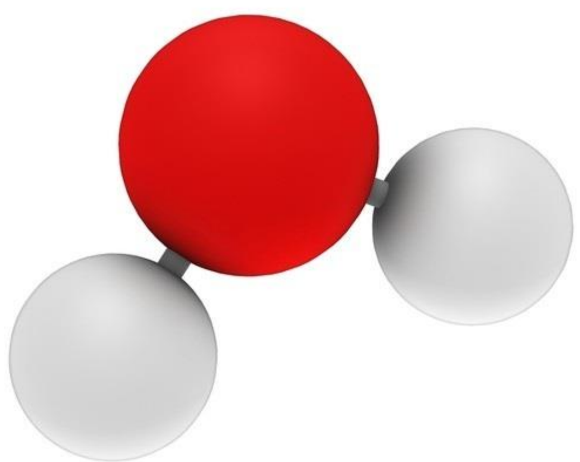
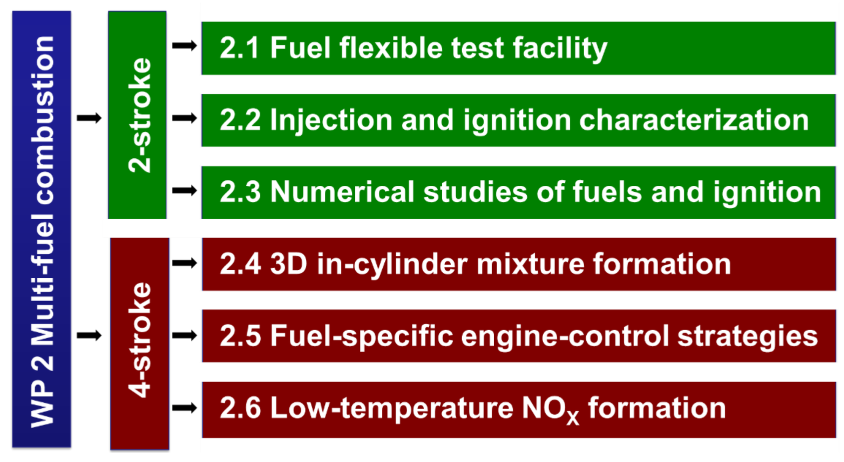


WP 2 Multi-fuel combustion

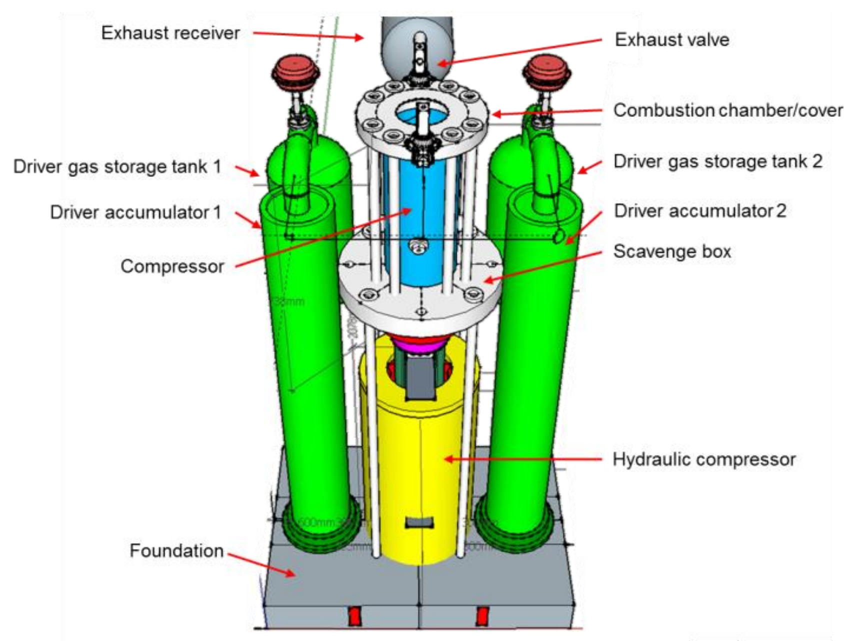
WP OBJECTIVES

The overall objective is to improve fuel flexibility of marine engines. In order to efficiently exploit a larger variety of fuels an increased understanding of injection, combustion and emissions formation is required. For this purpose we developed experimental facilities with optical access for tests under conditions relevant for marine engines. For furthering understanding of ignition and emission formation numerical tools were also developed and applied. Finally, novel engine control strategies were developed to fully exploit potential benefits of such fuels.



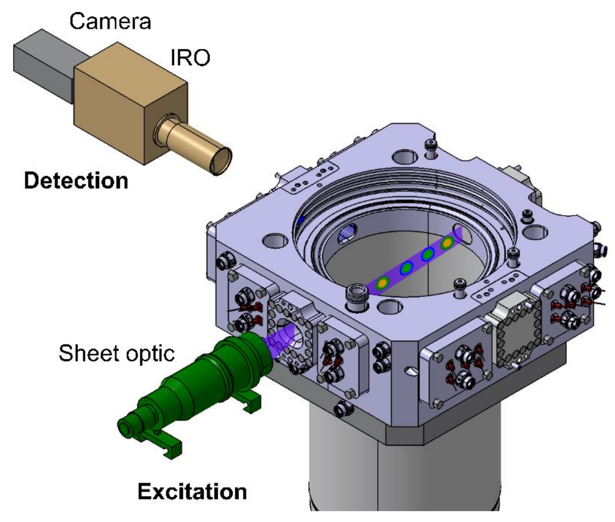
ACHIEVEMENTS & FINAL RESULTS

A test combustion chamber for controlled experiments under realistic conditions designed, but not completed.

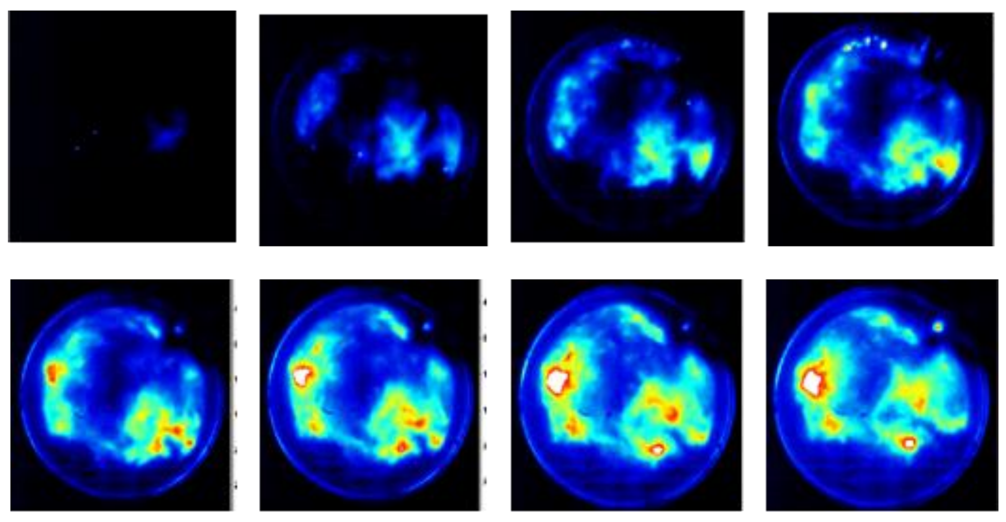


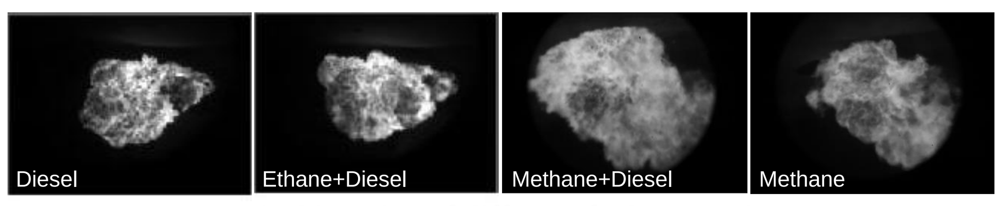
Test combustion chamber concept

Optical cylinder head and measurement of 3D in-cylinder mixture formation on dual-fuel engine.



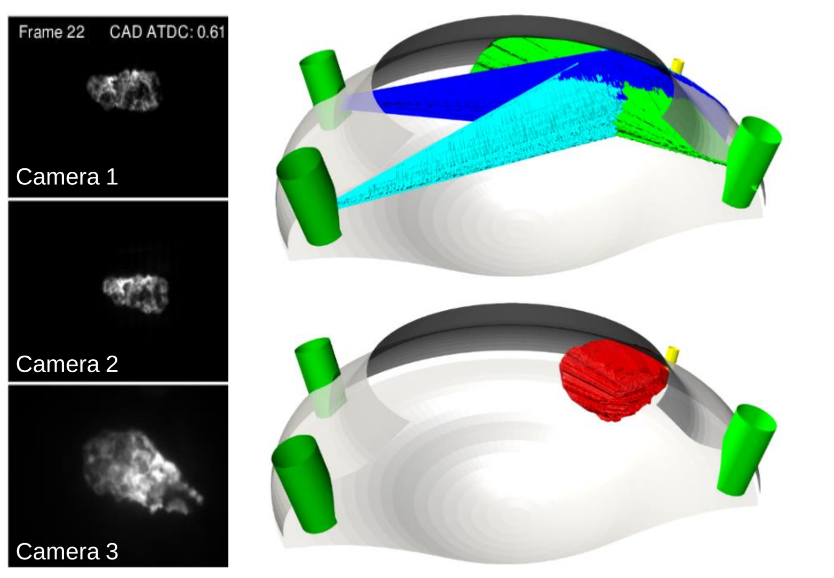
Optical cylinder head for medium speed dual-fuel engine


Measurement of flame luminescence with vertical access

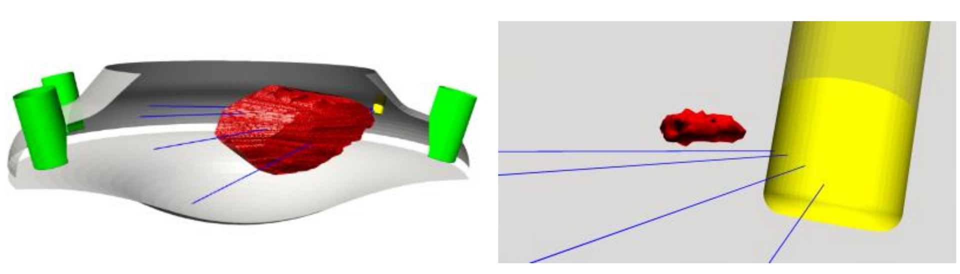


Optical imaging of different fuels on engine

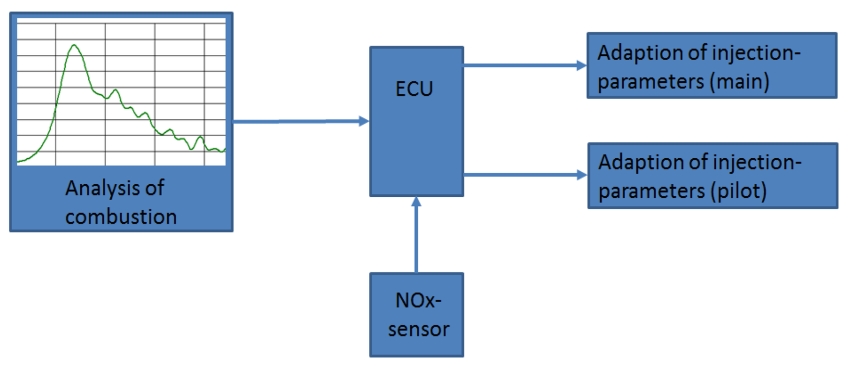
Optical tests on several fuels performed on the 4T50ME-X engine. Those include multi-camera 3D imaging.



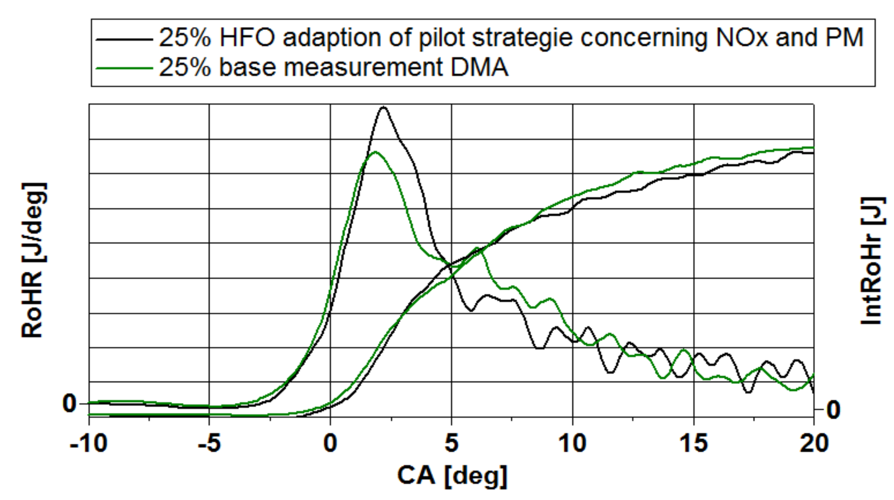
Tri-camera flame imaging for spatial mapping of flames using space carving


Developed flame (left) and initial ignition kernel (right)

Fuel-specific engine-control strategy developed on single cylinder engine and validated on full scale dual-fuel engine.



Concept for fuel-flexible engine



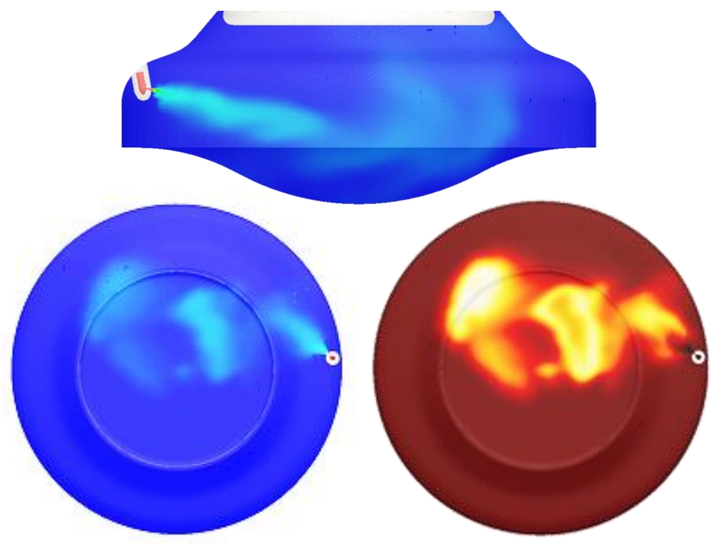
Optimised pilot-injection strategy with HFO

Detailed chemical kinetic models for new alternative fuels developed and CFD of single and multi-fuel performed.

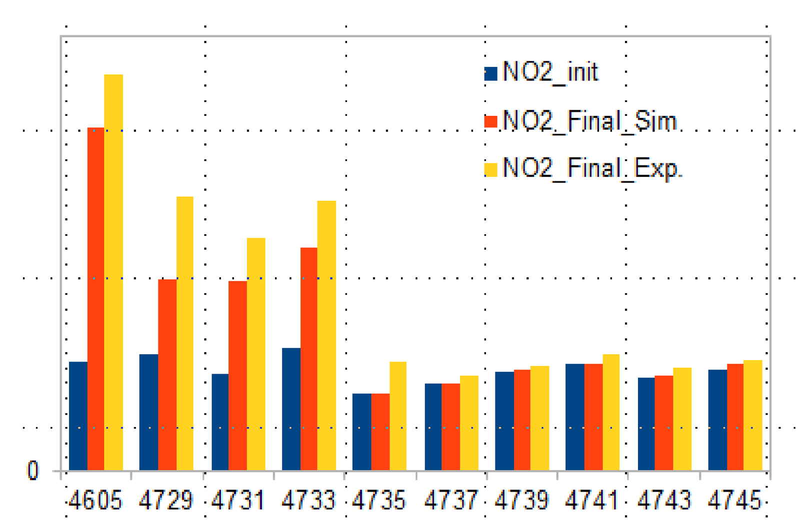
Model	No. of Spec.	No. of React.	Evaluation conditions: Fuel	Evaluated Parameter	Range of T [K]	Range of P [atm]
DTU-C2	68	665	Methane	Components evolution [a]	600–900	100
				Ignition delay (RCM)	800–1250	15–80
				Ignition delay (Shock tube)	900–1800	7–456
				Flame speed		1–10
			Ethane	Components evolution [a]	600–900	20–100
				Components evolution [b]	1000–1500	40–613
				Ignition delay (RCM)	900–1025	10–80
				Ignition delay (Shock tube)	1000–1500	16–21
				Flame speed		1–10
			Ethanol	Components evolution [a]	600–900	50
				Ignition delay (RCM)	800–1000	10–50
				Ignition delay (Shock tube)	1000–1600	10–77
				Flame speed		1–12
DTU-C3	133	1114	Propane	Components evolution [a]	500–900	100
				Ignition delay (Shock tube)	900–1400	10–40
DTU-C4	236	1626	Butane	Components evolution [a]	500–900	100

[a] measured in DTU high-pressure flow-reactor
[b] measured in shock tubes

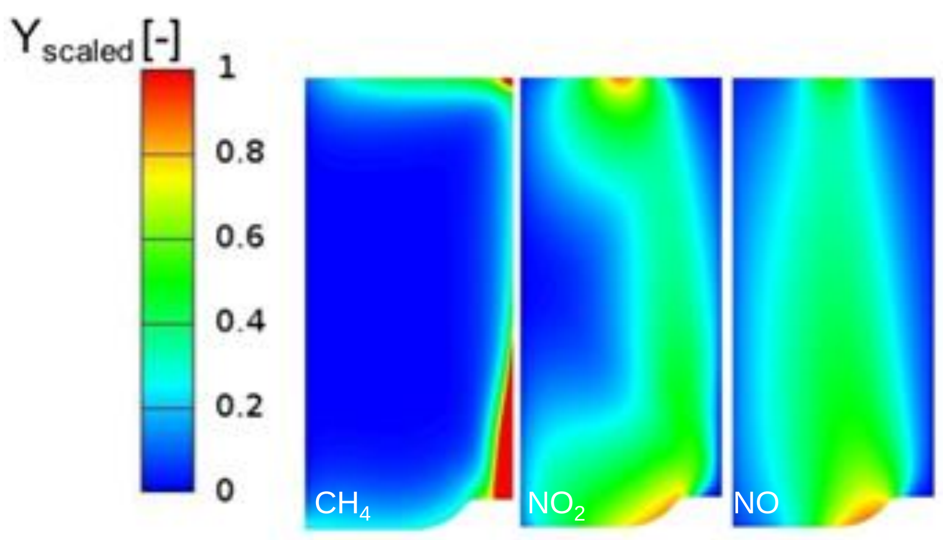
Overview of detailed chemical kinetic models


Mixture fraction and temperature calculated using CFD for dual-fuel combustion on low-speed engine

Numerical model to predict NO_2 formation in a dual-fuel medium speed engine



Comparison between NO_2: simulation vs. experiment (exhaust duct model)



Simulated concentration in combustion chamber at BDC

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