WP6: Model-based Control and Operation Optimization

Objectives / Expected Results

WP Leader: Dr. M. Moser, T. Moeller

Cut operating, maintenance and deployment costs

- Develop systems, methods an processes for improved engine lifetime performance

Reduction of emission

- NOx: expanding operation range emission reduction technologies
- Particle: novel lubrication injection system

Enhance dynamic performance

- Model-based control

Increased part load efficiency

- Cylinder cut-out

Partners:

University of Bremen

Vienna University of Technology

Karlsruher Institute of Technology

Linköping University

Aventics GmbH

Technical University of Denmark

National Technical University of Athens

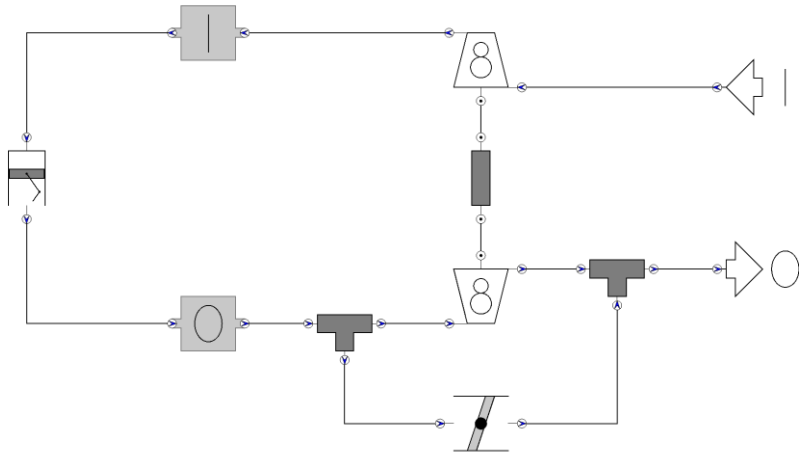
WP 6.1: Predictive model-based engine control

Objectives

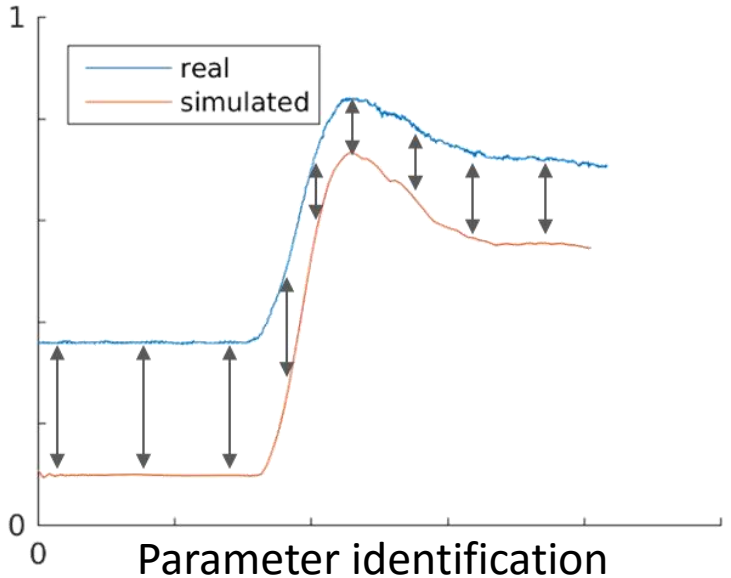
- Enhance dynamic engine performance with the help of multiple-in, multiple-out controllers

Current Status

- Already implemented:
  - ✓ TC
  - ✓ Intake/ Outtake – Receiver
  - ✓ Junctions
  - ✓ Wastegate
  - ✓ Jet Assist
- First simulations in OpenModelica
- Parameter identification (minimize difference between simulation and measurement)



Model arrangement

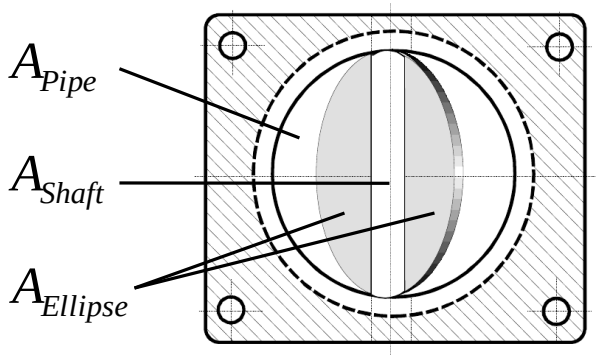


Parameter identification

WP 6.1: Predictive model-based engine control

Next steps

- Increase numeric stability
- Implementation of:
  - LQR & MPC Controller
  - Fuel path
  - Etc.
- Parameter identification of the whole model



$$\dot{m}_W(t) = c_d \cdot A_{geo}(t) \cdot \frac{p_2(t)}{\sqrt{R \cdot \vartheta_2(t)}} \cdot \psi(\Pi_2(t))$$

$$A_{geo}(t) = A_{Pipe} - A_{Shaft} - 2 \cdot A_{Ellipse}(t)$$

Deliverables

- M36 - Validation of selected multiple-in, multiple-out controller

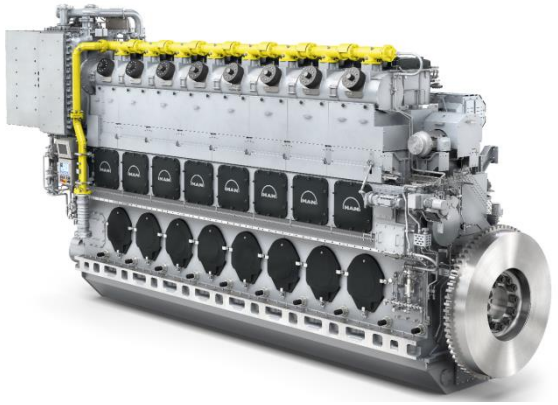
WP 6.2: Efficiency increase at part load

Objectives

- Reduction of emissions and efficiency increase due cylinder cut-out

Current Status

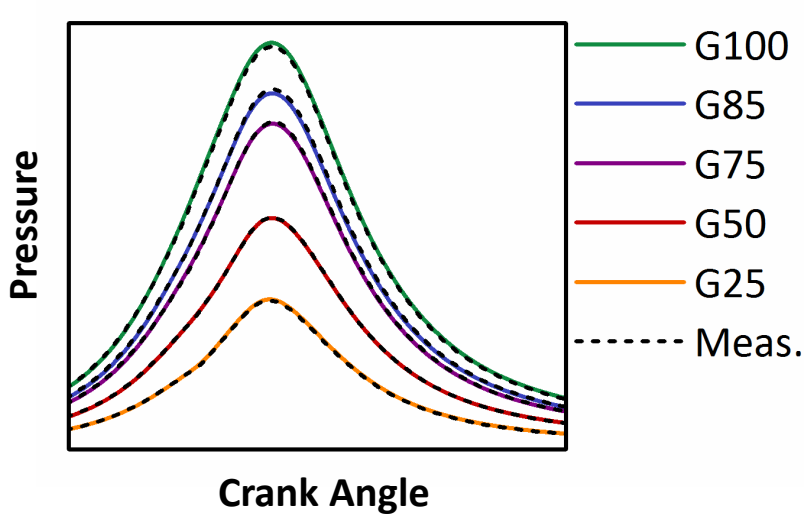
- Investigation of cylinder deactivation on torsional vibrations
- Calibration of single cylinder model
- Three Pressure Analysis and parameter optimization of combustion-model
- Calibration of the multi cylinder engine model



WP 6.2: Efficiency increase at part load

Next steps

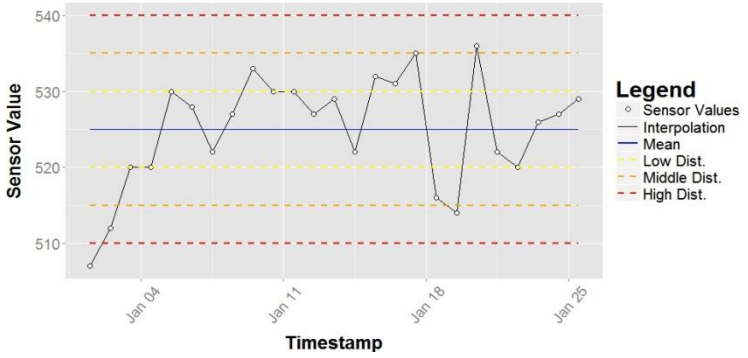
- Calibration of the combustion model
- Calibration of the knock model
- Calibration of the NOx model
- Investigation of cylinder deactivation



Deliverables

- M24 - Study of different control concepts for cylinder cut out operation

WP 6.3: Development of intelligent algorithms for failure detection and plant analysis

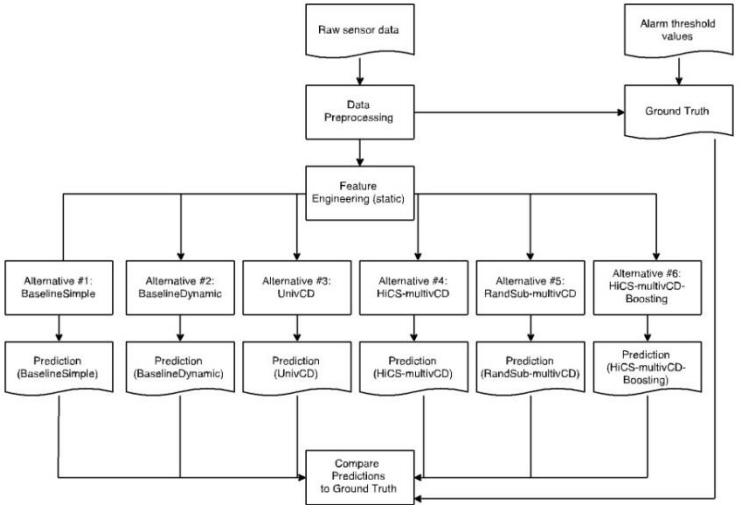


Objectives

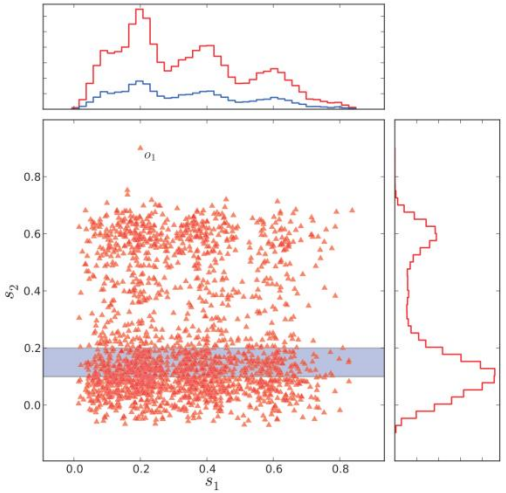
- New outlier-detection and subspace search methods for improve engine lifetime performance

Current Status

- Data preprocessing concerning static and dynamic features
- Proposed frameworks investigated (BaselineSimple/Dynamic, univCD, HiCS-mCD, RandSub-mCD, HiCS-mCD-Features, HiCS-mCD-Ensemble)
- Various evaluation metrics which are based on errors and successes defined
- Frameworks validated based on evaluation metrics



WP 6.3: Development of intelligent algorithms for failure detection and plant analysis



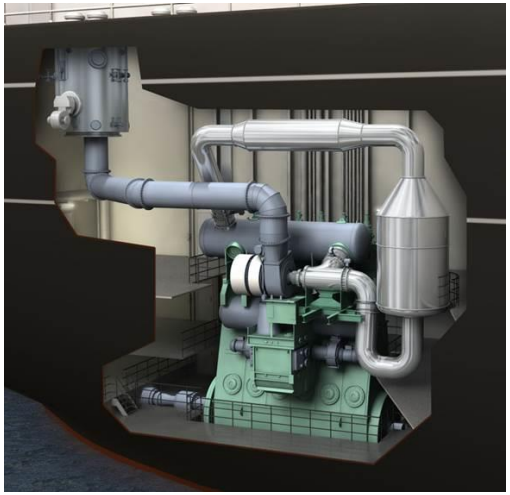
Next steps

- Run and analyse frameworks on new data
- Identification of further patterns
- Investigate tailored subspace-search methods
- Design a change detection method

Deliverables

- M12 - Study the result quality of existing subspace-search methods on uncertain data ✓

WP 6.4: Methods for evaluating engine performance via modeling and simulation

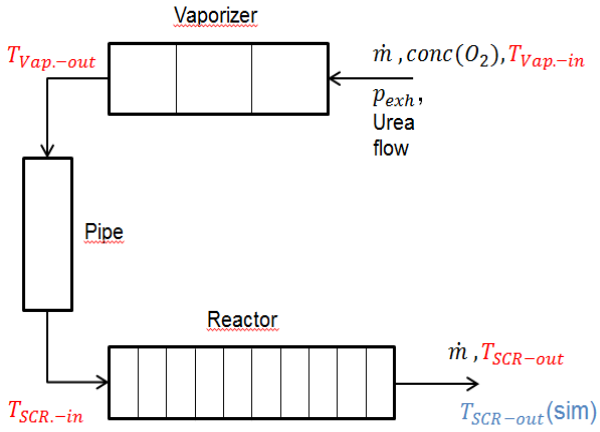


Objectives

- Improve NO_x reduction in non normative engine operation by expanding the operation range of NO_x reduction technologies

Current Status

- Detailed SCR model is created and validated
- SCR+Engine model is prepared
- EGR+Engine model is prepared



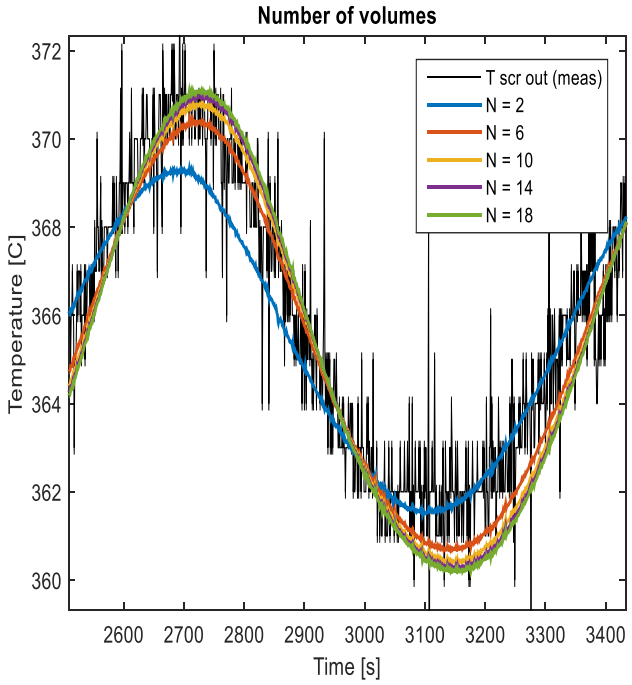
WP 6.4: Methods for evaluating engine performance via modeling and simulation

Next steps

- Further investigation of EGR models
- Compare models and validate against real life data
- Create a standard cycle to compare performance

Deliverables

- M36 - Test of EGR during maneuvers on sailing vessel



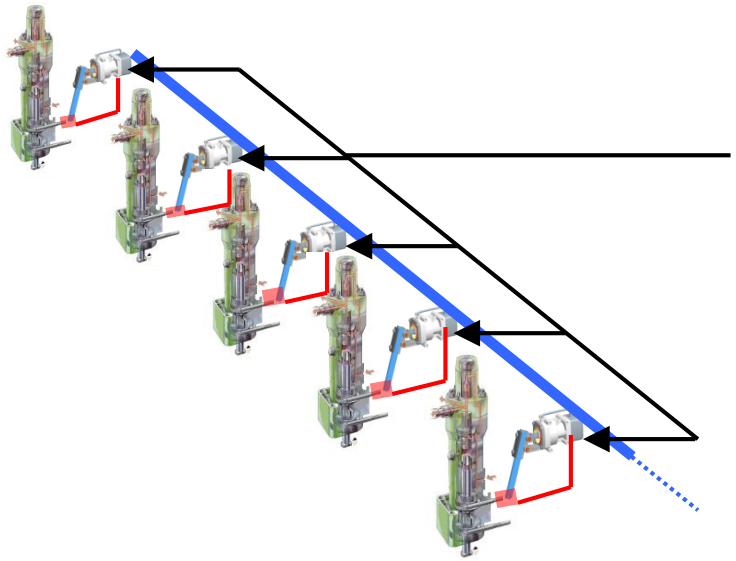
WP 6.5: Continuous combustion control & monitoring of mechanically controlled engines

Objectives

- Develop retrofit solution, incl. full scale demonstrator, for continuous engine performance optimization

Current Status

- Electronically controlled actuator for fuel injection: prototype sample designed and being produced
- Integration within the existing cylinder pressure measuring system designed



WP 6.5: Continuous combustion control & monitoring of mechanically controlled engines

Next steps / in progress

- Laboratory test rig
- Implementation of VIT control algorithms (integration with online cylinder pressure control)

Deliverables

- M24 - Full scale field test demonstrator installation

WP 6.6: Lifetime managed engine software deployment

Objectives

- Develop fleet solution for un-attended & secure engine software management

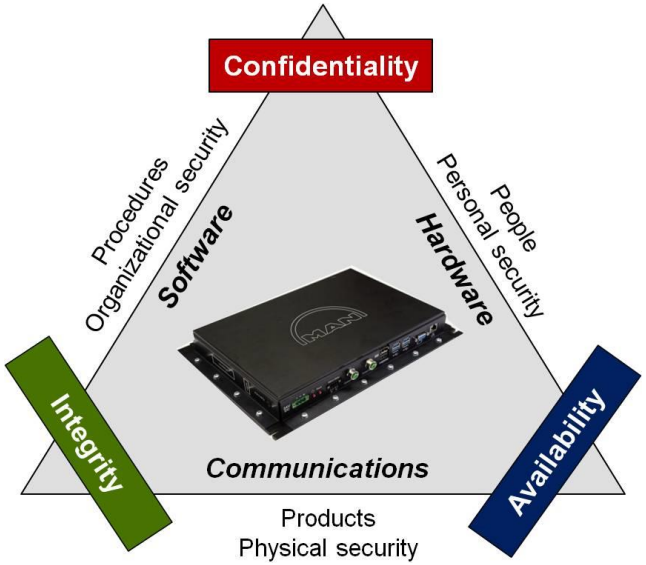
Current Status

- Robust and secure data transport mechanism
- Development of hardened secure onboard control system platform
- Design of strong identity provision between multiple partners
  - ➢ multifactor authentication
  - ➢ multilayer data encryption

WP 6.6: Lifetime managed engine software deployment

Next steps

- Development of production and deployment process of hardened secure onboard control system platform, including software and hardware
- Prototype implementation and verification of the solution for identity provision



Deliverables

- M36 - Validation of security scheme and lifetime software management process.

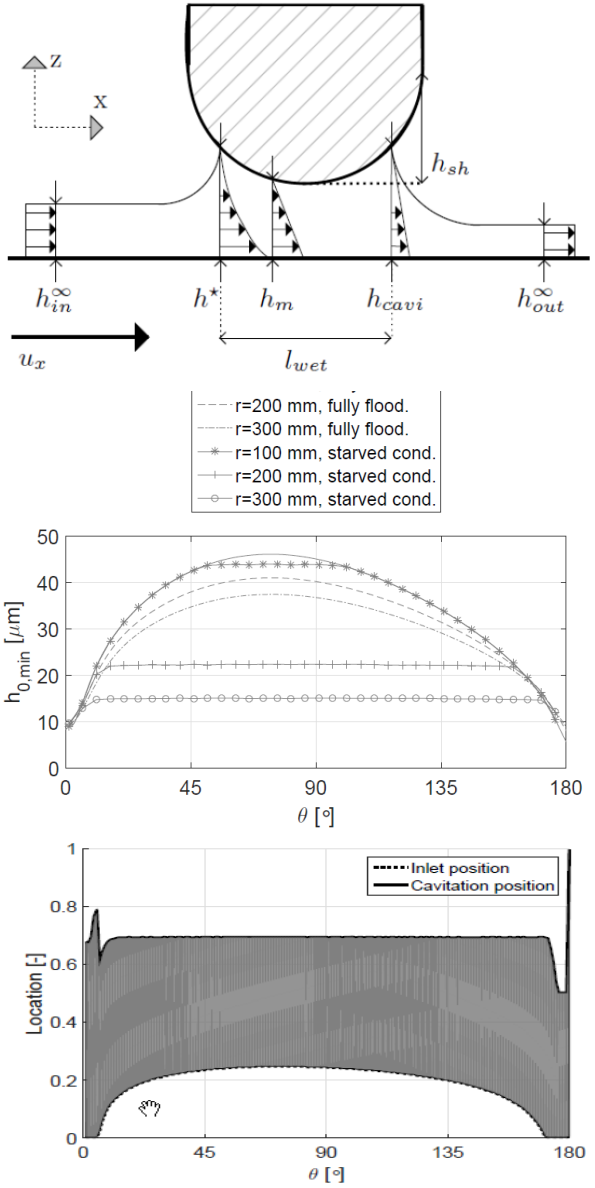
WP 6.7: Lifetime performance improvement by reduction of lubrication rate

Objectives

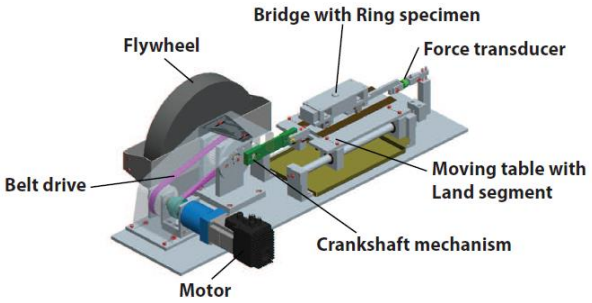
- Develop novel lube oil injection strategy in order to improve engine lifetime performance and cost

Current Status

- Preliminary investigation of existing lube injection system completed (experimentally)
- Model generation in progress
- Experimental investigation of oil film breakdown on DTU-test rig are carried out
- Modelling of oil flow of DTU- test rig (shape of the ring, available amount of oil in front of the ring)



WP 6.7: Lifetime performance improvement by reduction of lubrication rate

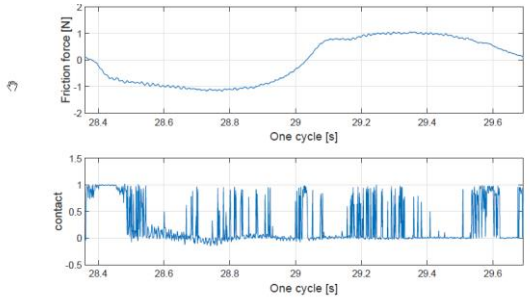


Next steps

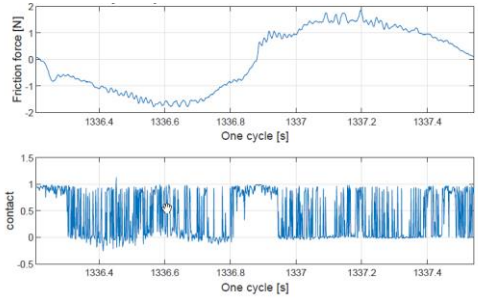
- Implement multi-ring mass flow balance into system
- Experimental investigation of oil usage in piston ring pack

Deliverables

- M36 - Parametric study of the net flow of oil in a piston ring pack (theory vs. experiment)



(a) Friction force and contact measurement after 20 cycles.



(b) Friction force and contact measurement after 1000 cycles.