



# The HERCULES (2004-2018) programme of R&D in large engine technologies

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HERCULES Coordinator

Presentation to SMM 2018  
Hamburg, Germany, 6<sup>th</sup> September 2018



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

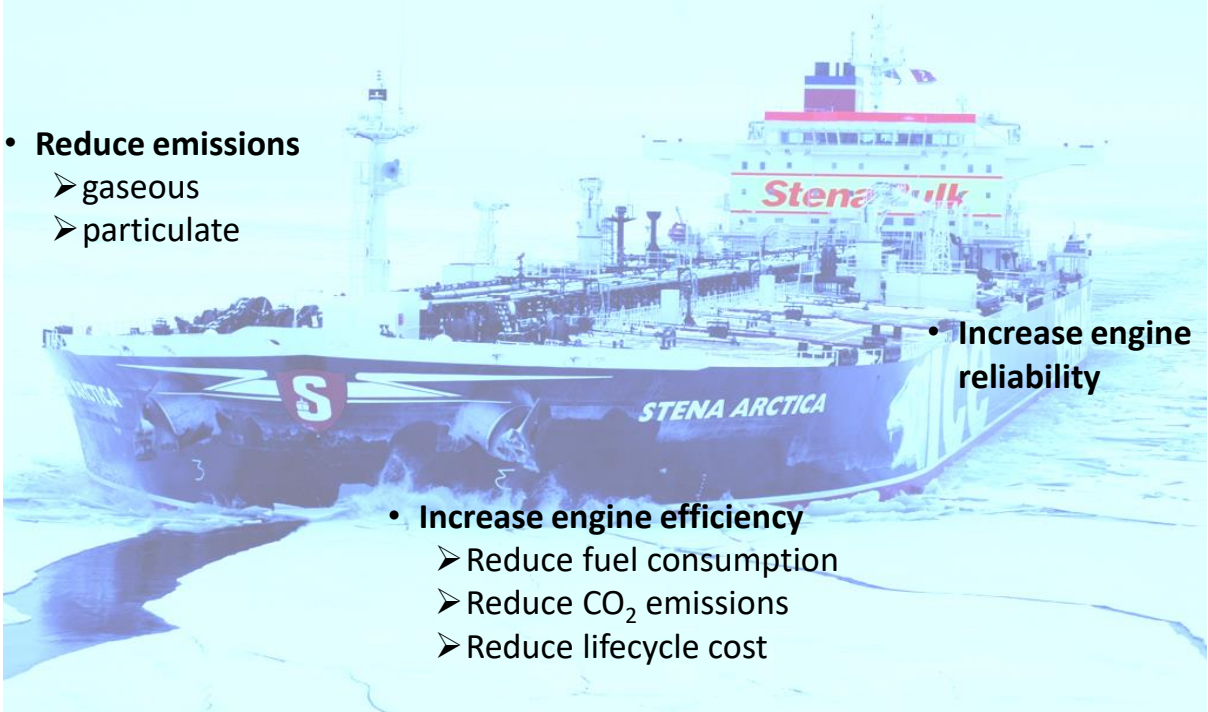
- **Reduce emissions**

- gaseous
- particulate

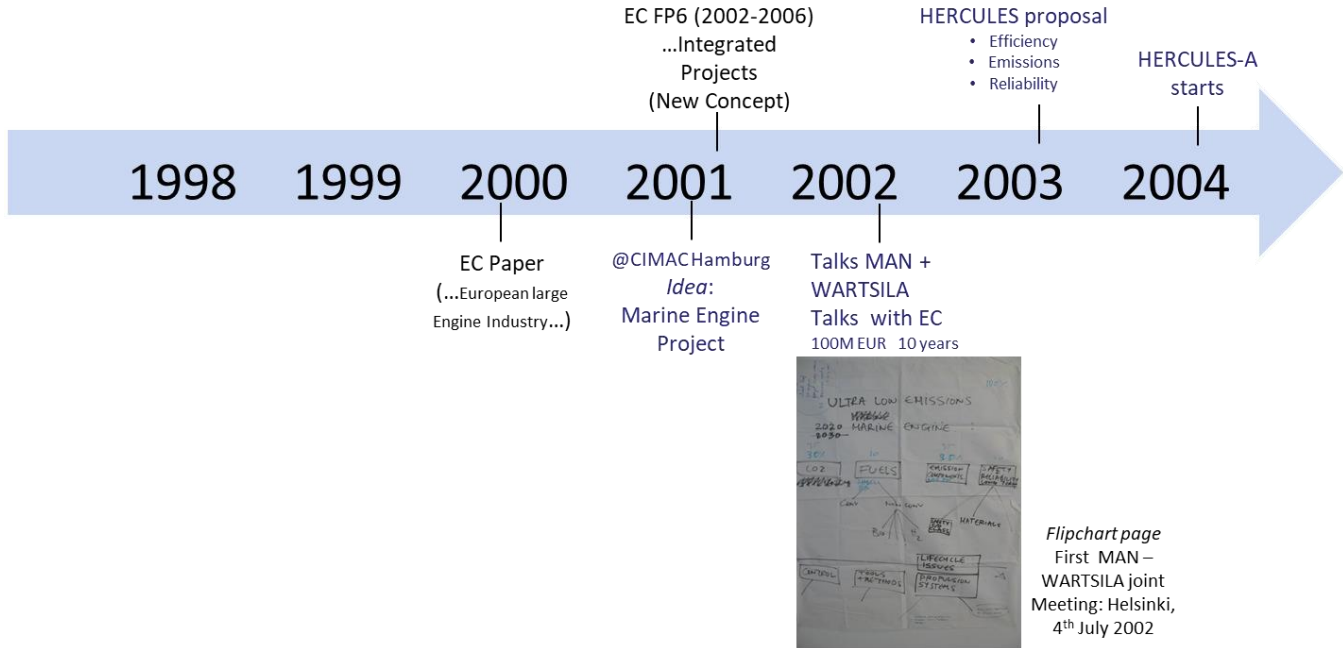
- **Increase engine reliability**

- **Increase engine efficiency**

- Reduce fuel consumption
- Reduce CO<sub>2</sub> emissions
- Reduce lifecycle cost

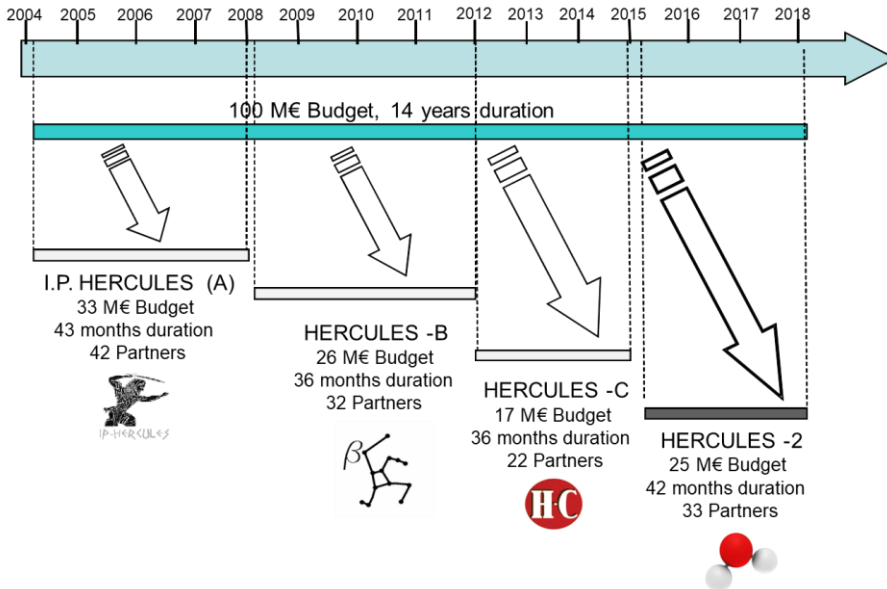


# HERCULES Mythology

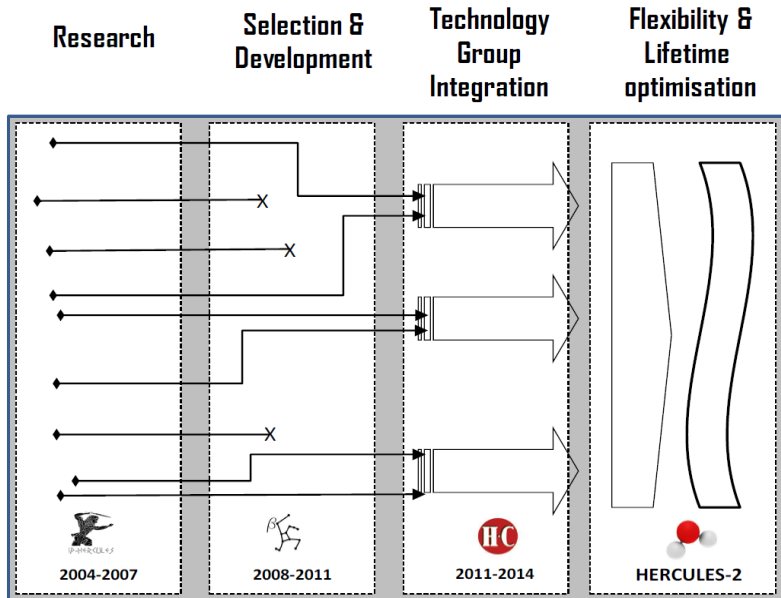


Flipchart page  
First MAN –  
WARTSILA joint  
Meeting: Helsinki,  
4<sup>th</sup> July 2002

# The HERCULES Programme Timeline



# The HERCULES Programme evolution



- **HERCULES A**

*High-Efficiency Engine R&D on Combustion with Ultra Low Emissions for Ships*

- **HERCULES-B**

*Higher-efficiency Engine with Ultra-low Emissions for Ships*

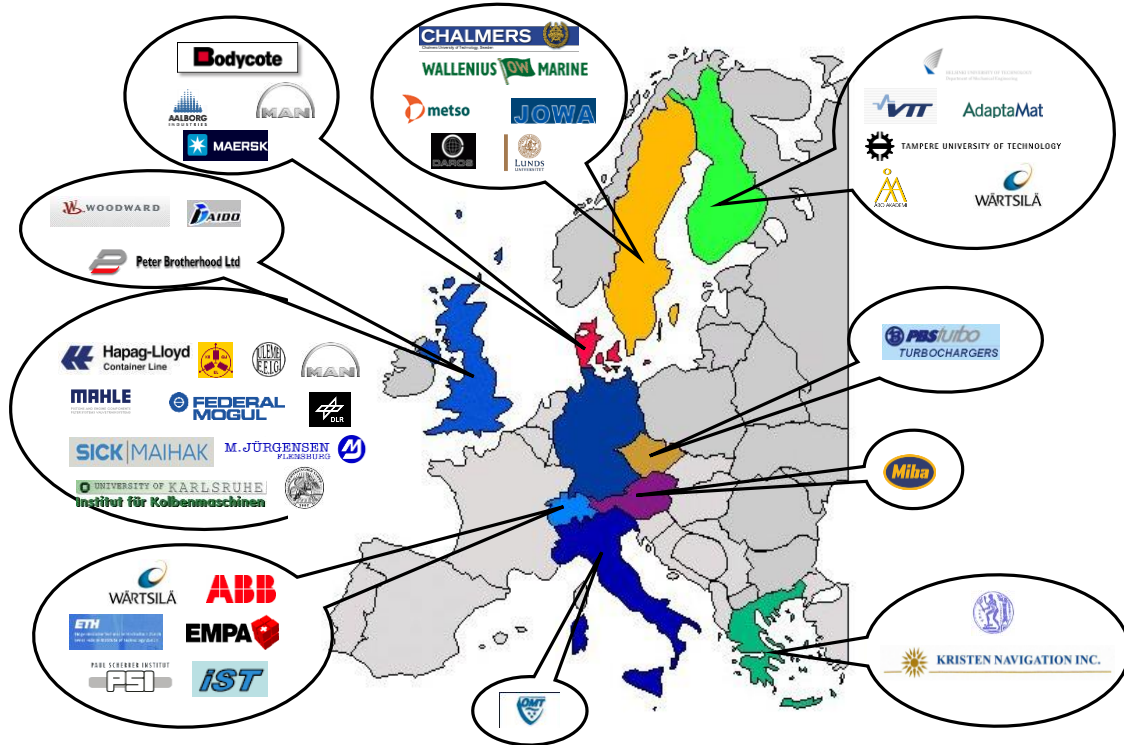
- **HERCULES-C**

*Higher-efficiency, Reduced Emissions, Increased Reliability and Lifetime, Engines for Ships*

- **HERCULES-2**

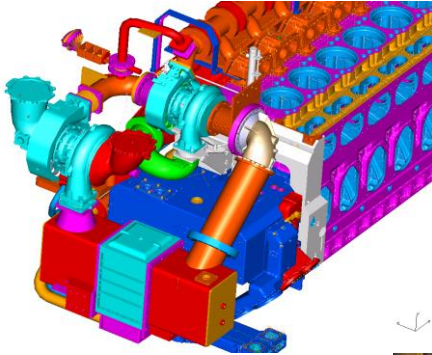
*Fuel flexible, near-zero emissions, adaptive performance marine engine*

# I.P. HERCULES-A – Consortium

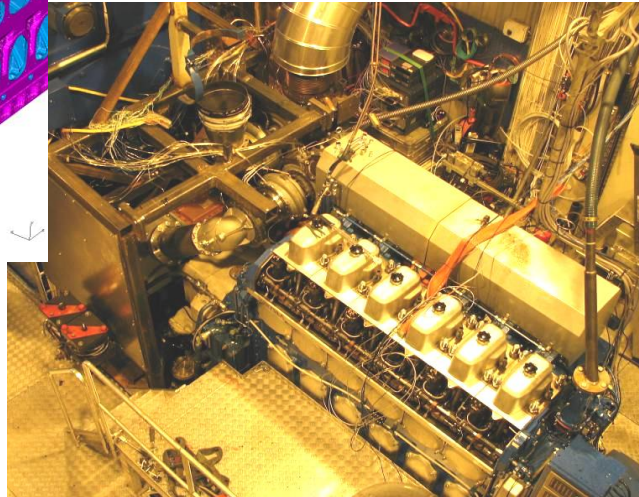


# H - A: Variable turbocharging

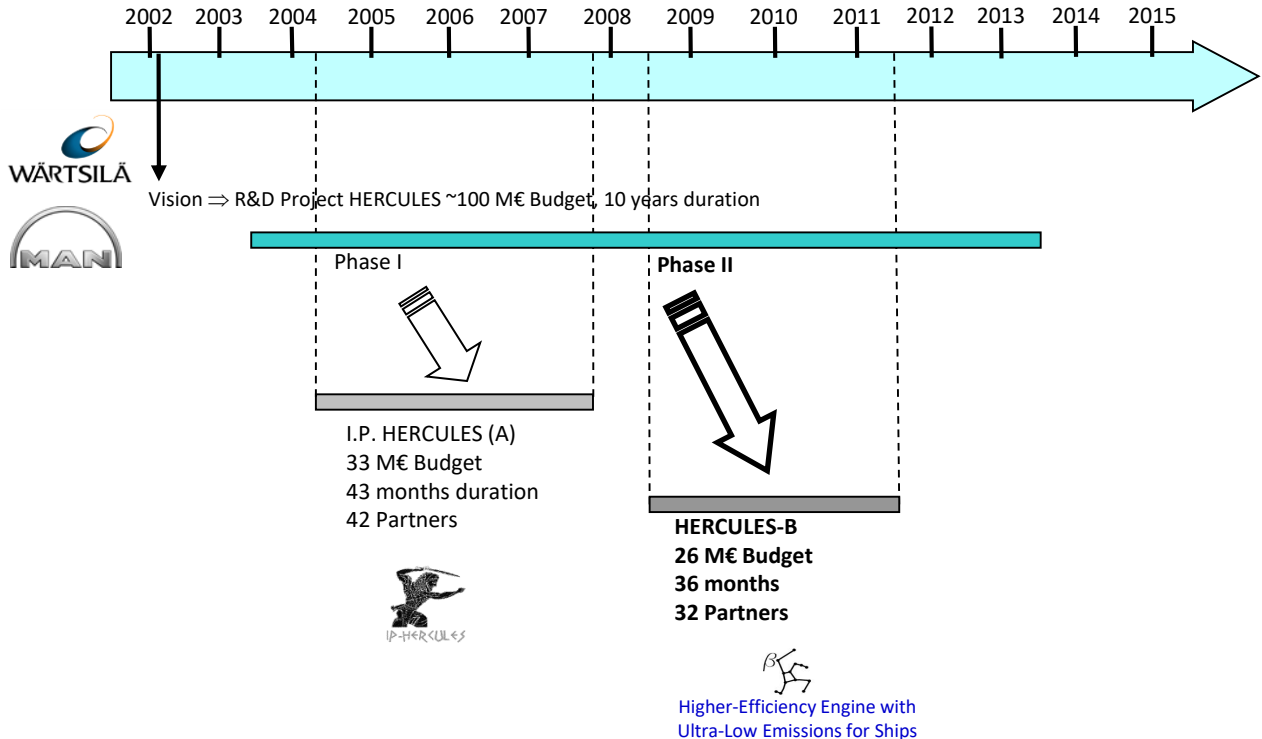
Two-stage turbocharged 4-stroke engine



CIMAC 2007 Congress: Best paper award !



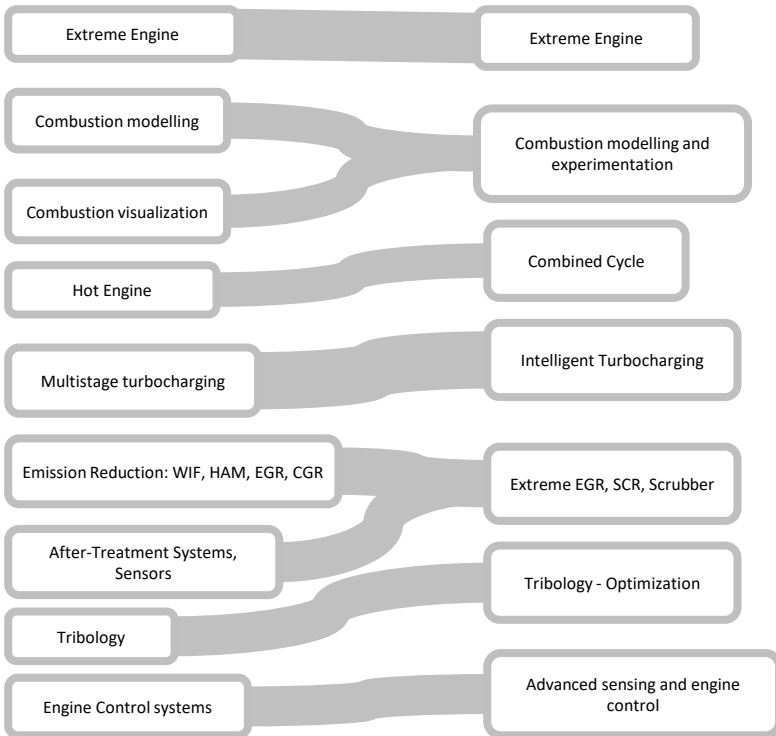
# HERCULES TIMELINE



SCP7-GA-2008-217878

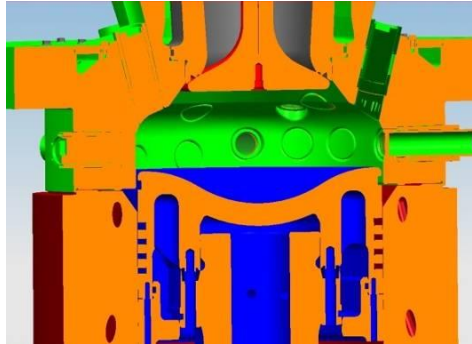








# Combustion process visualization development

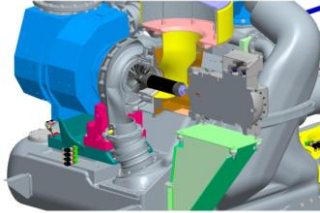


Optical cylinder covers for 2-stroke

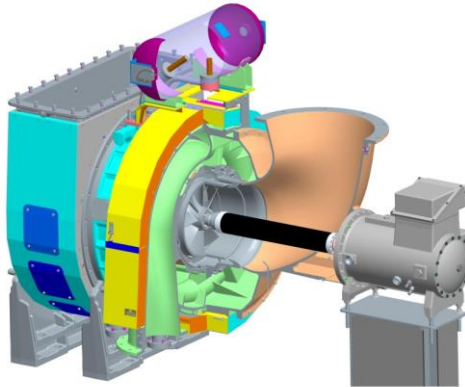




# Advanced intelligent turbocharger



PTI / PTO



T/C with variable compressor inlet  
guide vanes



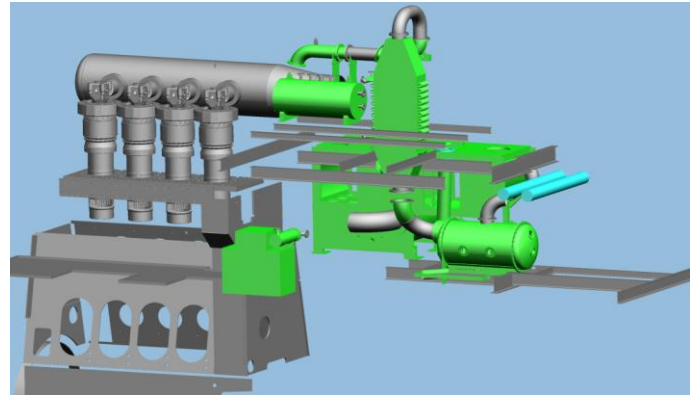
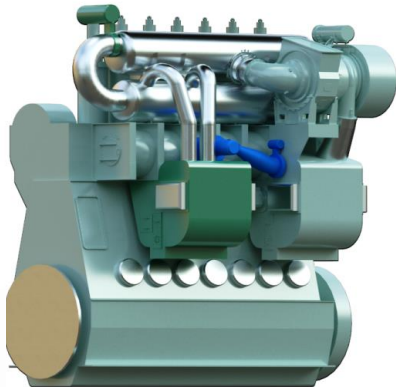
T/C with variable turbine nozzle  
vanes



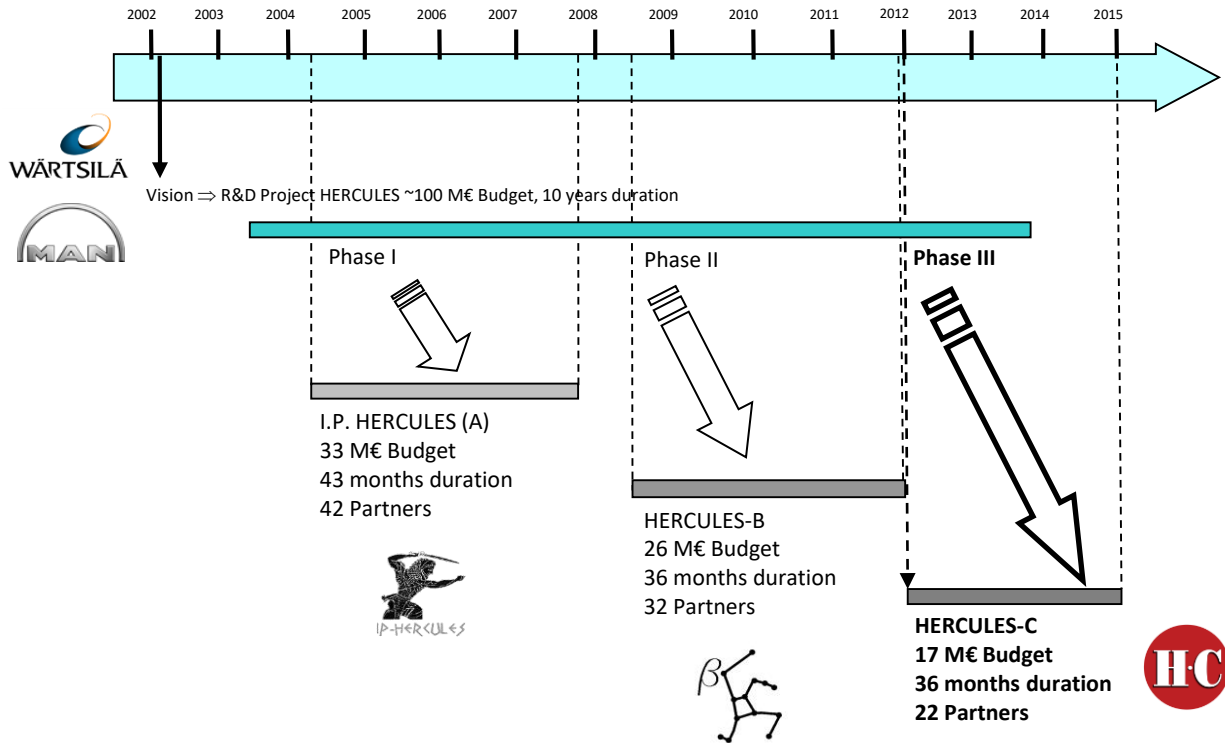
# Emission reduction - Exhaust Gas Recirculation and After-treatment

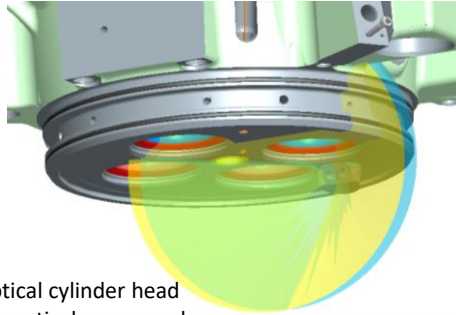


High Pressure Boiler  
installed on 4T50ME-X

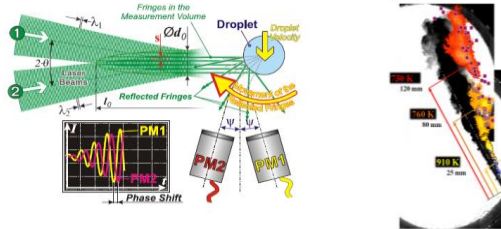
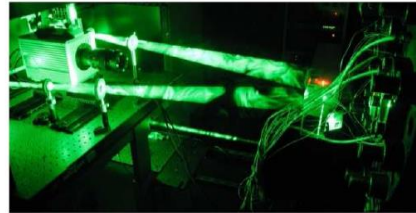
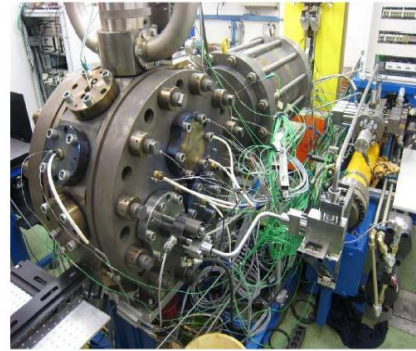


# Towards HERCULES-C





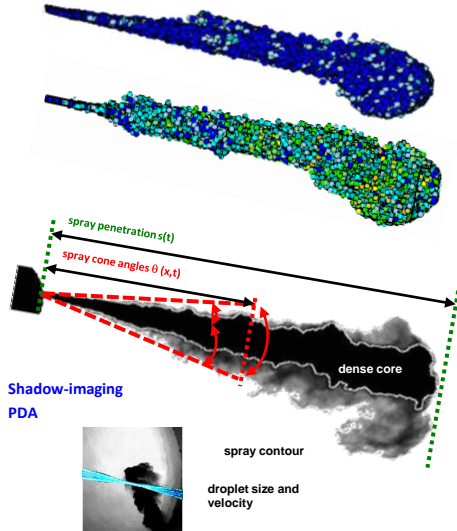
Optical cylinder head with optical access and viewing range



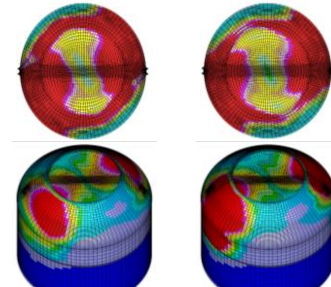
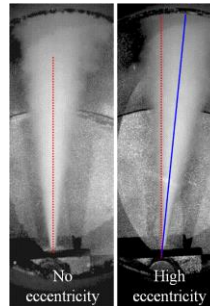
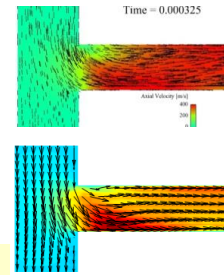
WP 3: Injection, Spray Formation and Combustion

(TIMESPAN: SHORT=S, MEDIUM=M, LONG=L)

WORK PACKAGE GROUP	ITEM	TIME
WPG2	Models for flow and cavitation applicable to large engine injectors	M
Fuel Injection Models & Experiments		



CFD investigations of the nozzle internal flow



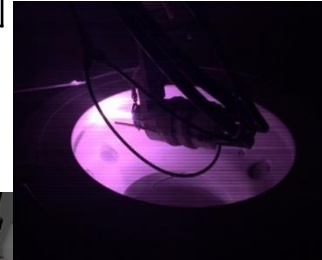
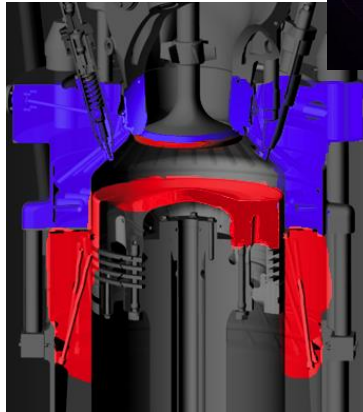
Nozzle bore eccentricity investigation

(TIMESPAN: SHORT=S, MEDIUM=M, LONG=L)

WORK PACKAGE GROUP	ITEM	TIME
WPG5 New Materials & Tribology	Low friction and wear engine piston rings	S
	Increased performance main engine bearings	M
	Thermal Barrier Coatings for piston crowns	M

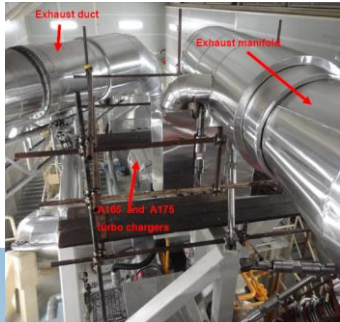
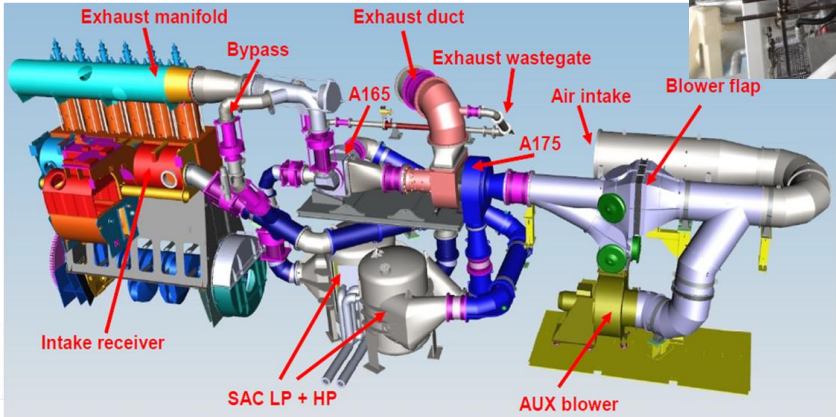


Thermal Barrier Coatings

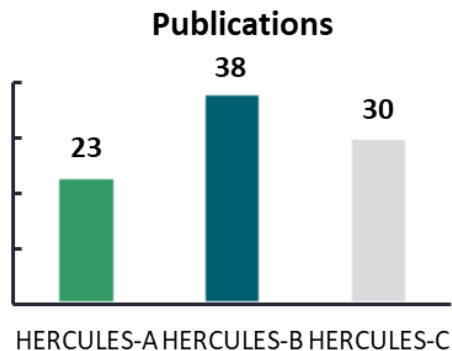
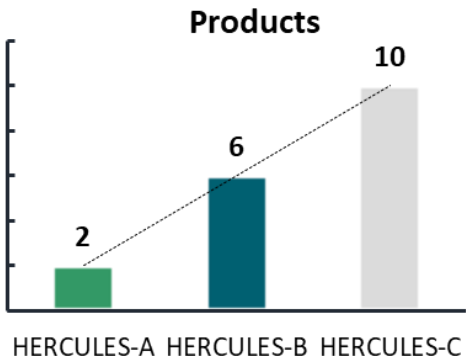
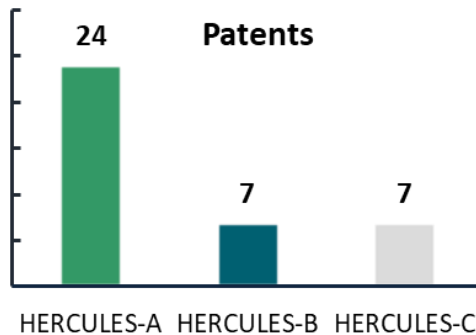
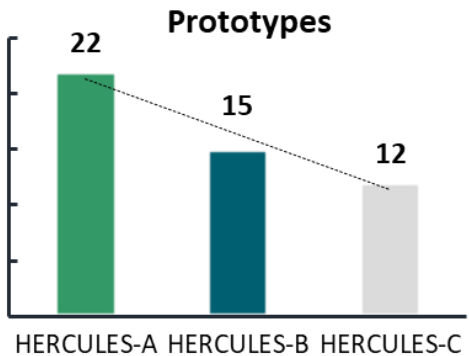




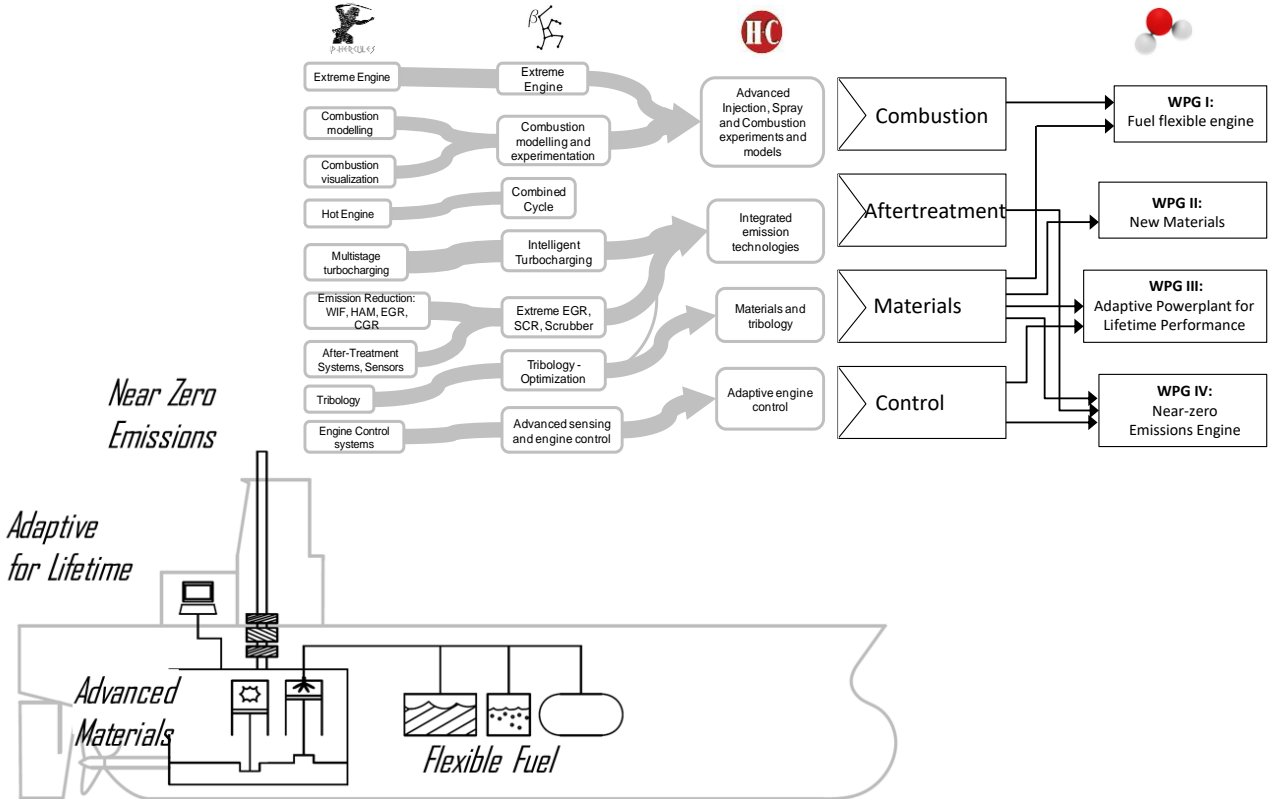
# Full scale experimental setup for complete variability of turbocharging system combined with EGR



# Metrics of HERCULES



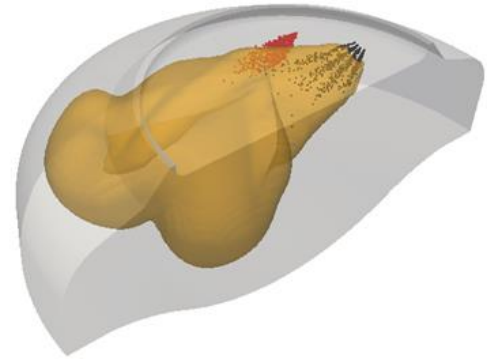
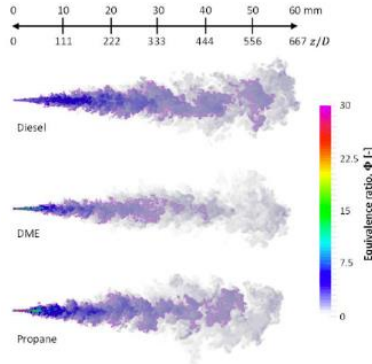
# Links among HERCULES Projects



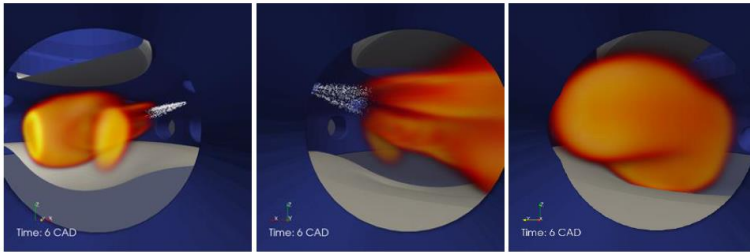


# WPG I: Fuel flexible engine

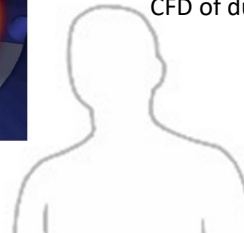
Large Eddy Simulation (LES) of evaporating fuels: Diesel, dimethyl ether (dme) and propane



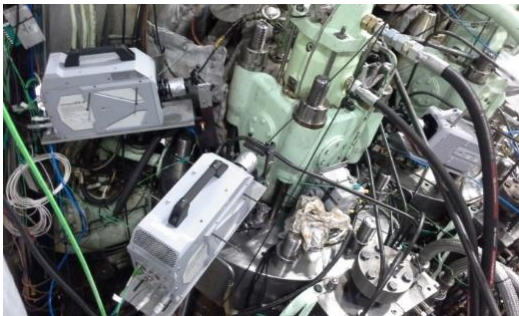
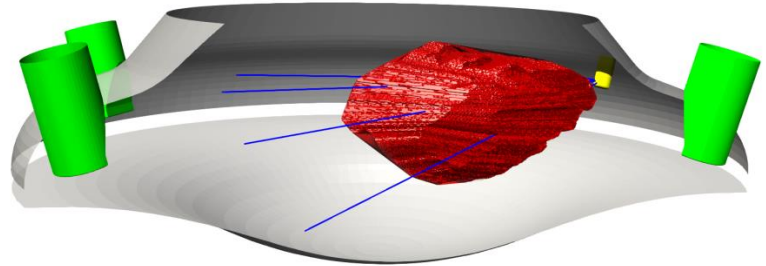
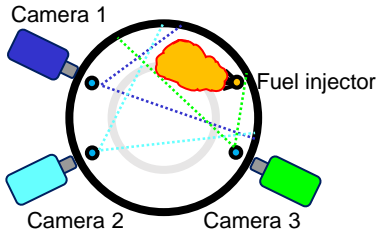
CFD of dual-fuel combustion in two-stroke marine engine



Flame rendering from CFD, as it would appear from the three cameras



# WPG I: Fuel flexible engine

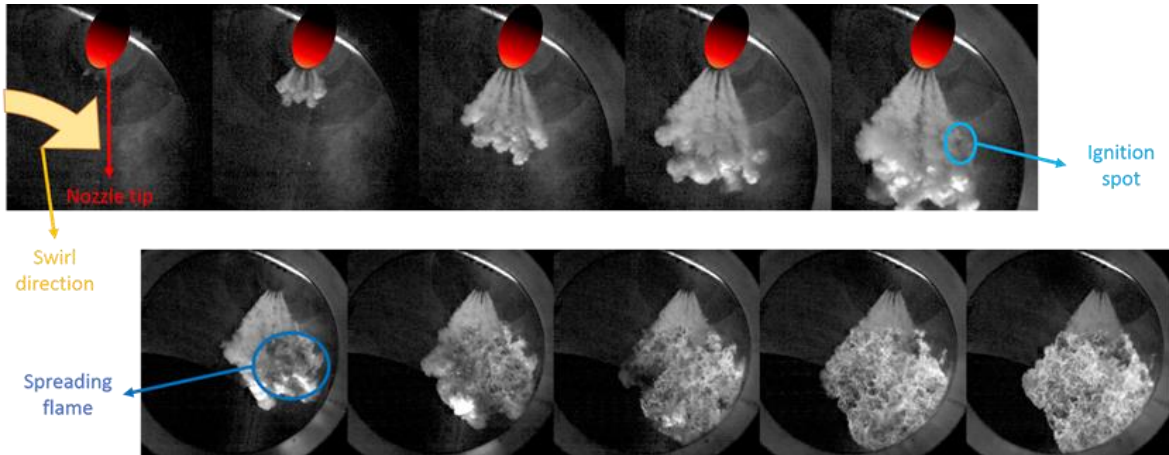


Triple-camera high-speed imaging on two-stroke dual-fuel engine  
reconstructed 3D flame kernel





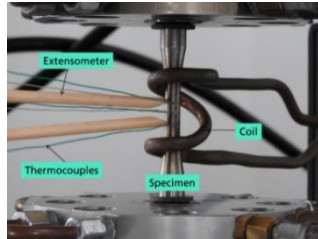
# WPG I: Fuel flexible engine



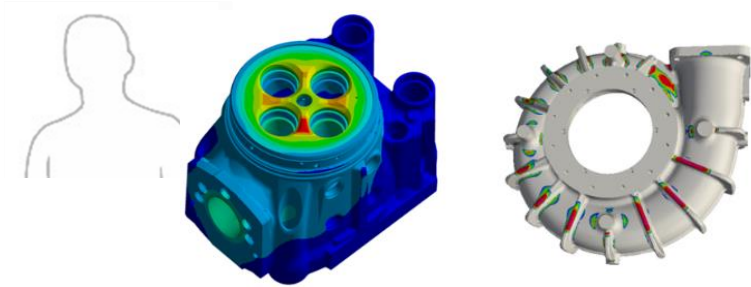
Multi-camera mapping of 3D flame shape in two-stroke dual-fuel engine



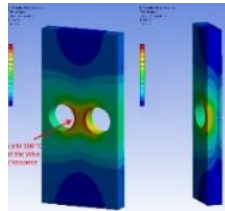
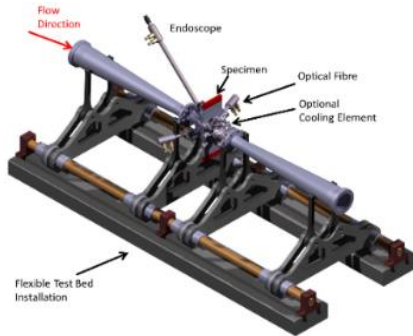
# WPG II: New Materials (Applications in engines)



Test set-up for thermomechanical fatigue



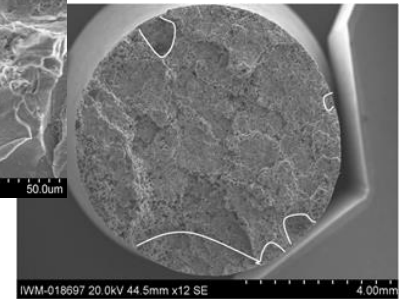
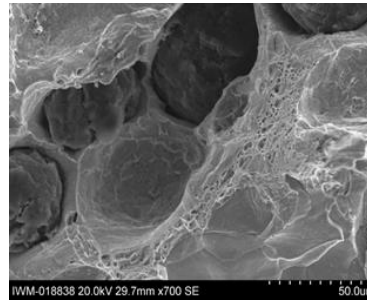
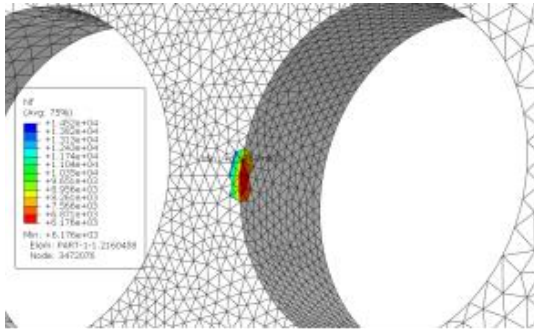
New materials investigation for cylinder head and turbine casing



TMF test rig and specimen



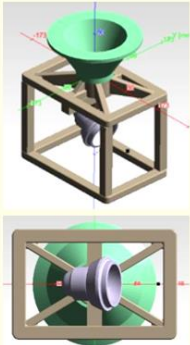
# WPG II: New Materials (Applications in engines)







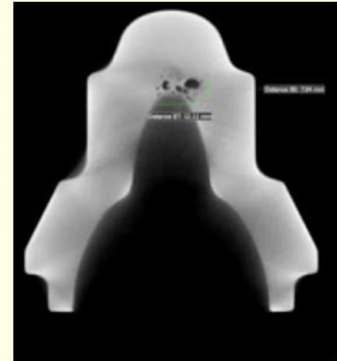
## Casting simulations



## Investment casting

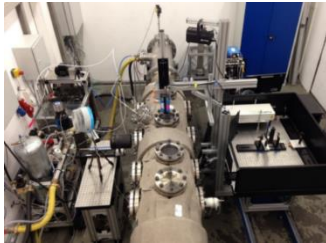


## NDT-testing via CT-scans





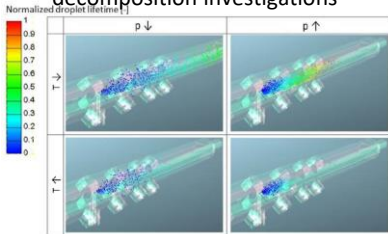
# WPG IV: Near-Zero Emissions Engine



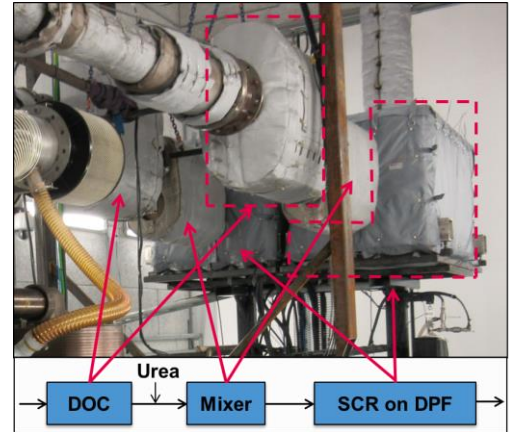
Hot gas test rig for urea decomposition investigations



Mini SCR system for urea mixing/evaporator study



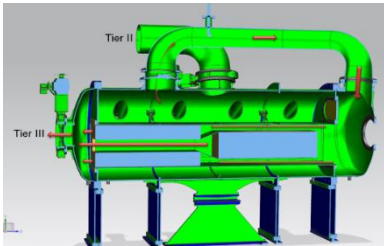
Simulated spray behaviour at different operating conditions



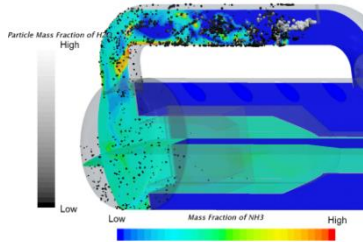
Exhaust aftertreatment (EAT) system, Diesel Oxidation Catalyst (DOC) & SCR coated Diesel Particulate Filter (DPF), installed in full scale.



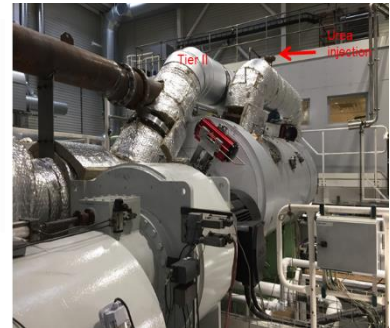
# WPG IV: Near-Zero Emissions Engine



Engine integrated High Pressure SCR system



Exhaust gas flow inside the integrated SCR



Engine Integrated SCR Installation on a 2 stroke 4 cylinder diesel engine.



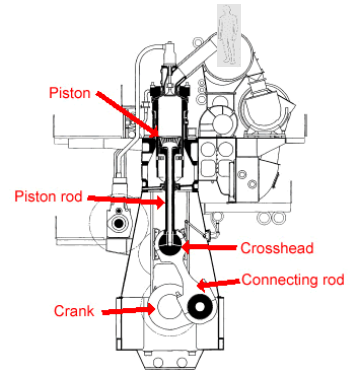
# WPG IV: Near-Zero Emissions Engine



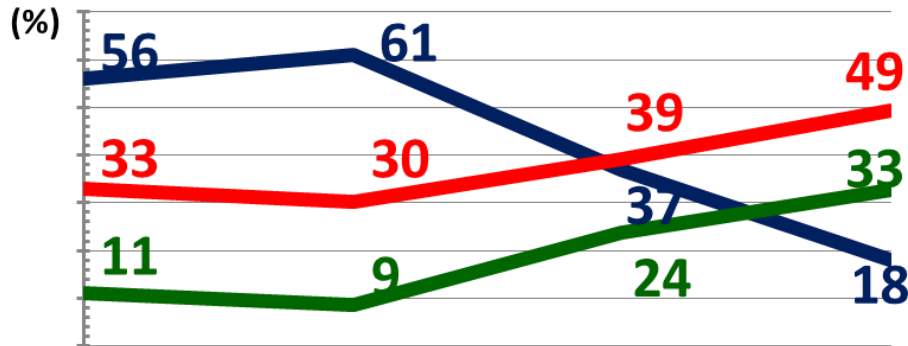
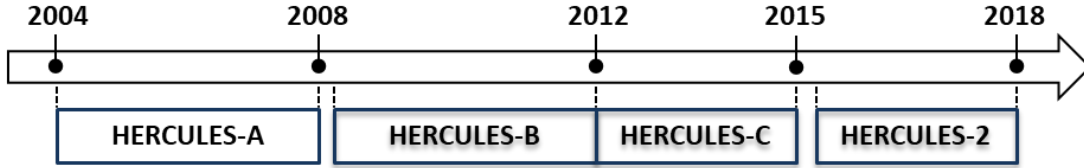
Installation of field test catalyst device in exhaust manifold



Inspection of field test catalyst device in exhaust manifold



Percentage allocation of budget into 3 main areas of R&D in the 4 HERCULES Projects (189 subprojects)



% of individual project budget

— Efficiency

— Emissions

— Reliability & Lifetime

Total 102 M€

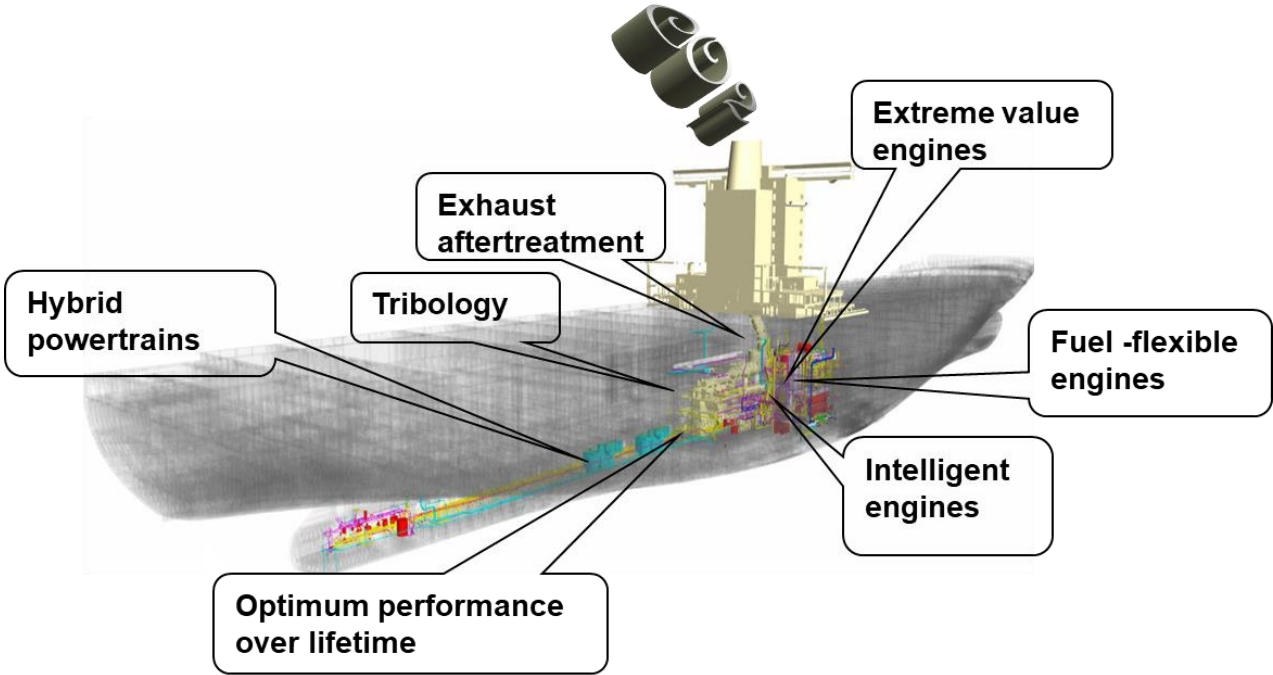
43%

38%

19%

<i>TECHNOLOGY AREA</i> <i>TECH ITEMS</i>	COMBUSTION	TURBO CHARGING	EMISSIONS ATU	MATERIALS FRICTION	MONITOR CONTROL OPTIMIZATION
Multi-Turbo/ VVT		✓			✓
PTI/PTO		✓			✓
Increased Pmax. Cyl.	✓	✓		✓	✓
Cylinder auto-tuning					✓
Water-in-Fuel	✓		✓		
SCR			✓		✓
Tribology				✓	
WHR- Hot Engine				✓	✓
EGR			✓		✓
Cylinder cut-out					✓
Dual Fuel /Multi Fuel	✓				✓

# Near future in ship propulsion engines



# Final Comments

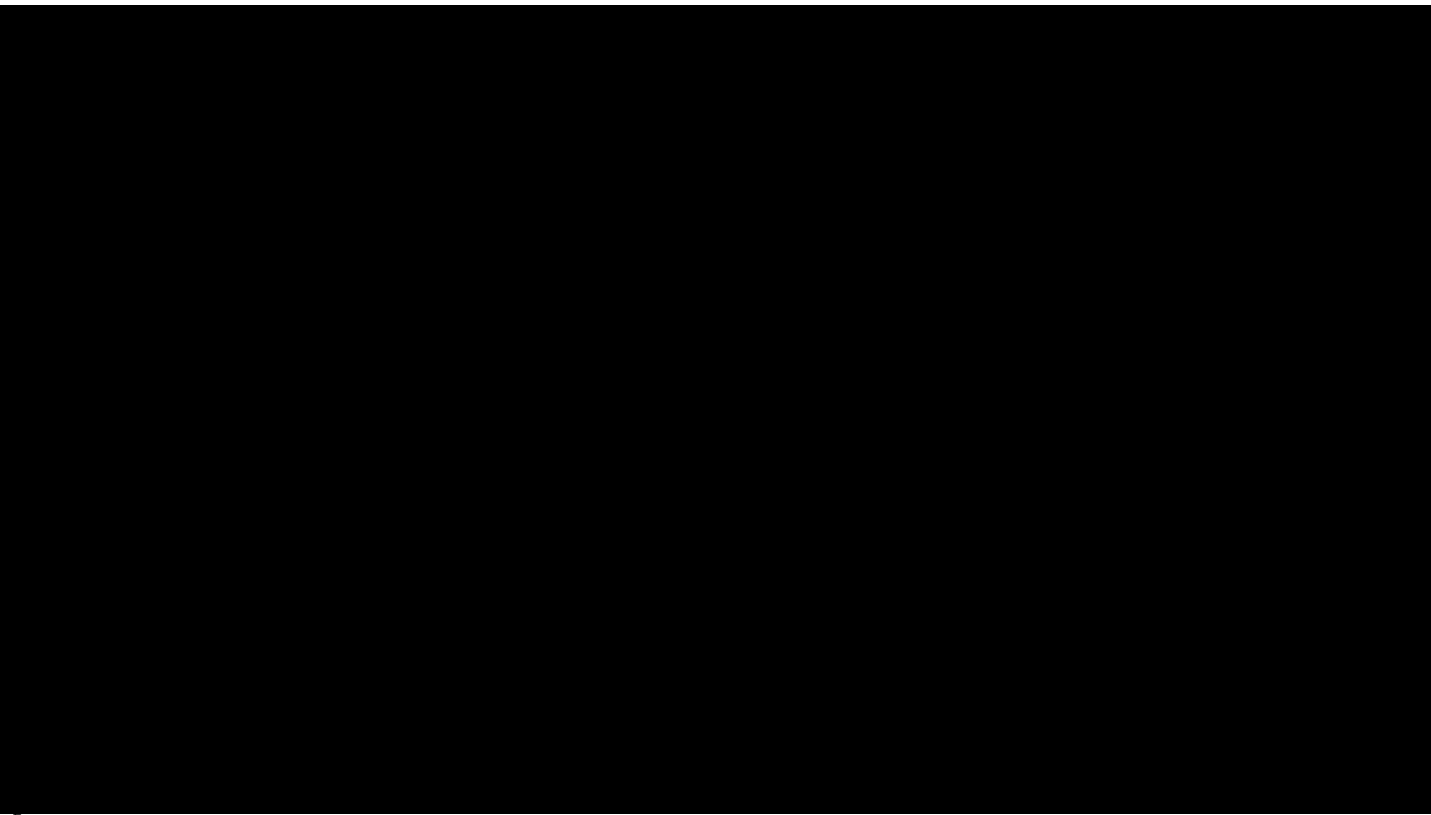
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- The longevity of alliances is often used as proxy of their performance.
- The HERCULES alliance of 14 years has been demonstrably successful.
- Many results of R&D already matured into products.



# HERCULES Program Partners



# Contact

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