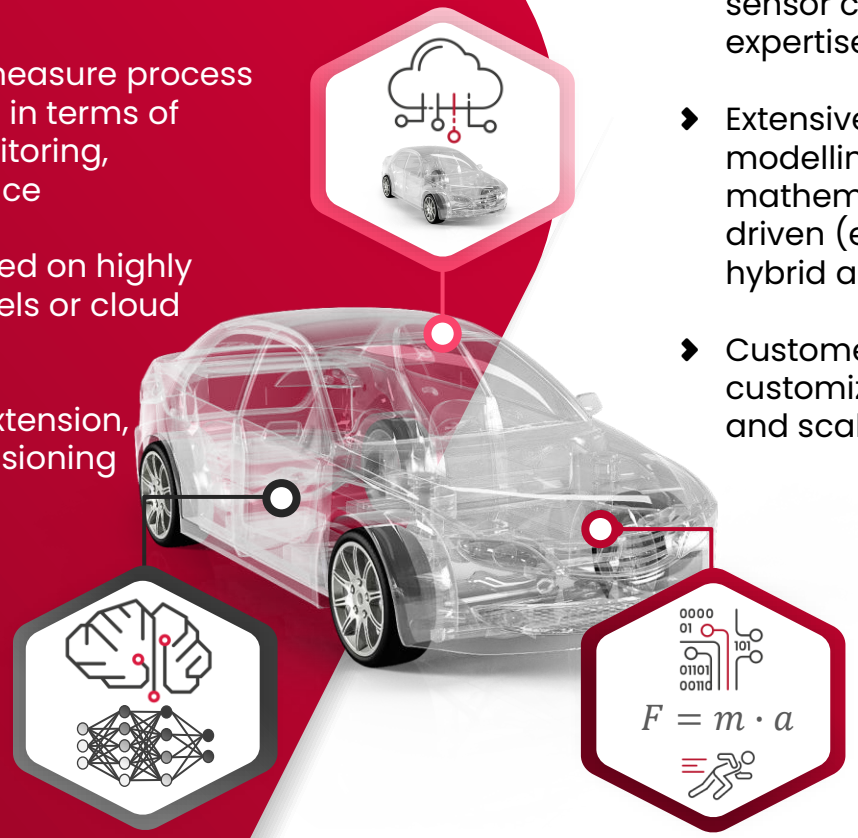
FEV Signature Solutions

Virtual Sensors for Controls and Diagnostics

Take control & monitoring of your system to the next level with our virtual sensors

FEV offers

- Emulation of physical sensors or hard-to-measure process variables, providing significant advantages in terms of system efficiency, costs and condition monitoring, additionally enabling predictive maintenance
- Virtual sensors for various applications based on highly accurate, real-time capable software models or cloud based solutions (digital twin)
- Additional services such as modification/extension, integration (incl. white box option), commissioning and calibration
- Already validated solutions applicable to automotive and non-automotive applications



Why FEV

- 45+ years of engineering excellence, trusted by global OEMs and Tier-X suppliers to deliver new sensor concepts with comprehensive system expertise in various technical areas
- Extensive experience with state-of-the-art system modelling and observation (physical or mathematical, Kalman Filter) as well as data driven (e.g. Neural Networks, Gaussian Process) or hybrid approaches
- Customer-centric solutions: Transparent and customizable, enabling you to extend, integrate, and scale your own development

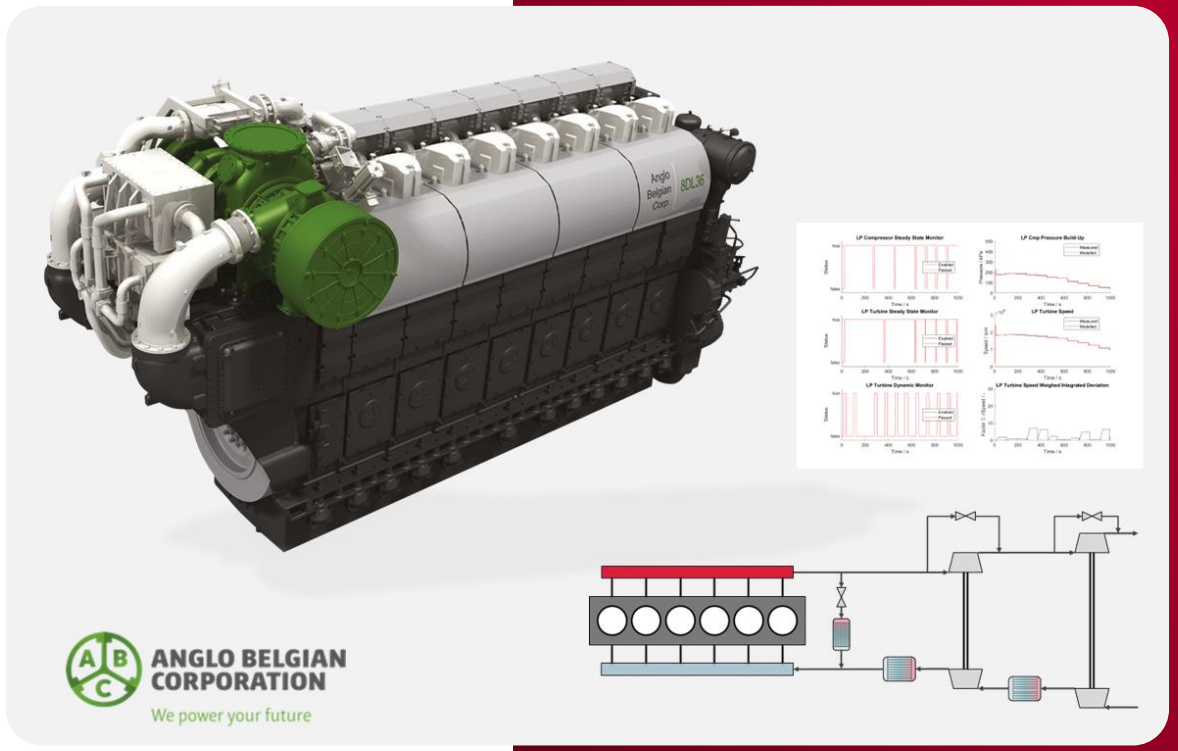
Reference project FEV propulsion
Courtesy of Anglo Belgian Corporation

SOFTWARE DEVELOPMENT AND INTEGRATION SUPPORT

- Implementation of model-based monitoring algorithms for various engine components using a digital twin

FEV involvement

- Development of model-based monitoring algorithms for various engine components
  - Fuel system (Pump/Injectors)
  - Pistons, valves, bearings
  - Turbocharger, wastegate
  - Charge cooler and bypass
  - Sensors (Pressure/Temperature/Speed)
- 6/8 cylinder inline engine
  - Dual-stage turbo charging
  - High/low temperature cooling circuits
- Digital twin
  - In-cylinder pressure-based combustion model
- Complete onboard environment
  - Information directly available
  - Simplified pinpointing

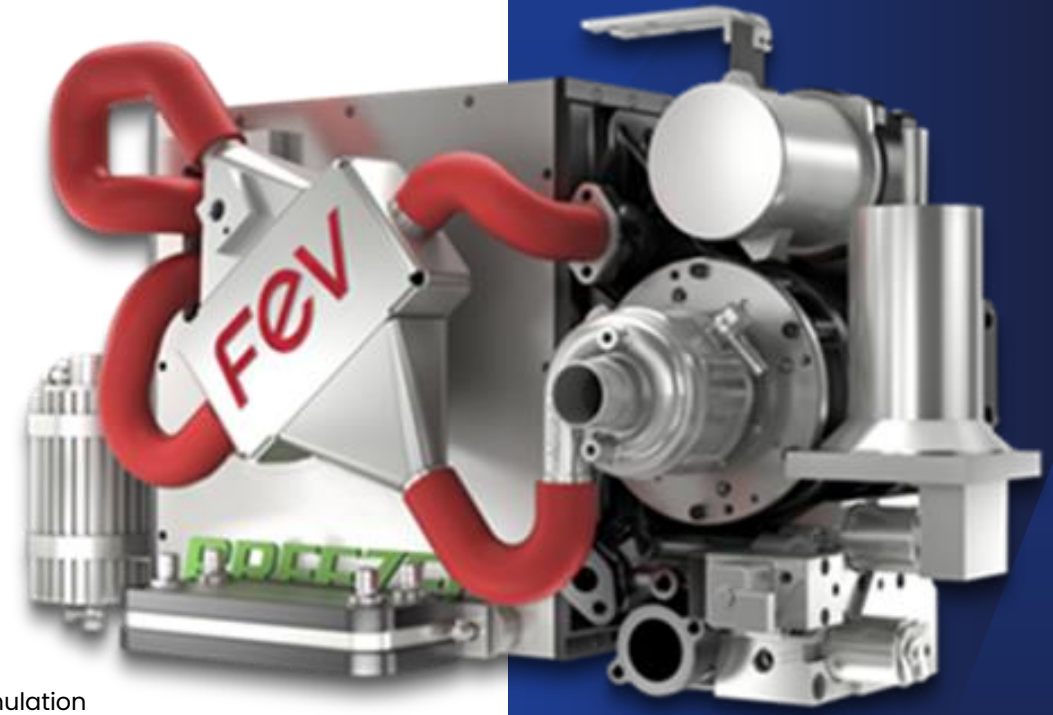


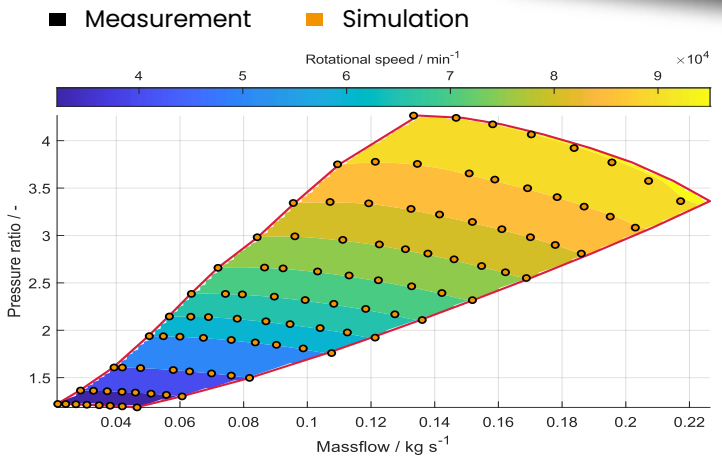
Reference project FEV aerospace
Virtual air mass flow sensor for fuel cell system

- FEV was development partner for a aerospace fuel cell system
- **Successful elimination of the air mass flow sensor**

FEV involvement

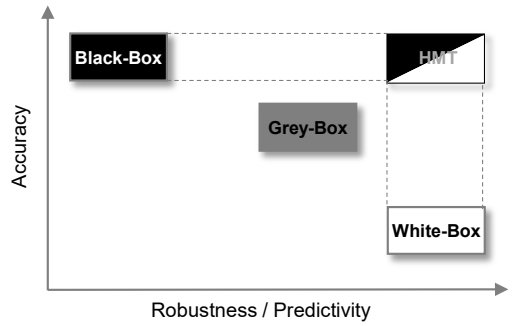
- Virtual Air mass flow sensor
  - Customer requires elimination of the air mass flow sensor from the fuel cell system due to package constraint
  - Development of a control unit function to calculate the air mass flow based on other measured input
  - FEV's virtual air mass flow modeling approach based on redesigned compressor maps was used to calculate:
    - Corrected air mass flow
    - Compressor compression ratio
    - Compressor efficiency





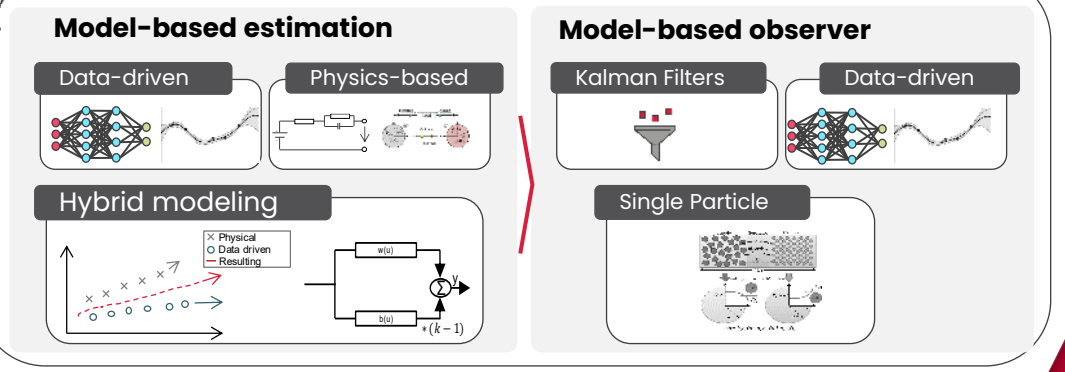
Our approach for full accuracy / robustness potential - hybrid models

Schematic classification of models



- Black-box models show high accuracy in trained area but lack extrapolation capability
- White box models show good extrapolation capability

Hybrid Modeling approach



- Hybrid models exploit the full accuracy/robustness potential of both black- and white-box models
- Generic model layout consisting of the following elements:
  - Combination of data-driven (Neural Networks / Gaussian Process) and physics-based models
  - Decision logic to weigh the impact on the model output
  - Continuously training black-box model with selected data from fleet. Training can be performed on the embedded system or in the backend.
- Technology can be applied to all process models used for control or diagnostic purposes, e.g.:
  - State-of-Health modelling for battery systems based on cyclic and calendric aging allowing for an improved battery usage and increased lifetime
  - NOx emissions, temperatures, states of the exhaust aftertreatment system considering various aging effects

Get in touch with us for further information

www.fev.com/en/signature-solutions