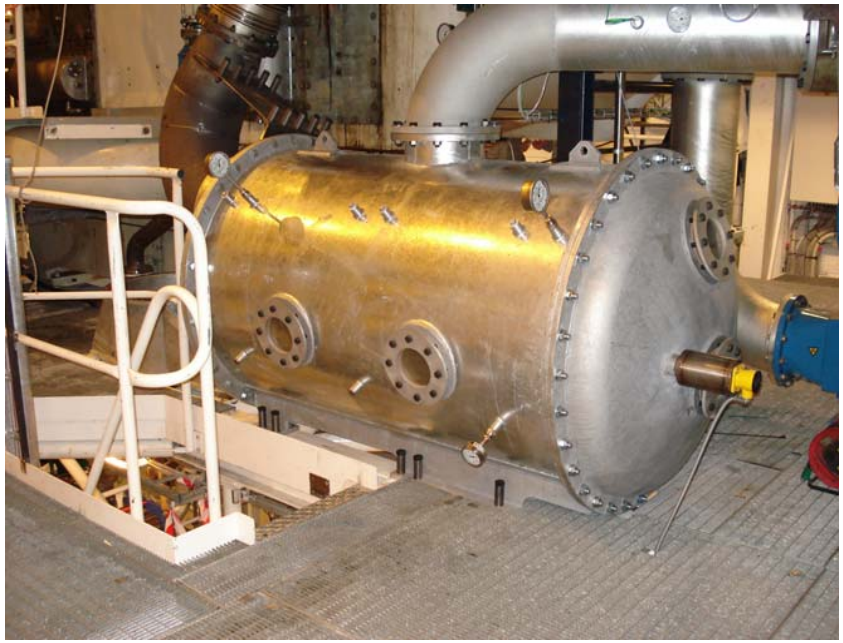
Fuel Water Emulsification module

Experimental emission measuring equipment and general setup on test engine

TASK 7.2: Emission reduction methods (internal – external – EGR)



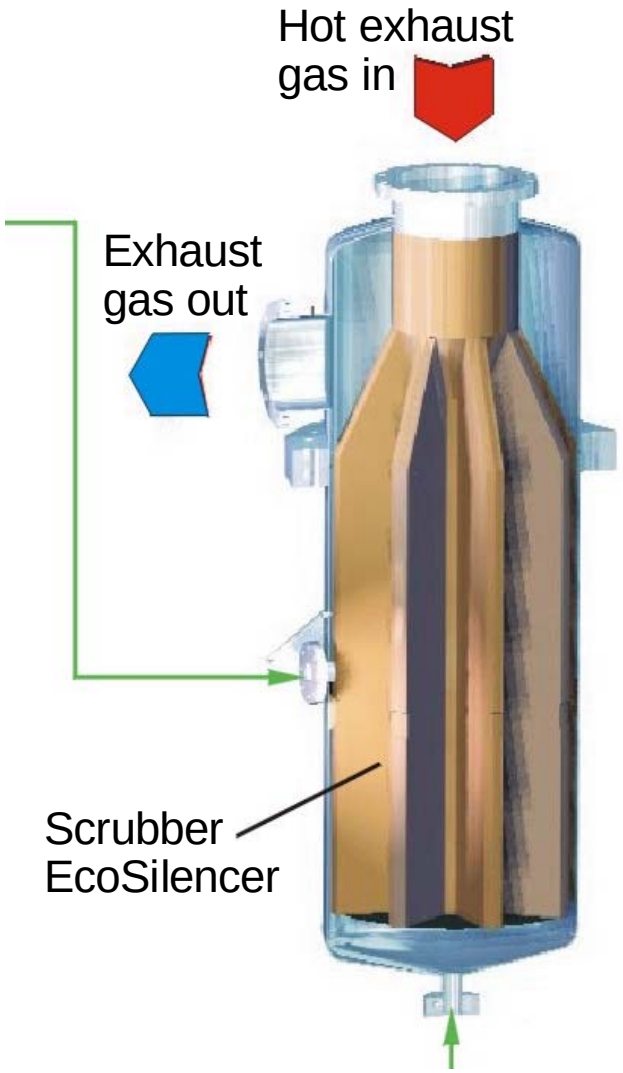
Exhaust Gas Scrubber



EGR Application on 4T50ME-X

Water Treatment System

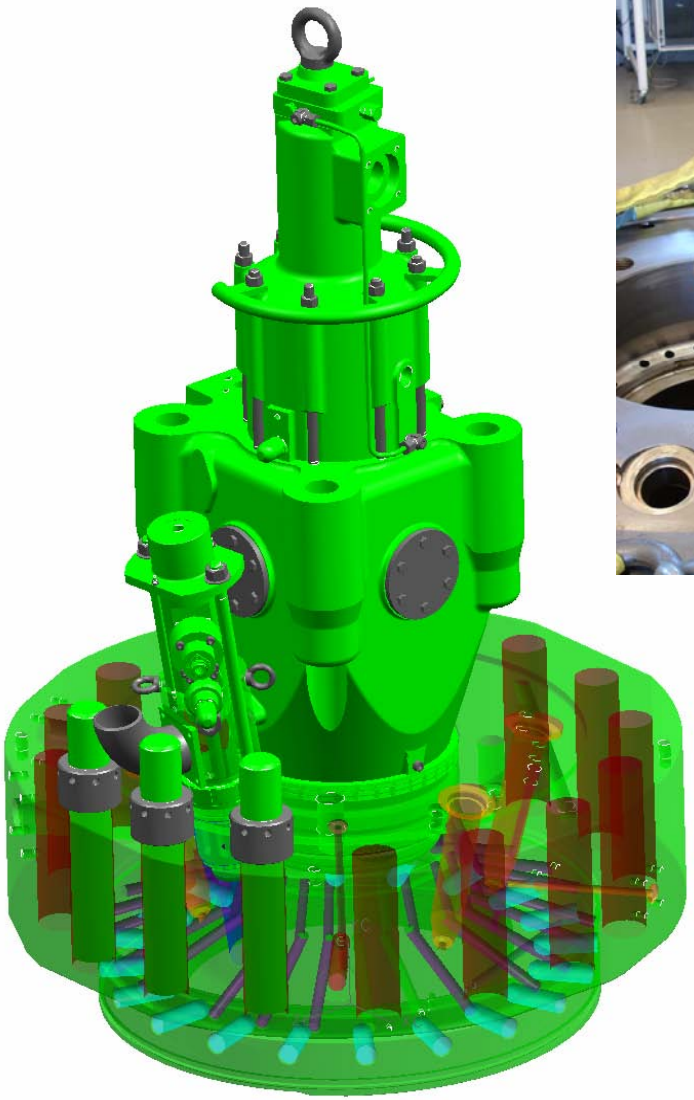
EGR prototype system at test plant in Copenhagen



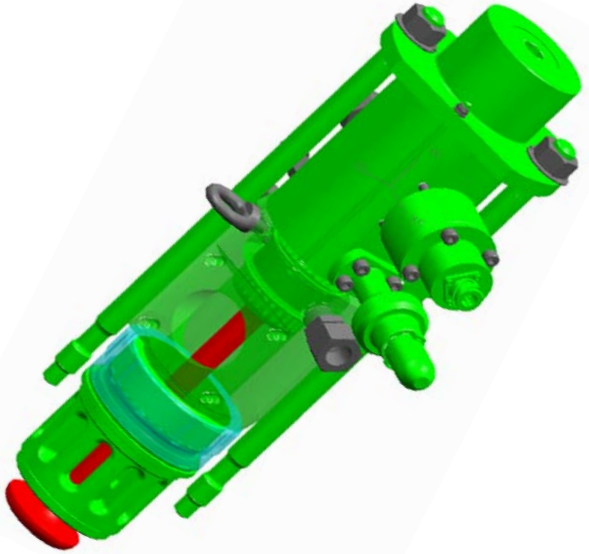
EGR scrubber and blower installed

TASK 7.2: Emission reduction methods (internal – external – EGR)

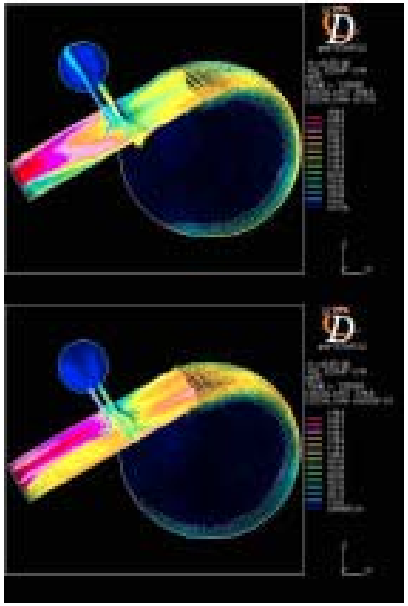
CGR cylinder cover
comprising CGR valve

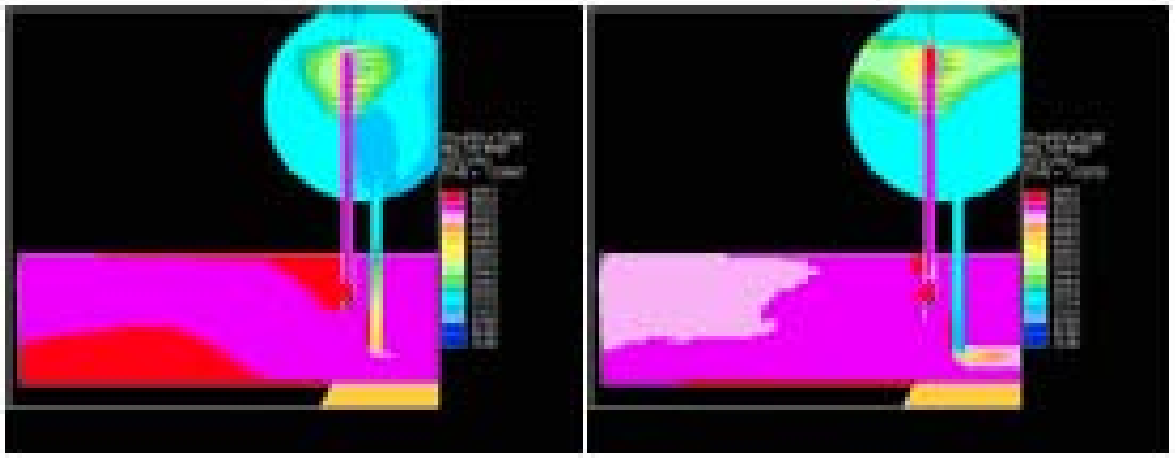


CGR valve with double function:
starting air valve and CGR valve

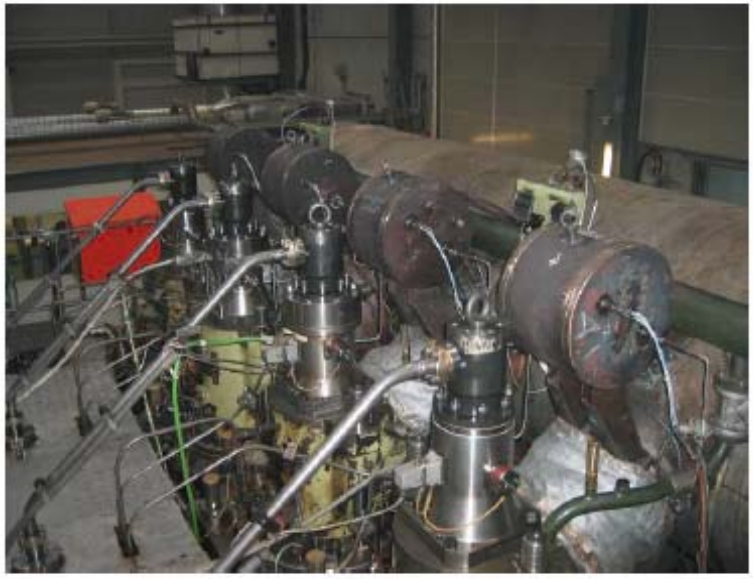


Sensors/Technologies for Single Cylinder Measurements





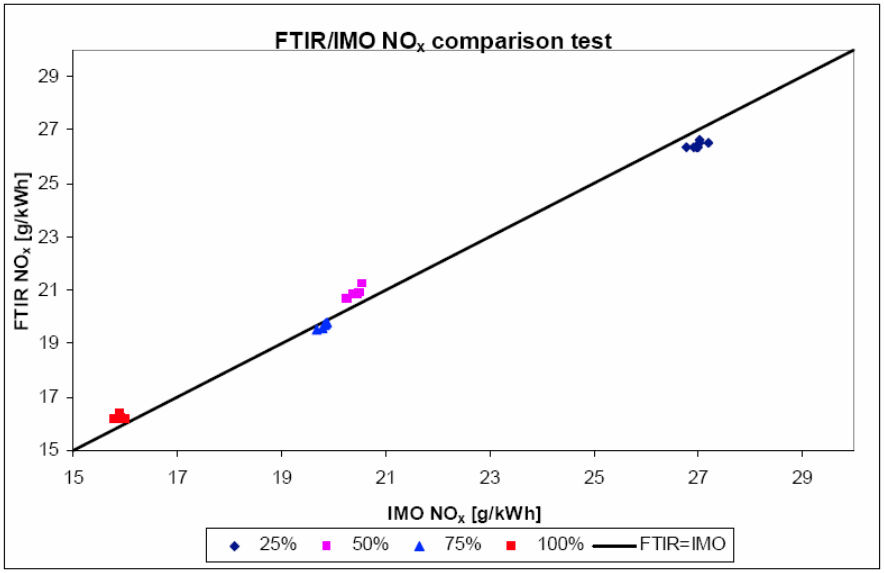
Temperature contour plot of the final CFD calculation

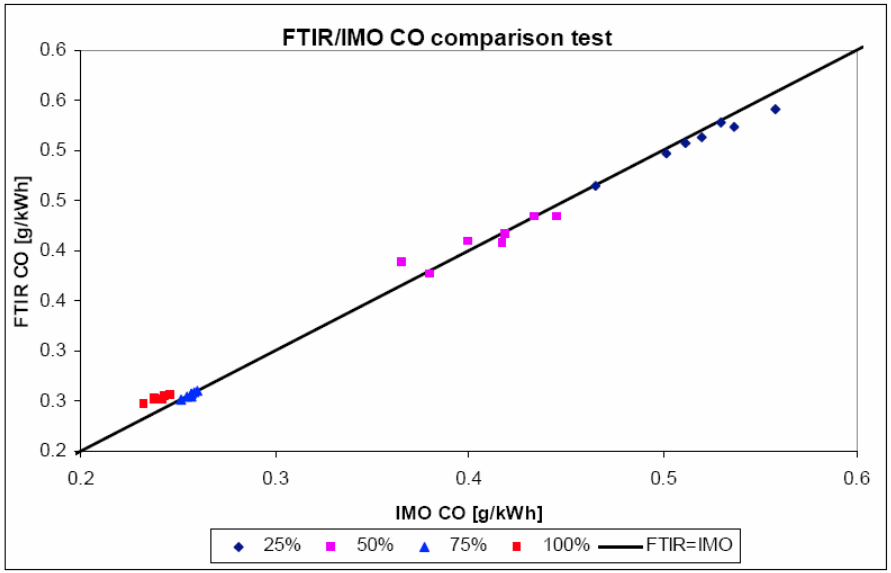


Pictures of manufactured and installed bypass receivers on the RTX-3 test bed engine

TASK 8.2: New measurement methods

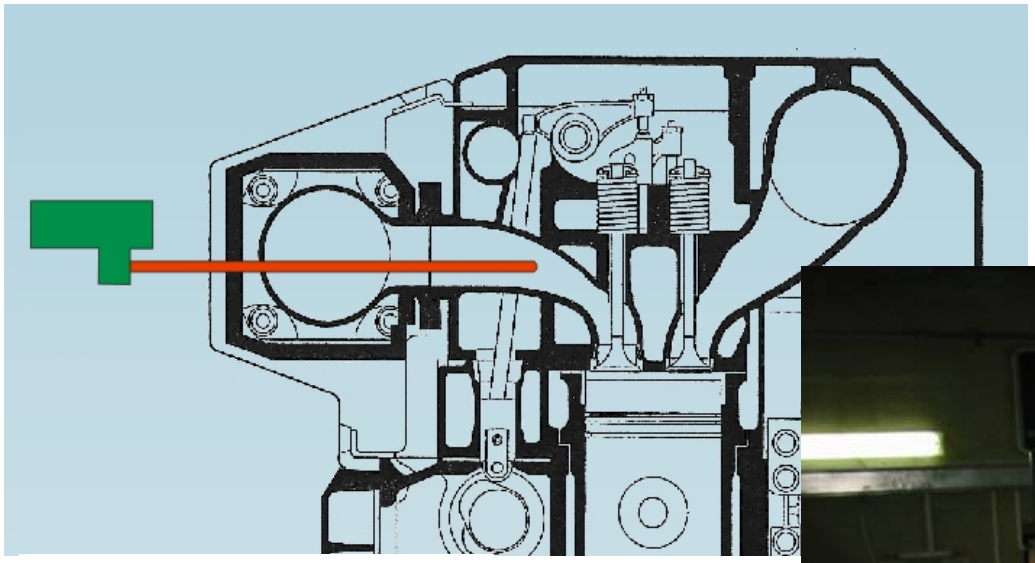
Fourier Transform Infrared spectroscopy (FTIR) multi component gas analyzer

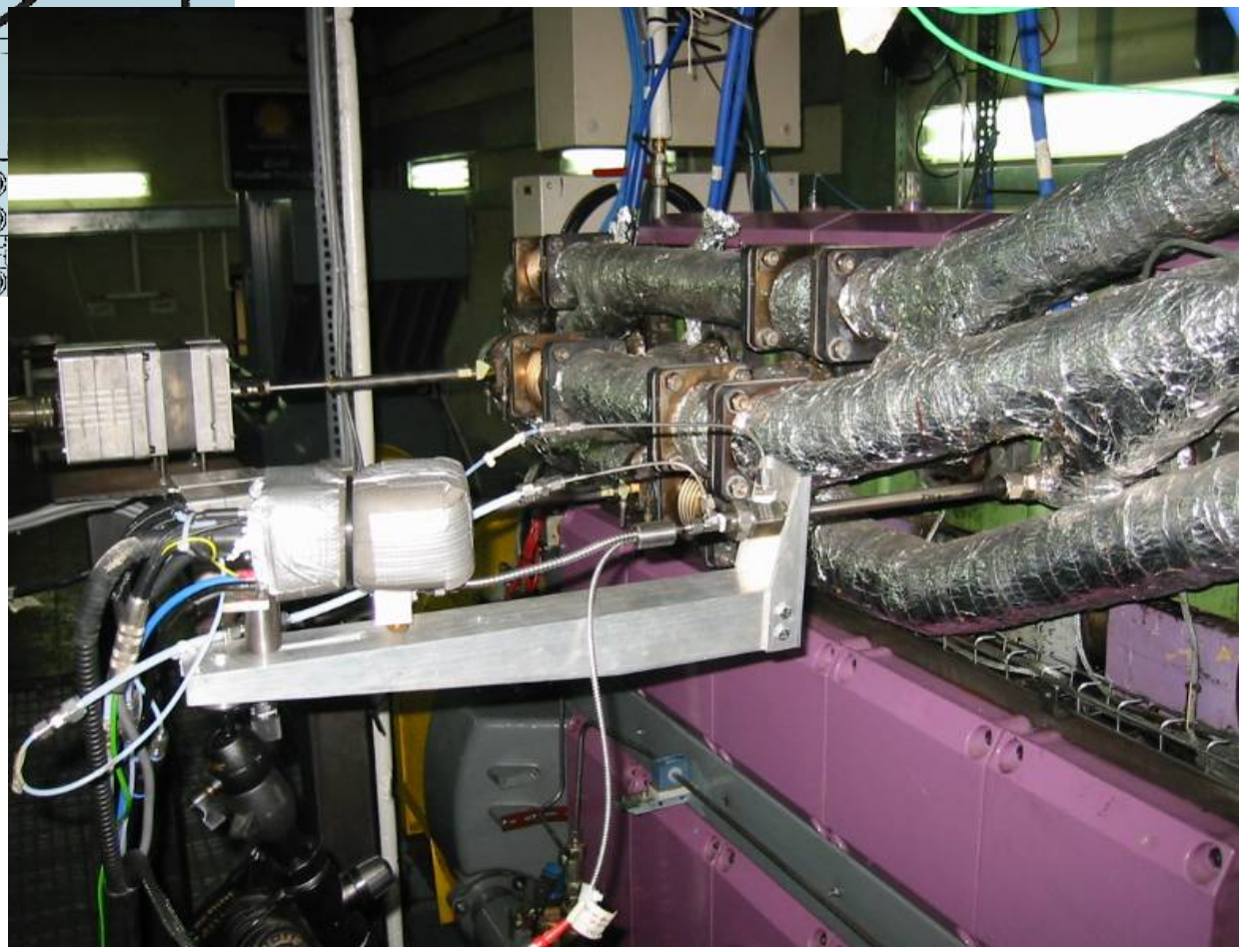




Comparison with IMO compliant (HCLD & NDIR) equipment

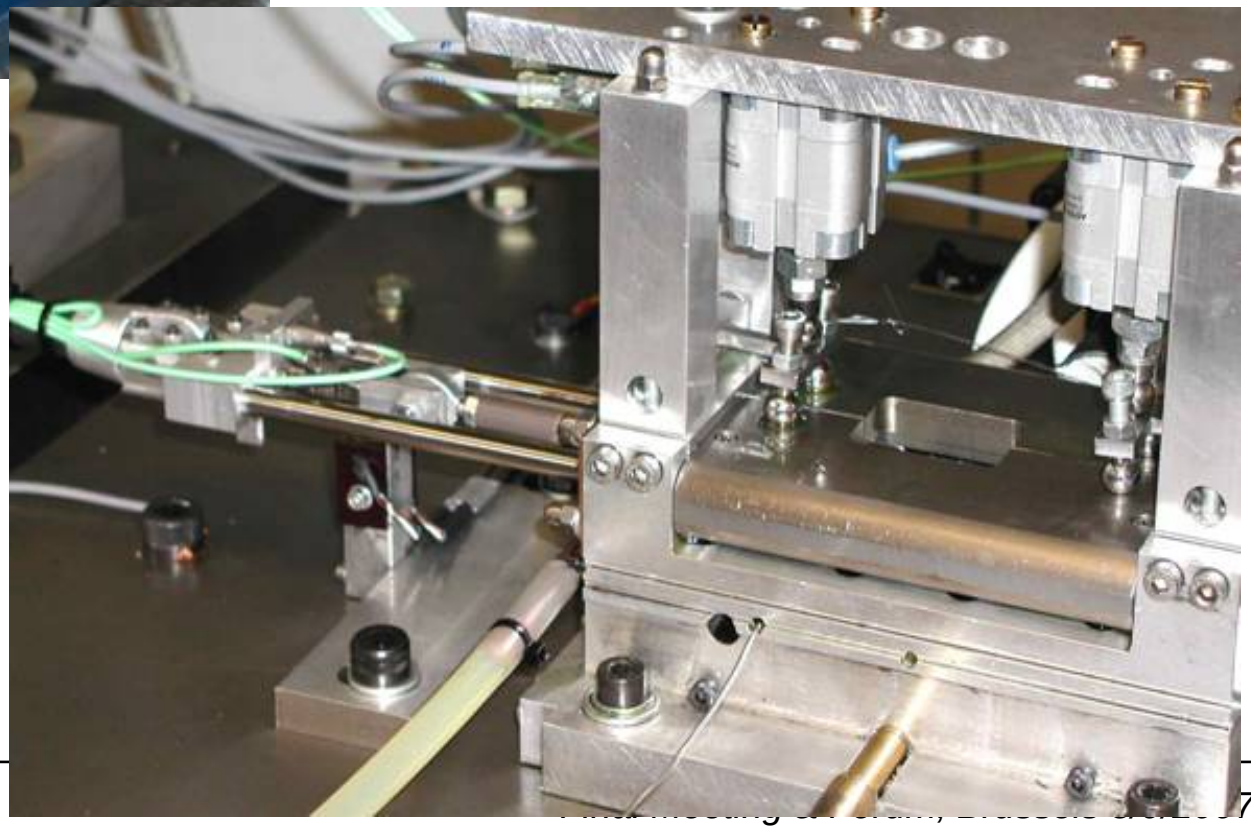
Ultra fast NOx Measurement





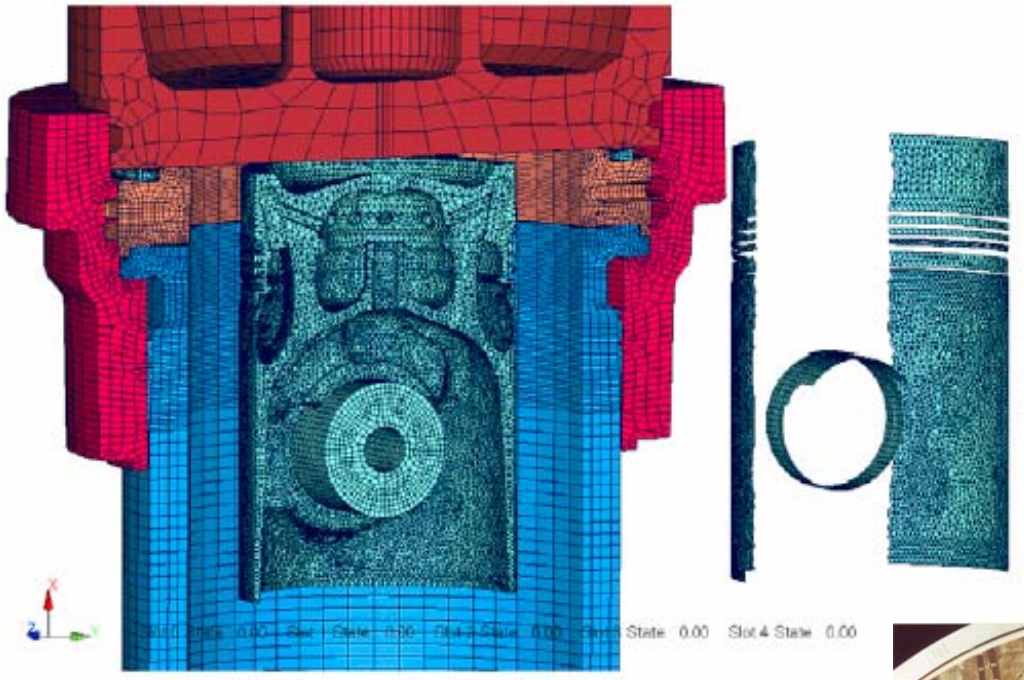
Engine tests of probe on L16/24 Research Engine

Friction loss mapping of W20 – full scale engine test rig

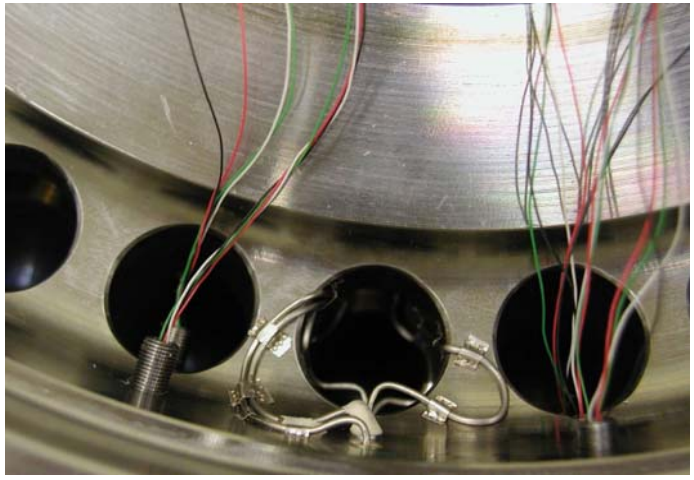


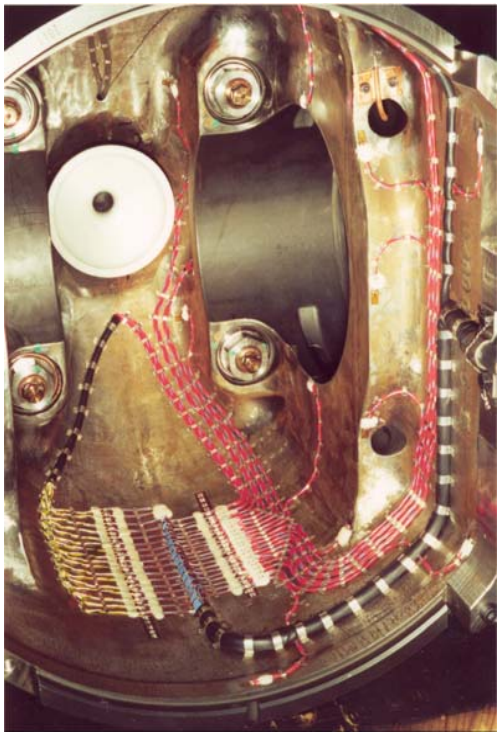
Piston ring / liner friction tester

TASK 9.2: Tribo-optimisation

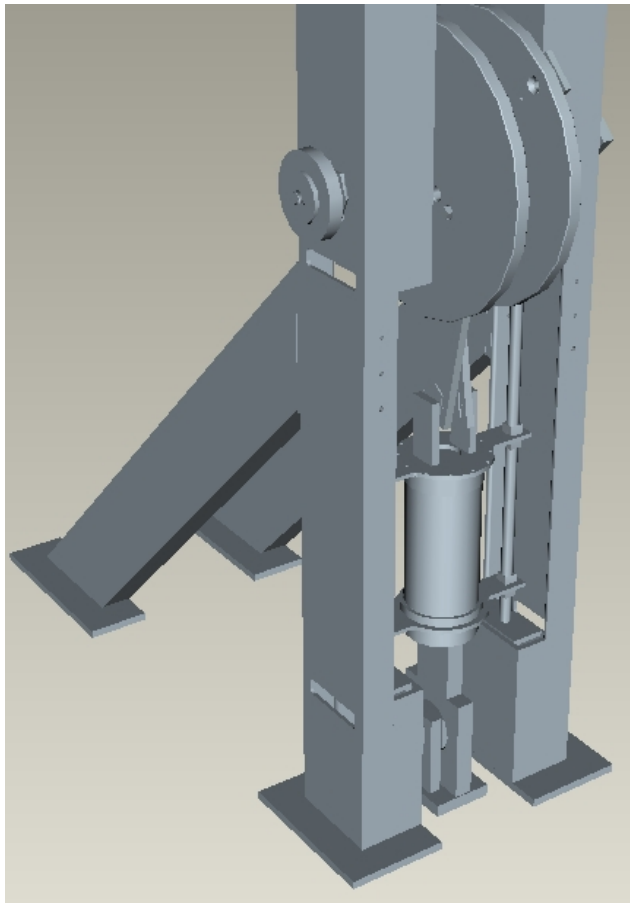


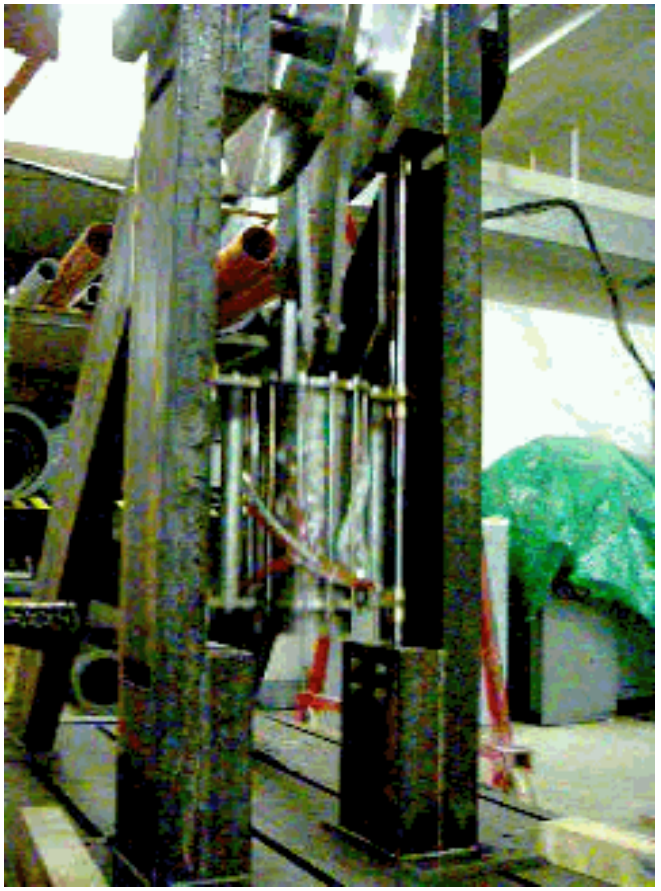
Measurements for calculation verification



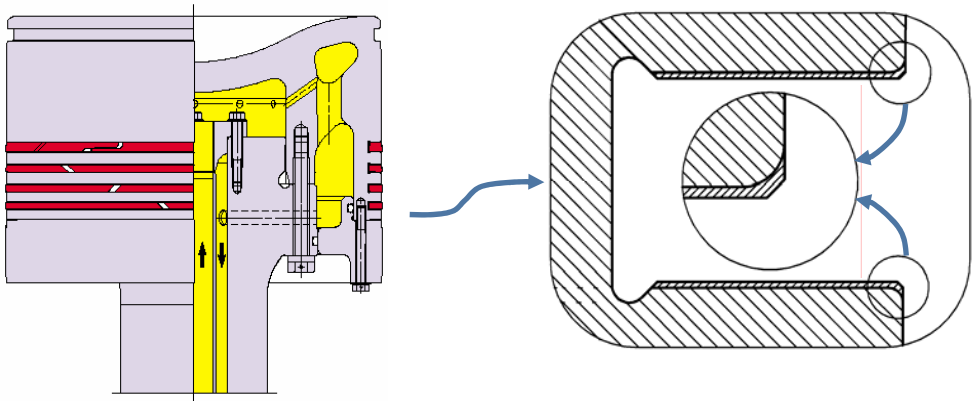


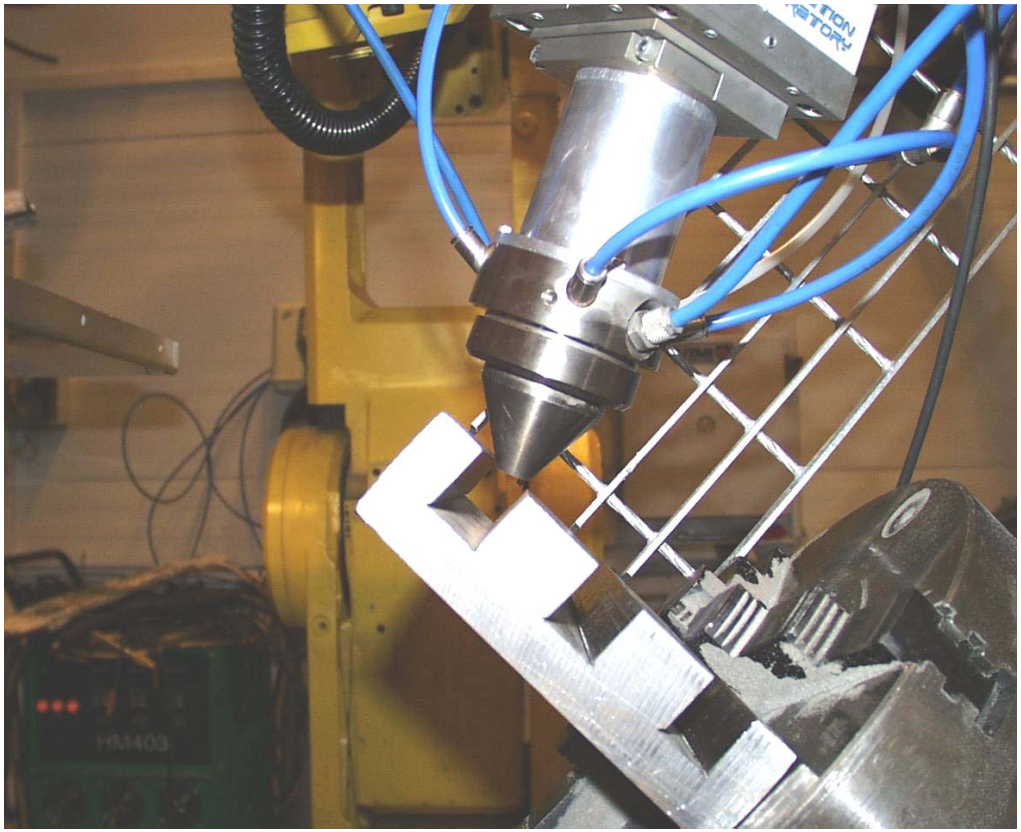
Piston Ring Friction Tester



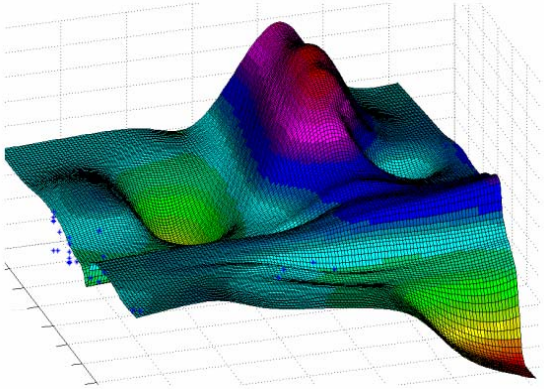


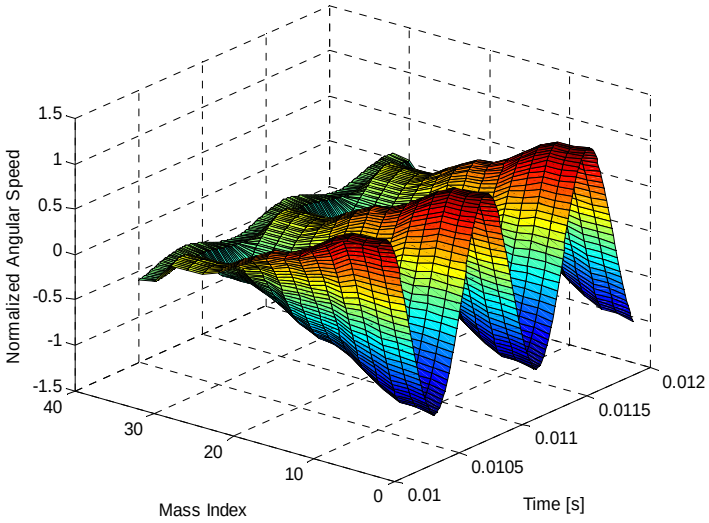
Wear resistant coating in piston ring grooves

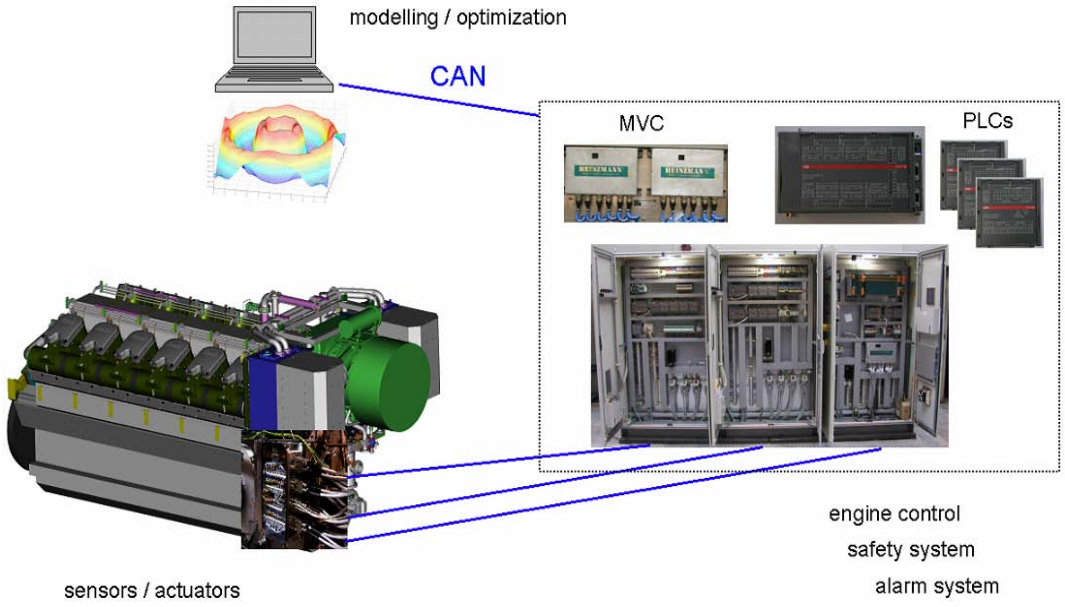


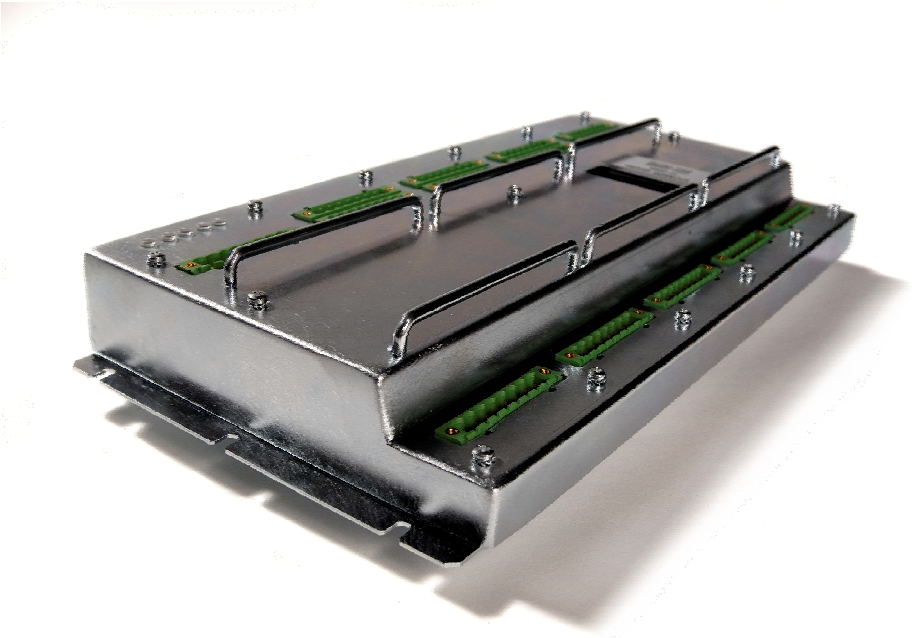


Modelling with Neural Networks







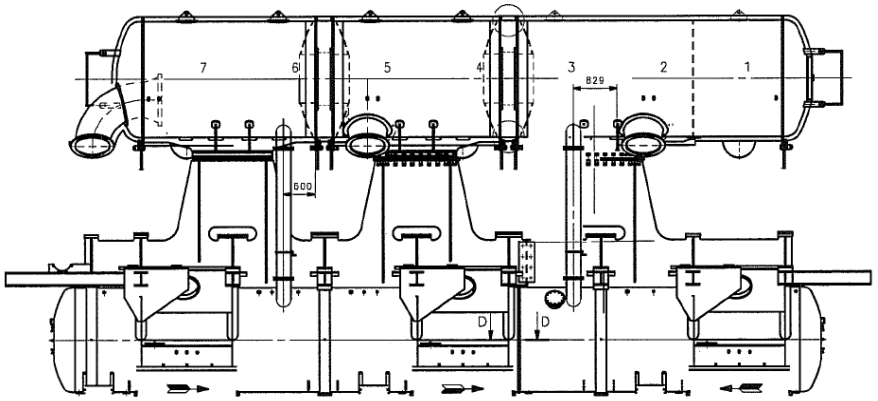


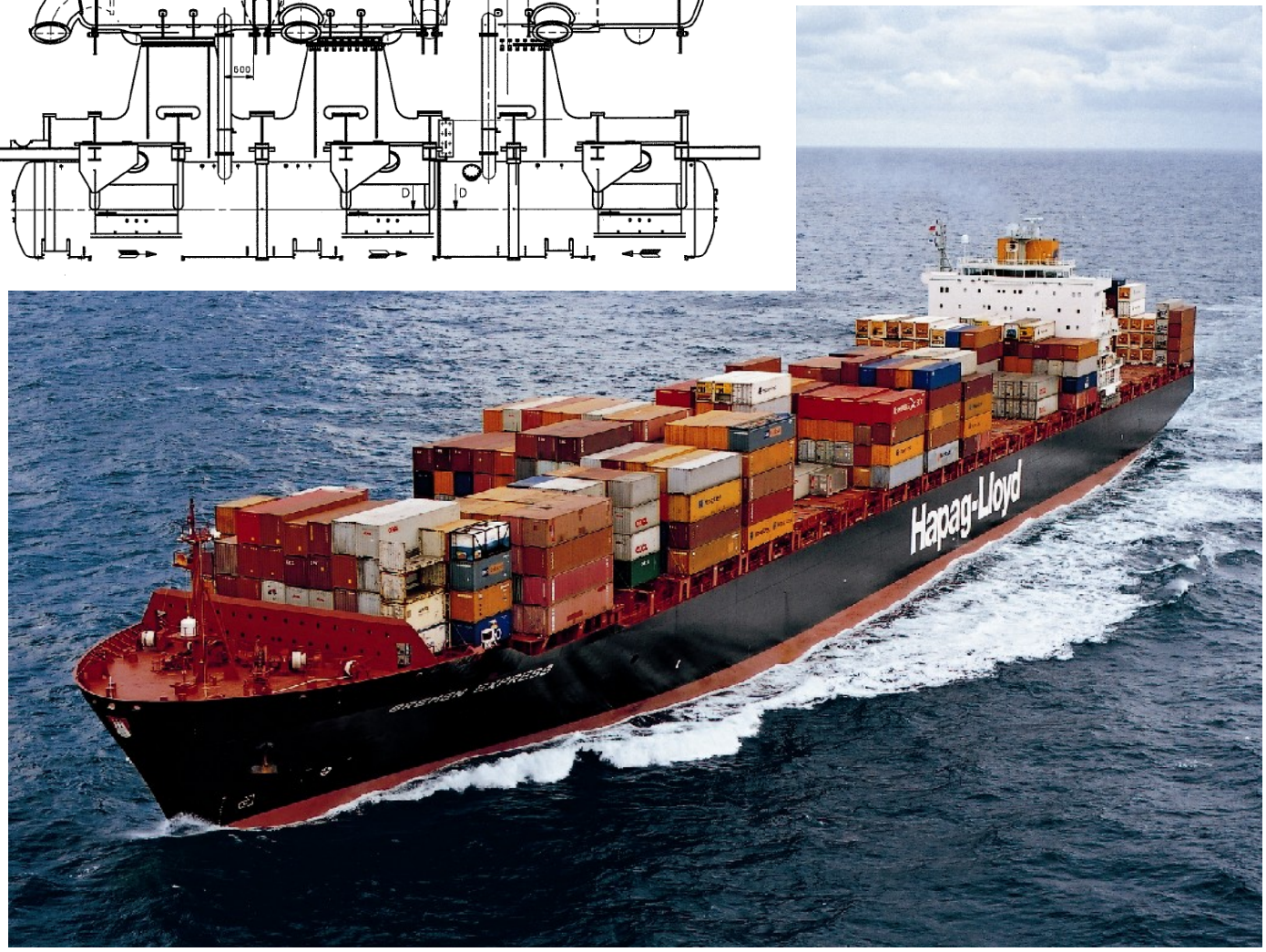
DEMONSTRATION / TASK 4.2: Hot Engine

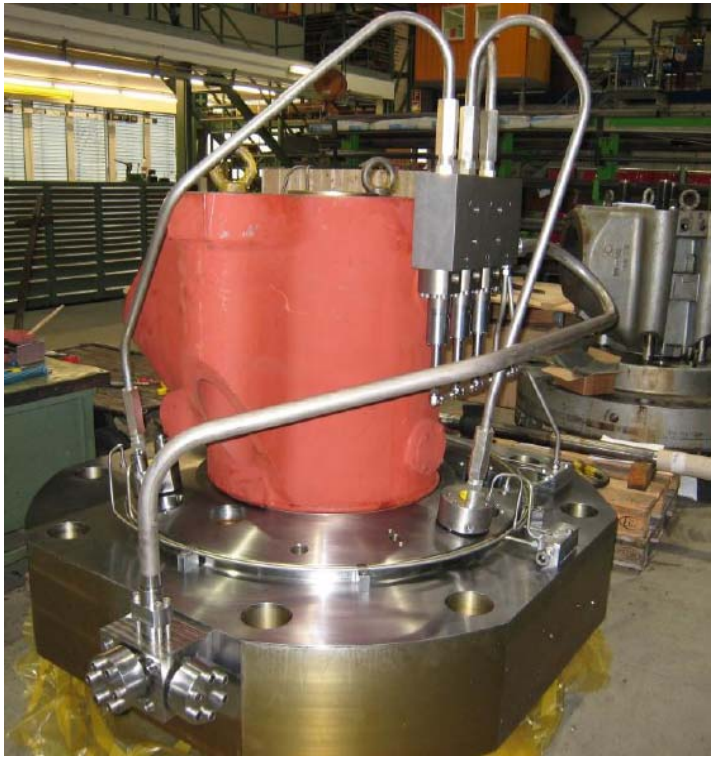
Bypass between scavenging and exhaust receiver

Piston and piston rings

"Hot engine" components onboard M/S "Bremen Express"





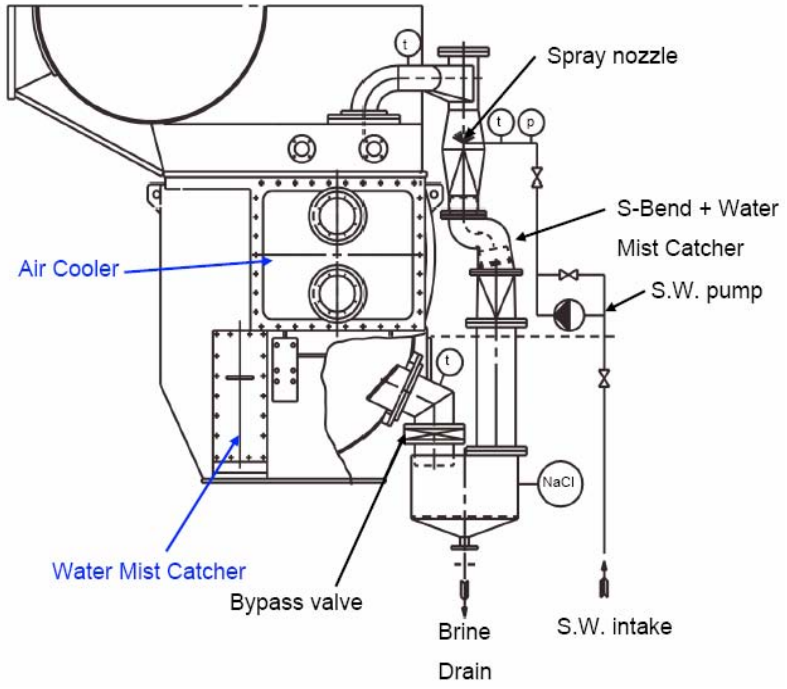


DWI system onboard “Maersk Montana”

Wetpac Humidification system onboard M/V “Manon”

New pump units installed on M/V Manon

Mini SAM System on M/V “Boheme”



Upper part

Lower part

Metal Foam Water Mist Catcher with deposits

Full Scale SAM System on M/V “Mignon”

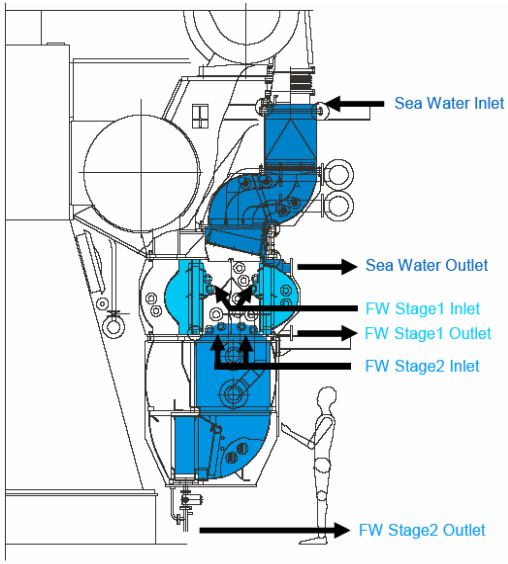


Fig. 13 Water Stages in the SAM system

Sea water injection unit

Changes on central cooling system

DEMONSTRATION / TASK 8.1: After-treatment methods

MCS100E HW measuring system onboard

Emissions monitoring equipment
(Multi-component analyzer)
onboard “Maersk Montana ”

FTIR emissions measuring system onboard “CMA CGM Verdi”

- Deliverable Reports

  68 Deliverables in Annex I - increased to 73 during the Project (52 / 73)

- Project Web-site: www.ip-hercules.com

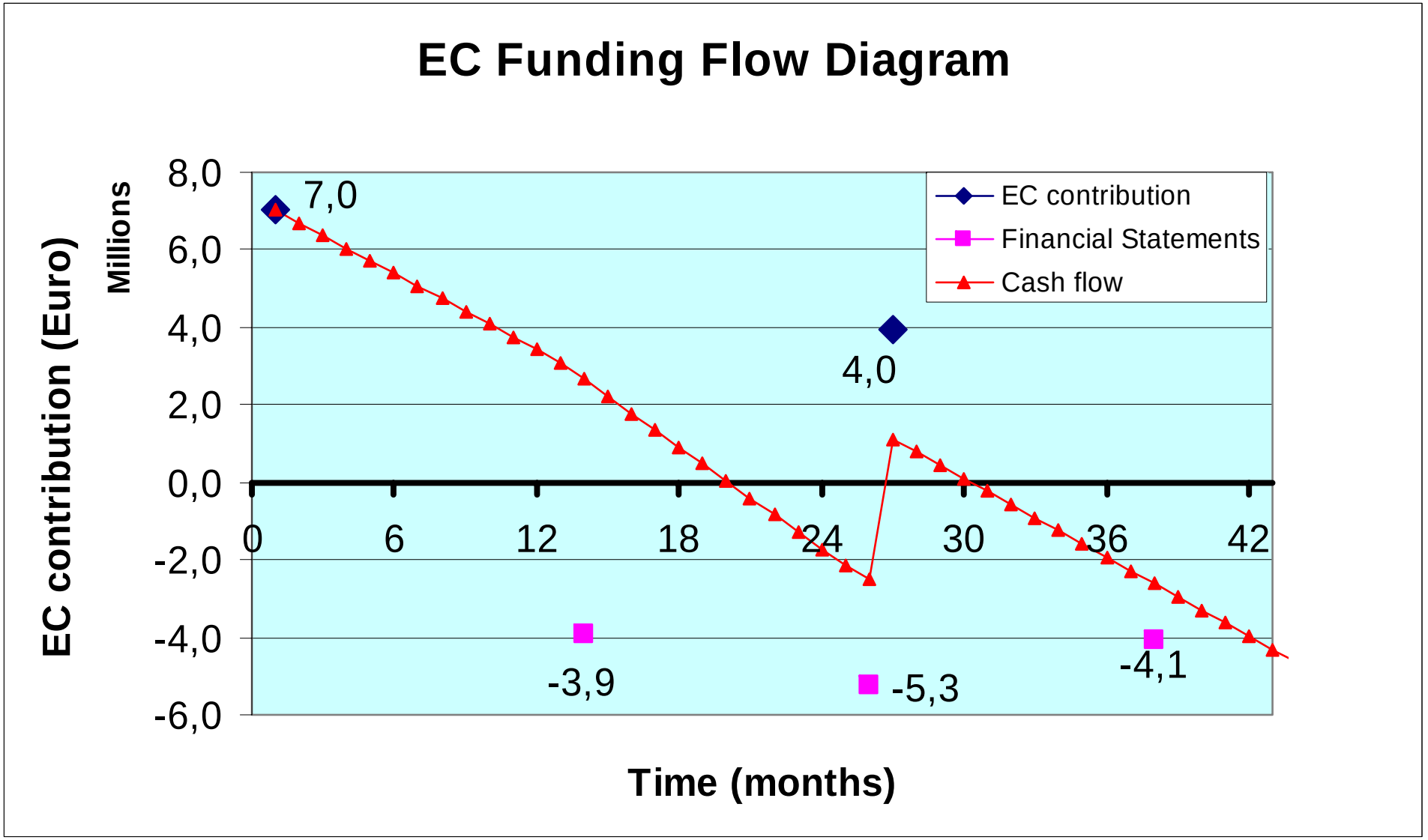
  Public Area (~40 External visits / day)

  Members area (Deliverables, Periodic Reports etc.)

- Publications

  ~30 Papers in International Journals or Conferences

  25th CIMAC Congress: 14 Papers / *2 Best Paper Awards (out of 3)*


EC Funding Flow Diagram
EC contribution (Euro)
Millions
8,0
6,0
4,0
2,0
0,0
-2,0
-4,0
-6,0
0
6
12
18
24
30
36
42
7,0
4,0
-3,9
-5,3
-4,1
EC contribution
Financial Statements
Cash flow
Time (months)

External Publicity

•20 Articles related to HERCULES in International Technical Press

•HERCULES included in EC/DG RTD "Star Projects" list

(http://ec.europa.eu/research/star/index_en.cfm?p=52_main)

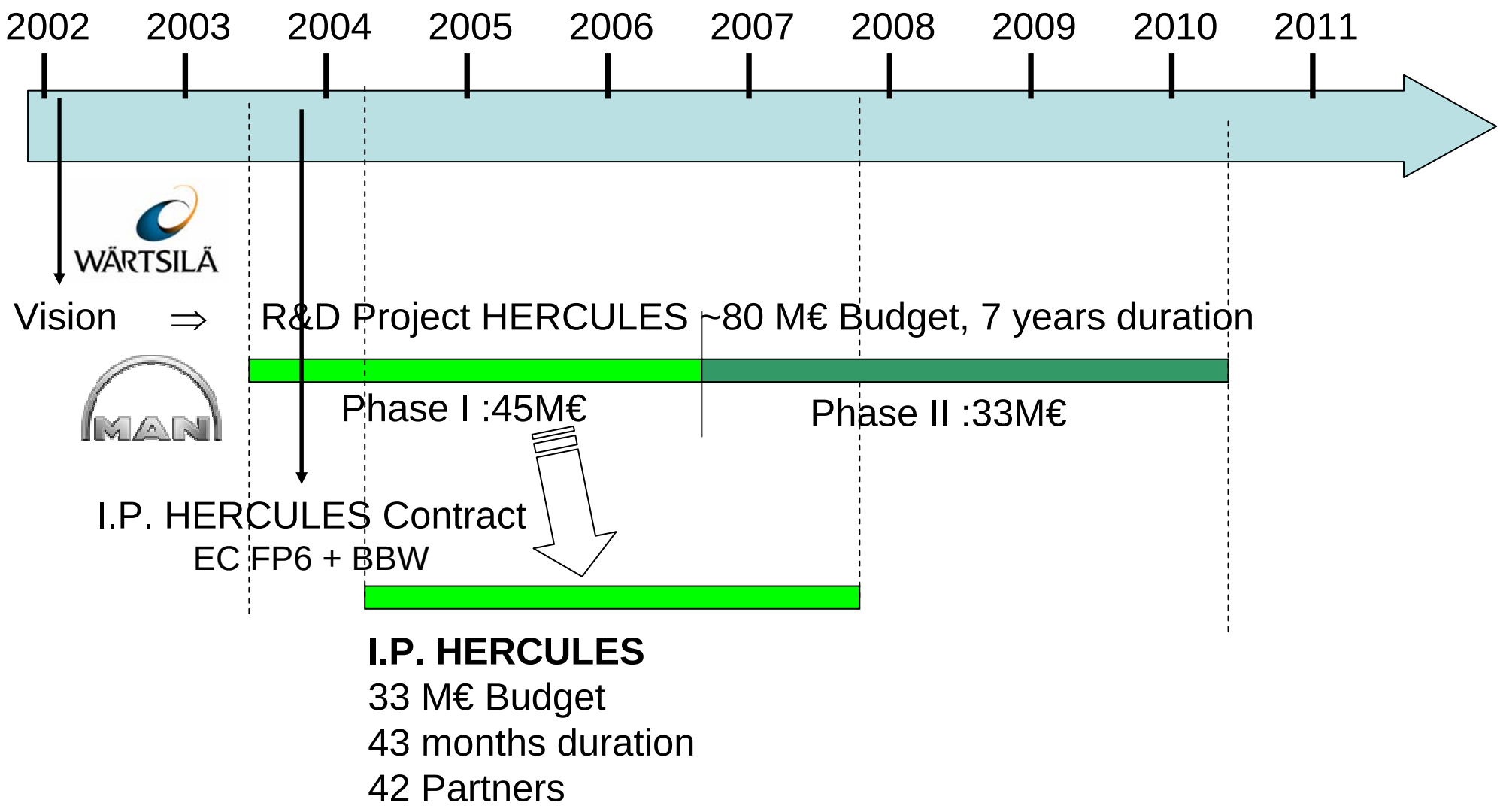
• BBC News Report: "Technology to make ships green" (12/2005)

(http://news.bbc.co.uk/go/pr/fr/-/2/hi/technology/4545494.stm)

“Futuris”: TV co-production between EuroNews Network and European Commission

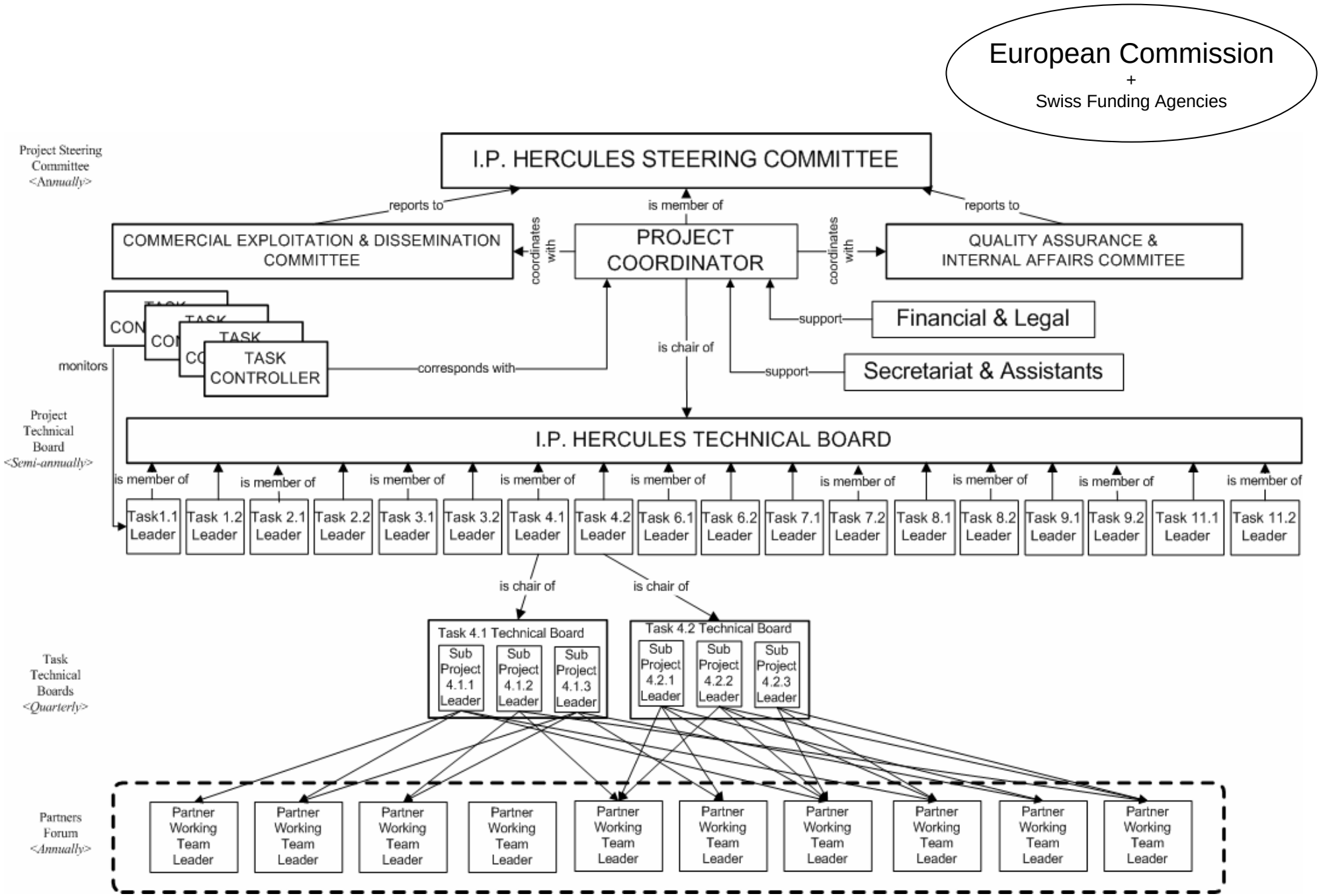
“Shaping the future of shipping”, April 2007

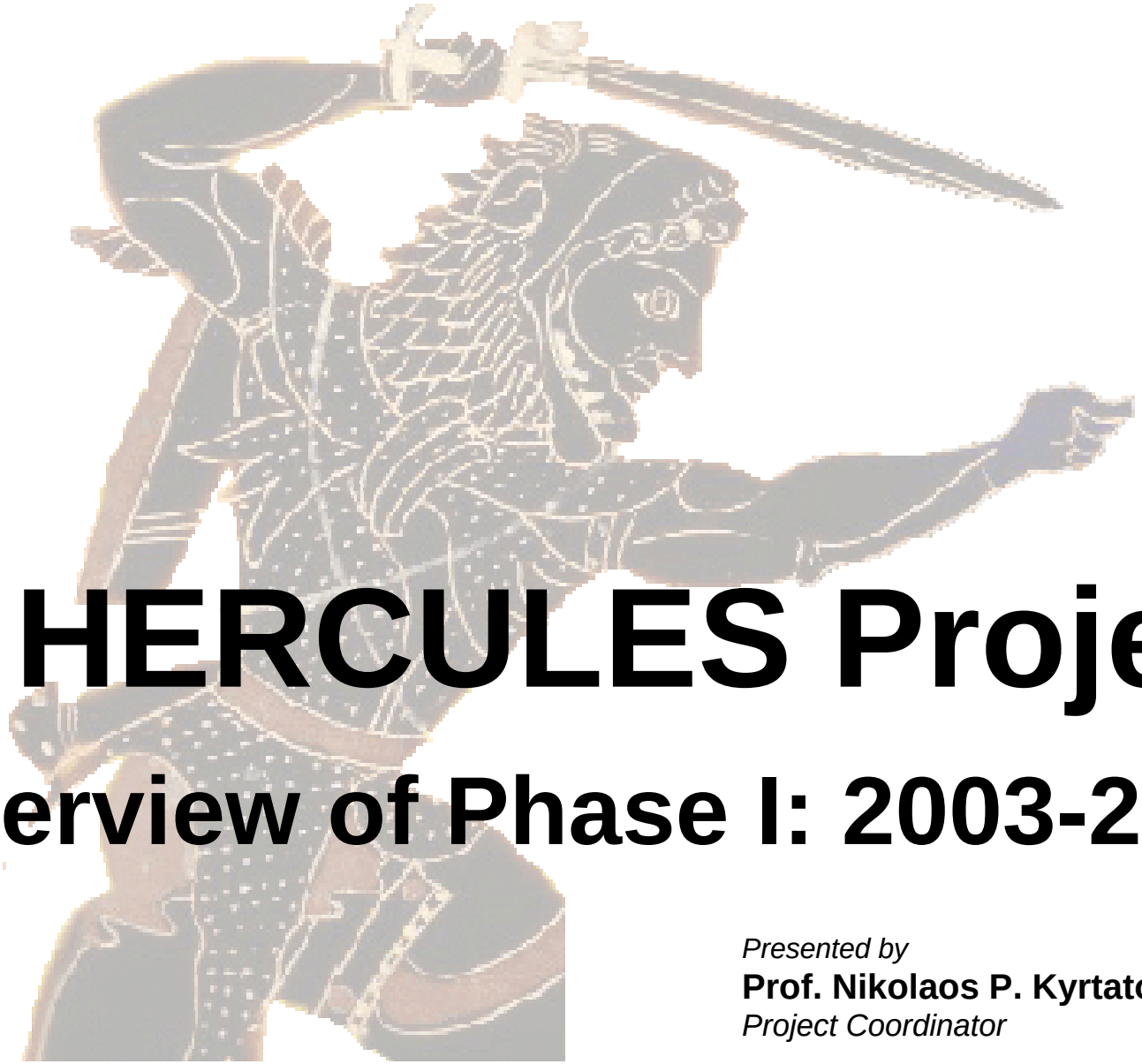
Project HERCULES



I.P. HERCULES
33 M€ Budget
43 months duration
42 Partners

I.P. HERCULES Management Structure





The HERCULES Project

An overview of Phase I: 2003-2007

Presented by
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