FEV Signature Solutions

AI-Driven Anomaly Detection for Diagnostics & Predictive Maintenance

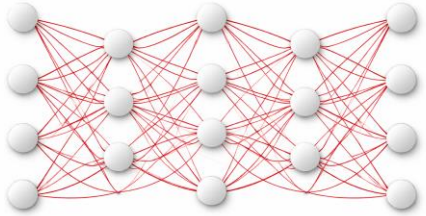
Improve service and reduce downtime as well as maintenance cost of your product

FEV offers

- Next generation diagnostics and predictive maintenance solutions leveraging physical or data driven models - with white box option
- Different model types tailored to the system and available data:
  - Physical system models
  - Cutting edge deep learning models (diffusion models) coupled with established methods like Generative-Adversarial-Networks (GAN) or Variational-Autoencoder (VAE)
- Customization for key predictive maintenance applications: anomaly detection, fault pin-pointing, remaining useful life estimation

Why FEV

- 45+ years of engineering excellence, trusted by global OEMs and Tier-X suppliers to deliver innovative, production-ready solutions with deep domain expertise
- Deep expertise in both domain knowledge and applied data science
- Complete lifecycle support - From concept to production, including design, simulation, prototyping, testing and deployment
- Customer-centric solutions - Transparent and customizable, enabling you to extend, integrate, and scale your own development



Reference project FEV propulsion

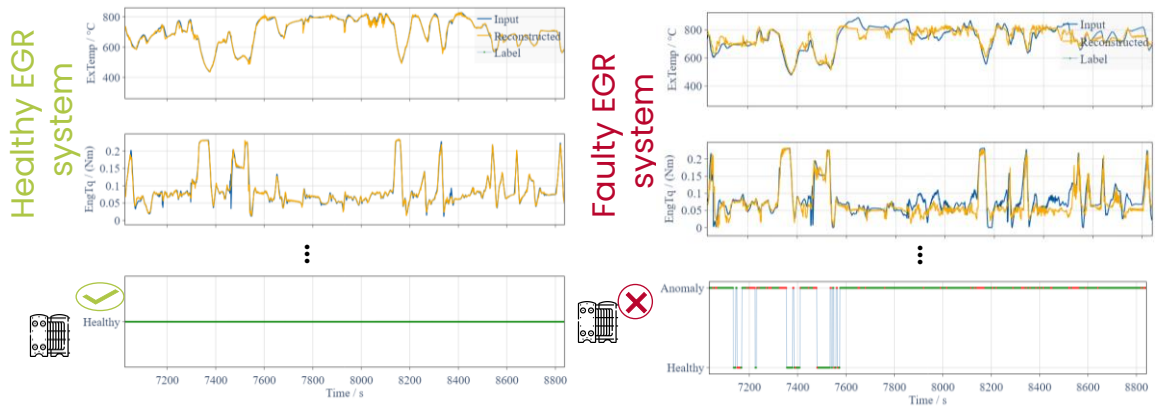
Unsupervised machine learning models for anomaly detection in IC engines / Next generation diagnostics

BACKGROUND: Detecting anomalies in powertrain systems is of high value to identify critical errors at an early stage. Healthy behavior can be described, e.g. by fleet data or the system's validated healthy behavior. Machine learning models were developed that learn healthy behavior based on unlabeled data.

Results

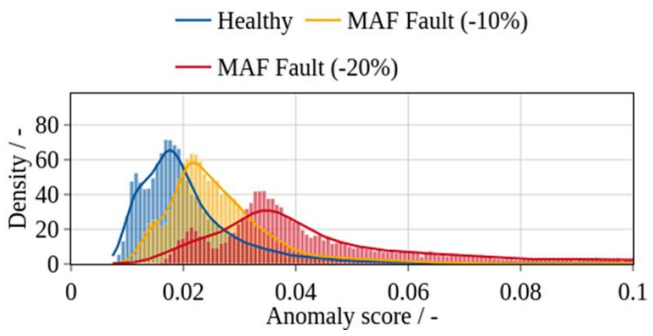
- Development of a simulation platform for emission-relevant fault investigation
- Development of generic training framework for unsupervised training of Variational Autoencoder (VAE)
- Development of VAE model with following requirements
  - VAE only trained based on *healthy* (i.e. expected) data
  - VAE to detect anomalies that have NOx impact
  - Two faults (EGR cooler fault, air mass flow sensor drift) used for validation
  - Next to detection of abnormal patterns in the time-series, ability to detect gradual system changes by VAE (e.g., due to faults with low severity)
- Analysis of the data representations of intermediate layers of VAE to support pinpointing of the present fault
- Hyperparameter search under evaluation of classification metrics

Identification of abnormal patterns

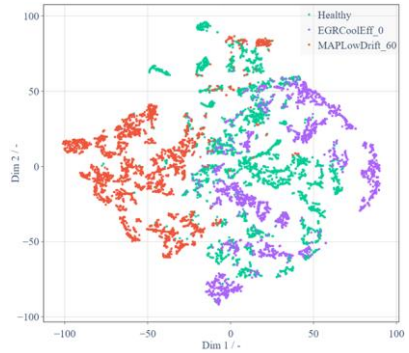


Classification metric[1]	EGR fault	
Accuracy	83.5 %	"How many samples were correctly predicted"
Precision	81.0 %	"How many of the predicted anomalies where actually abnormal?"
Recall	97.7 %	"How many of the actual anomalies where detected?"

IDENTIFICATION OF GRADUAL ANOMALIES



PINPOINTING THE FAULT



 | [1] Note: These metrics strongly depend on what we are considering to be *abnormal*

Reference project FEV propulsion
Courtesy of Anglo Belgian Corporation

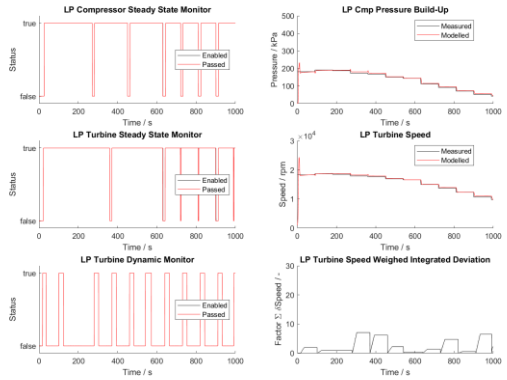
ANGLO BELGIAN CORPORATION [1]
We power your future

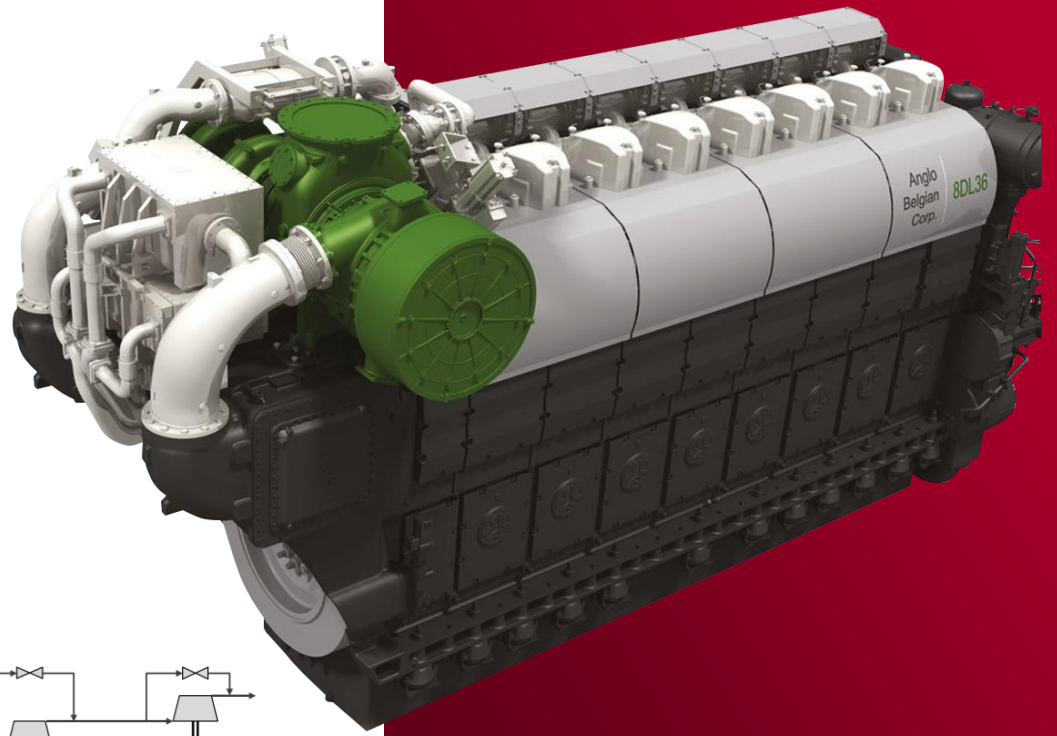
FEV propulsion

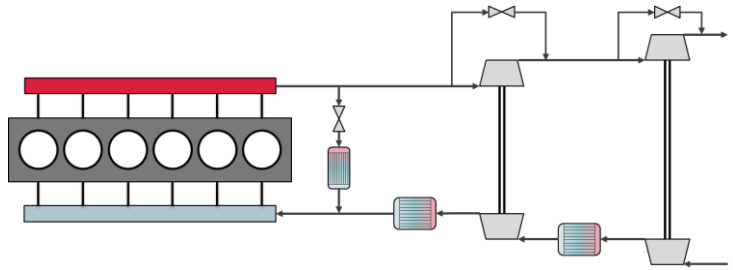
POWERTRAIN ENGINEERING

FEV involvement

- Monitoring algorithms for various engine components using a digital twin
  - 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







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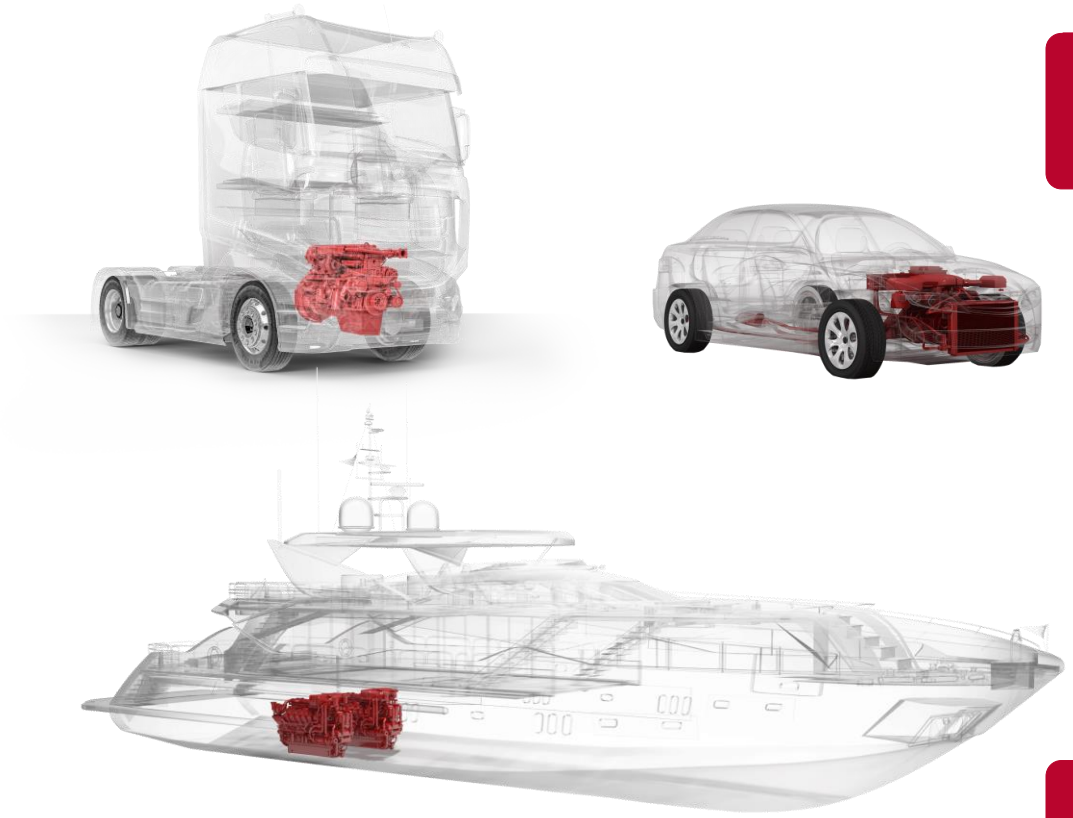
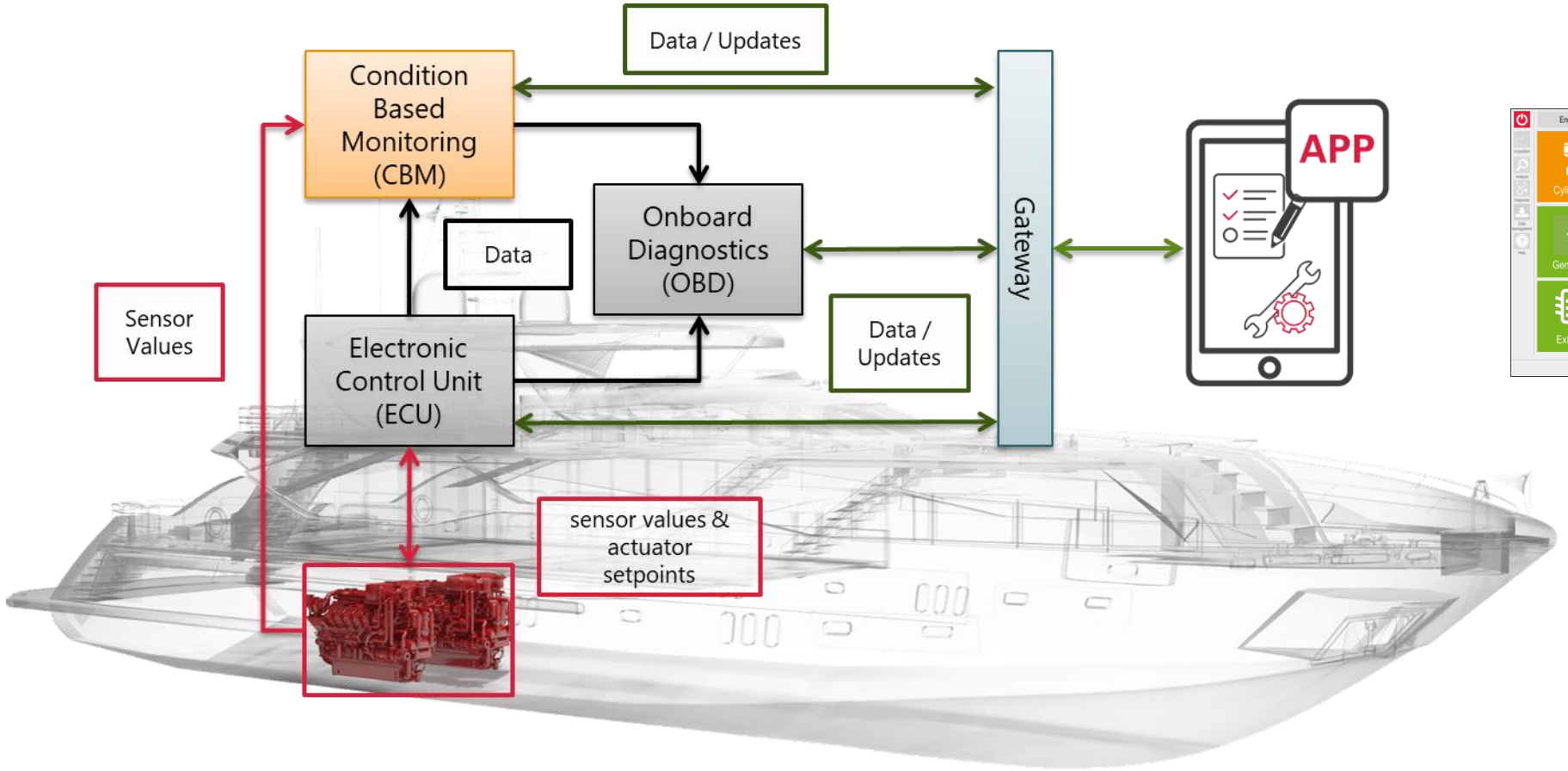
CORE FEATURES AND PIPELINE: FROM DETECTION TO PROGNOSIS



Predictive Maintenance	Monitor system condition and predict future failures based on a digital twin, enabling maintenance actions to be performed just in time.
Anomaly Detection	Identify abnormal behavior at an early stage by detecting deviations or irregular patterns, based on autoencoders, clustering and statistical methods.
Failure Pin Pointing	Verify the presence of a fault and determine its origin to assist maintenance and workshop teams.
Remaining Useful Life Estimation	Estimate the remaining operational lifespan of the system or component.
Digital Twin	Models based on physical principles and/or data driven approaches.

Illustrative example for real-time system condition monitoring



Get in touch with us for further information

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