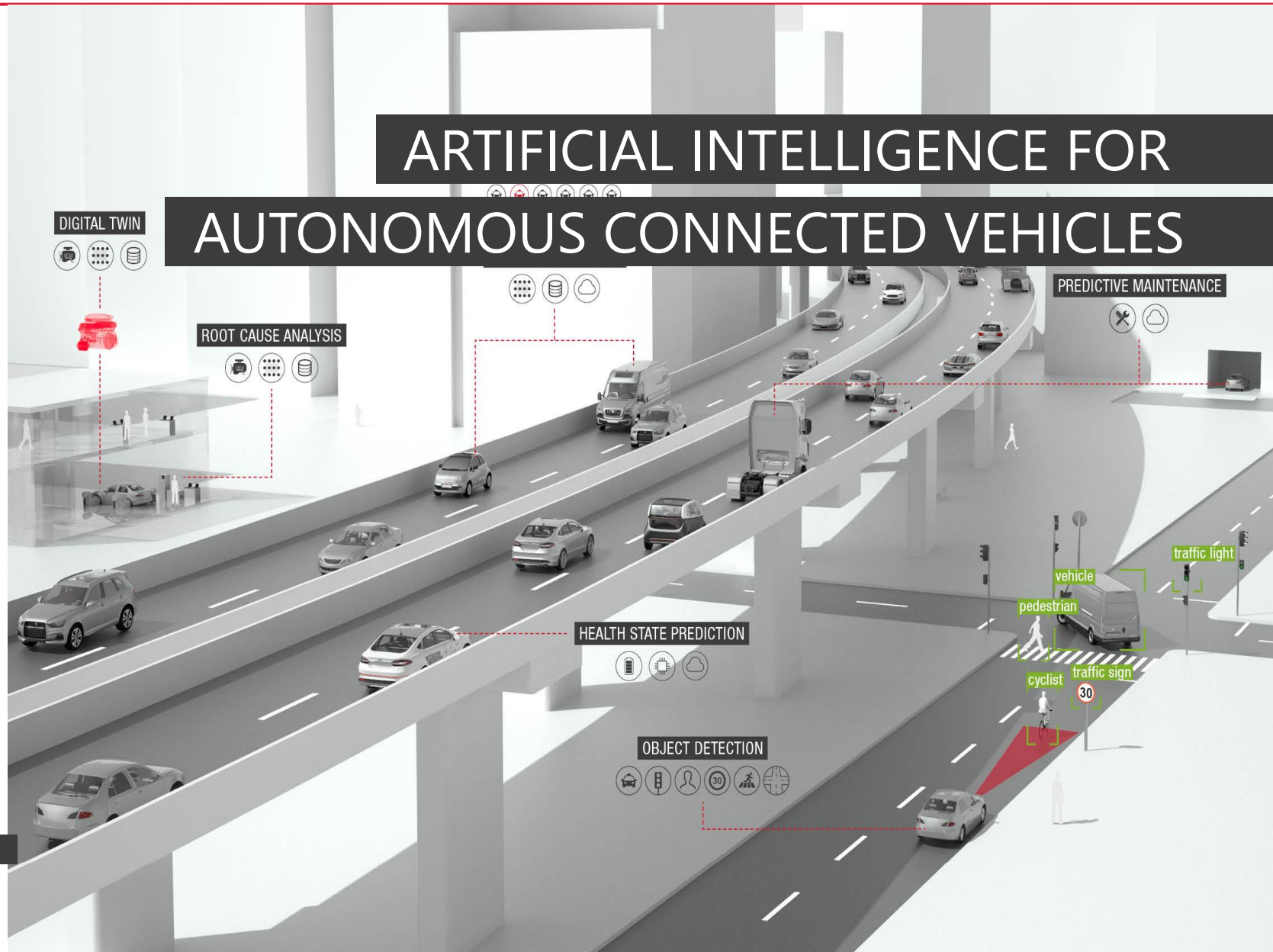
TORINO, 18.11.2021

ANDREA SANGUEDOLCE

PREPARED FOR

ITALY – CANADA CHAMBER OF COMMERCE

ARTIFICIAL INTELLIGENCE FOR AUTONOMOUS CONNECTED VEHICLES



Your Engineering and Consulting Partner

STRONG, COMPETENT AND RELIABLE

735 M€
Revenue in 2019

~200
Patent applications per year

42+
Subsidiaries on four continents

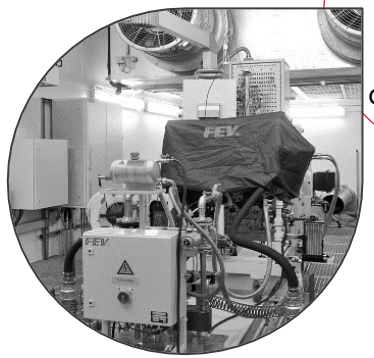
6,700
Employees globally

300+
Test cells for engines, T/M, e-drives, fuel cells & batteries

>40
Years of experience

>70%
Academics

>50
Different nations



Your engineering and consulting partner for the development of mobility

BUSINESS UNIT INTELLIGENT MOBILITY & SOFTWARE AS KEY AREA FOR AI APPLICATION

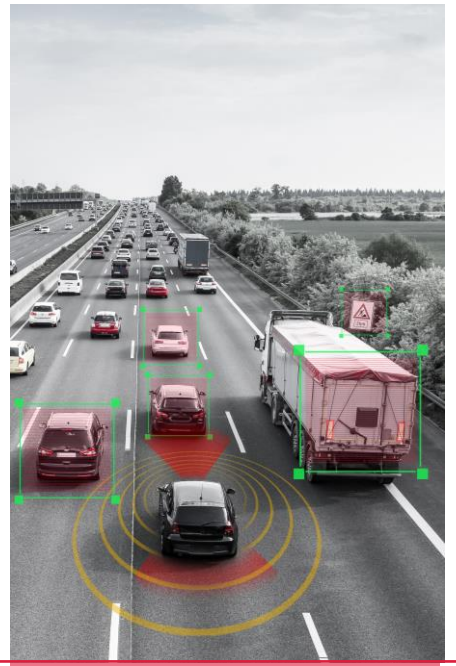
Vehicle Development

Powertrain Development & Electrification

ICE

hybrid

electric



Intelligent Mobility & Software

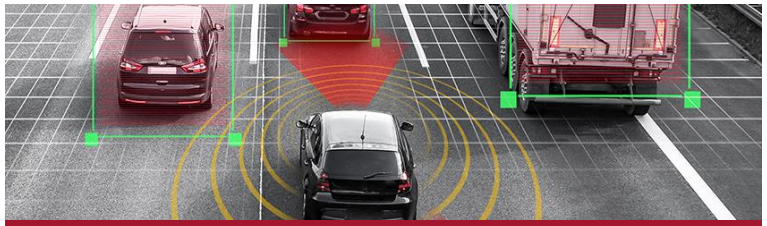
Consulting

Software & Testing Solutions

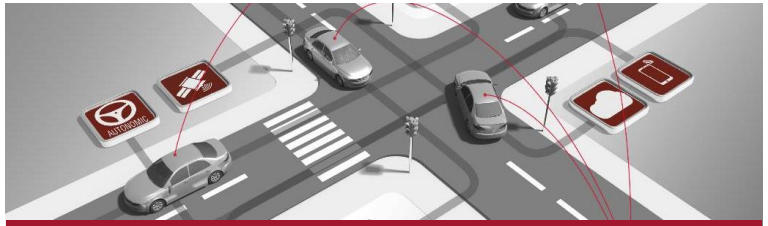
Business Unit Intelligent Mobility & Software

HOLISTIC COMPETENCE AND SYNERGIES NEED TO TACKLE FUTURE MOBILITY DEVELOPMENT

End customer experience of intelligent Mobility



Assisted and Automated Driving



Connected Mobility

Systematic, safe and secure Development Process

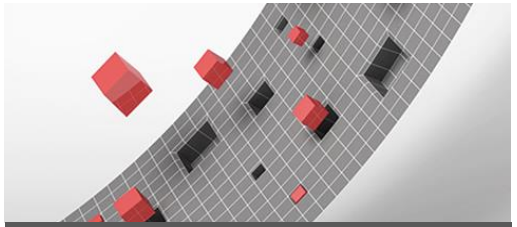
Systems Engineering

Functional Safety

Cybersecurity

Professional system integration & test

(Vehicle) Electronics



Software

Data Science

FEV combines Data Science and Automotive Domain Expertise

FROM DATA ACQUISITION TO APPLICATION DEPLOYMENT

Data Science
Extract information from data to answer questions or solve problems

Artificial Intelligence
Algorithms independently and automatically solve tasks which would usually require human intelligence

Machine Learning
Algorithms independently and automatically solve tasks by learning from data in an intelligent manner

Deep Learning
Machine Learning with models that have a deep structure (= many layers); usually involves Deep Neural Networks

Domain Expertise
Technical expert knowledge for automotive engineering

Data Science Services provided by FEV

DATA SCIENCE SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, DEEP LEARNING	ALGORITHM DEVELOPMENT FOR DATA ANALYSIS AND MODELING	DATA ANALYSIS & DATA MINING SERVICES
SEAMLESS INTEGRATION OF DATA SCIENCE SOLUTIONS INTO BACKEND SERVICES	**DATA SCIENCE**	ON-BOARD AND OFF-BOARD SOLUTIONS
VISUALIZATION & REPORTING	DATA SCIENCE PROCESS CHAIN DESIGN	TECHNICAL CONSULTING

Data Science as Key Technology

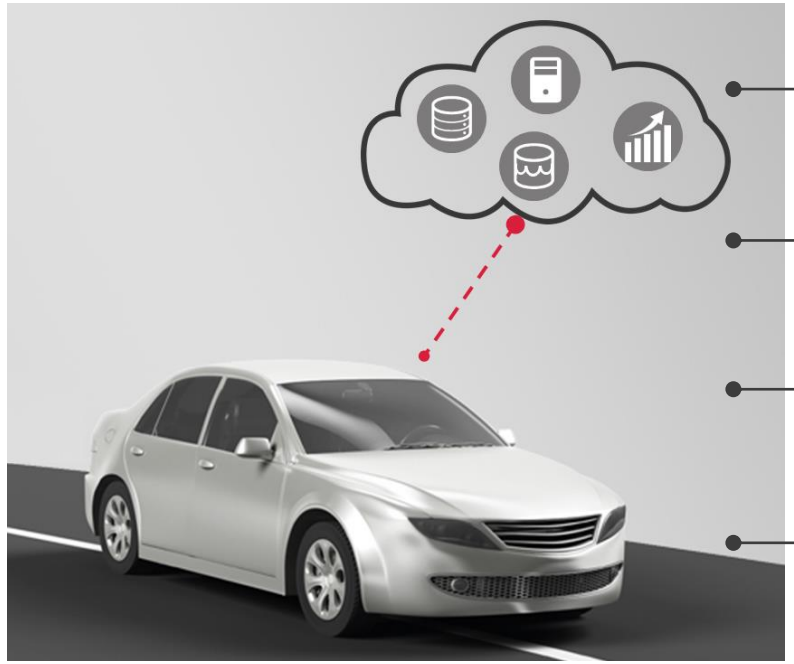
DATA SCIENCE AS ENABLER TO LEVERAGE THE POTENTIAL OF BIG DATA

A definition of Big Data

- Large amounts of data that cannot be processed efficiently with traditional applications
- Often impossible to be stored in the memory of a single computer

Benefits

- Big Data alone does not bring any benefit
- Data Science as key technology to leverage the potential of data
- The more specific the data and the clearer the objectives the larger the lever for Data Science



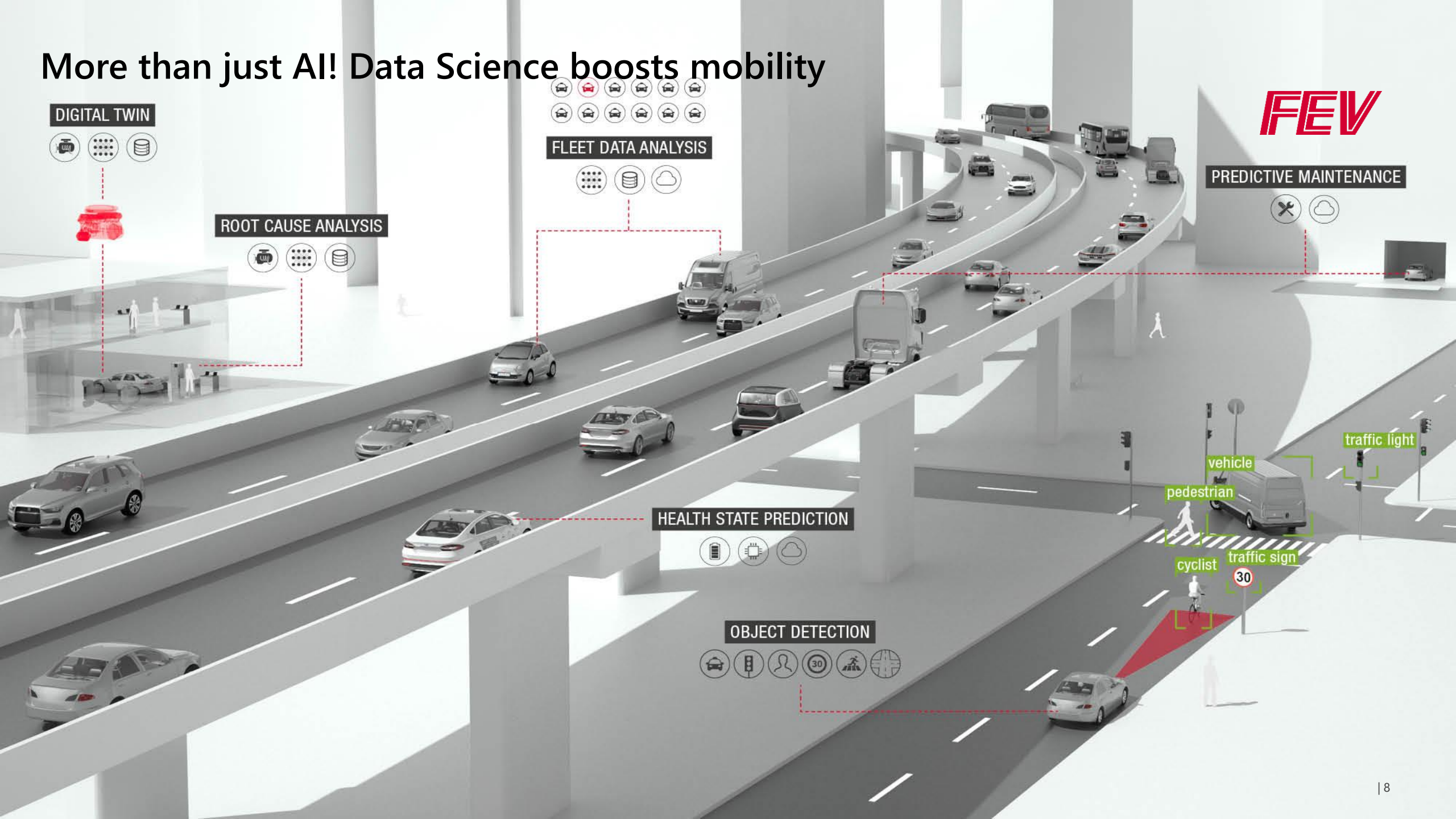
STATISTICAL ANALYSIS OF RDE DATA

OFF-BOARD ROOT CAUSE ANALYSIS

ADAS SYSTEMS TRAINING AND VALIDATION

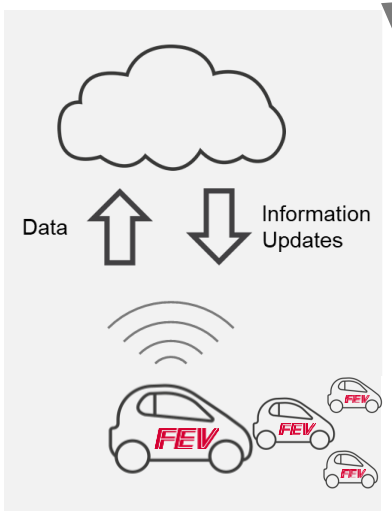
STATE OF HEALTH PREDICTION

More than just AI! Data Science boosts mobility



FEV Data Engineering and Data Science Development Process

FROM DATA ACQUISITION TO APPLICATION DEPLOYMENT II



Data Analysis
Modeling
Optimization
Data Science

Domain expertise
Automotive grade application know-how
Automotive Engineering

BUSINESS

System Analysis
From requirement to validation criteria definition

Data Acquisition
From architecture to filtered data storage

Data Analysis
From statistics evaluation to insight representation via data enrichment

Algorithms
From algorithm design to predictive capabilities

Deployment
From HMI interface design to backend solution integration

APPLICATION

Intelligent Mobility & Software AI projects – 1

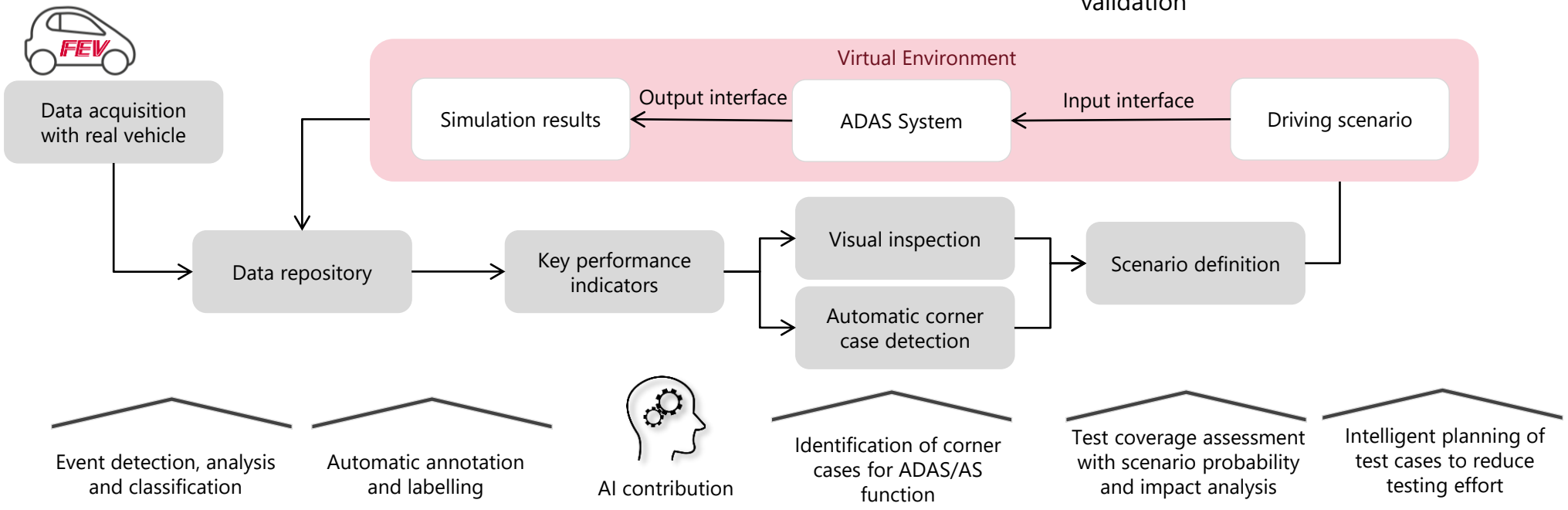
TRAINING AND VALIDATION FOR AI BASED FUNCTIONS IN ADAS SYSTEMS

MOTIVATION

- Testing & Validation of **ADAS/AD functions ≥ SAE 3** is an industry-wide challenge
- Application of massive parallel execution of **digital twin**

APPROACH

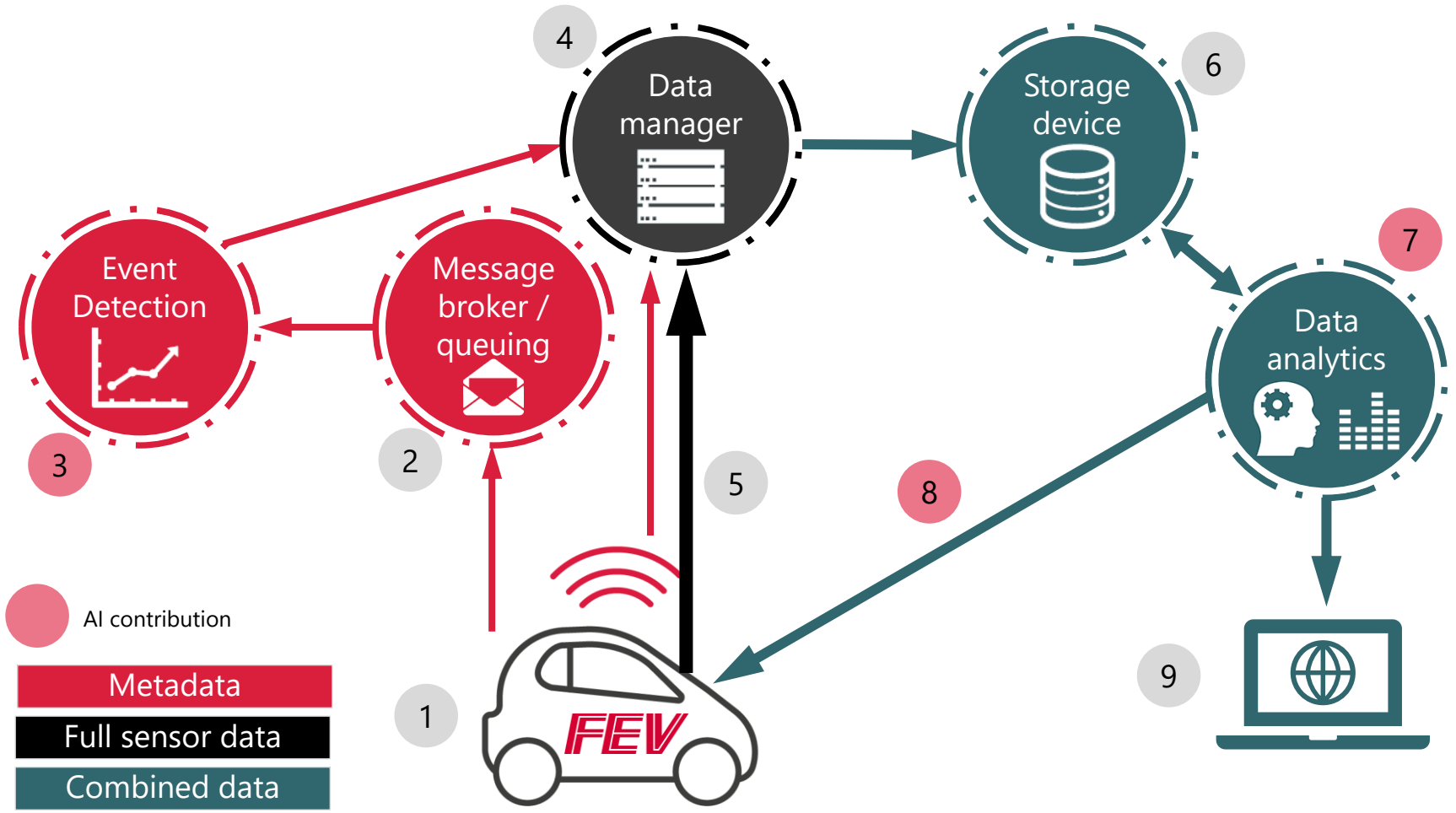
- **Scenario-based approach** used as framework for methodology development including **data science methods for identifying corner cases, weakness detection, etc.**
- Realization of **virtual environment** and interfaces for training and validation



Training and validation:
Project KImaDiZ partners

Intelligent Mobility & Software AI projects – 2

INTELLIGENT DATA COLLECTION FOR AUTONOMOUS VEHICLES



1. Offline acquisition within FEV ADAS vehicle
2. Live data acquisition in cloud
3. Data preprocessing and event detection
4. Data manager
5. Secure data transfer from vehicle through data management
6. Data division to cloud storage
7. Data analysis of overall data
8. Update algorithms
9. Web-interface for signal and video validation

Source: FEV

Intelligent Mobility & Software AI projects – 3

BATTERY LIFETIME ESTIMATION IN BATTERY MANAGEMENT SYSTEMS

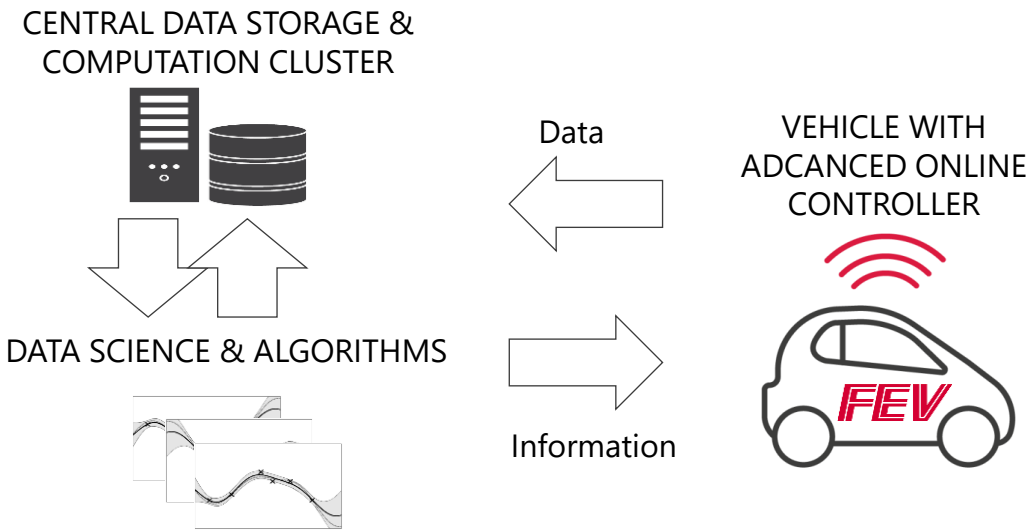
STATE OF THE ART

- Physical or empirical models for State Of Health (SOH) estimation (e.g. Equivalent circuit models, electrochemical models)
- On-board computation of SOH estimation

DATA SCIENCE BASED APPROACH

- Increasing model accuracy by **integration of ML approaches**
- Continuous on-line **model improvement** and **additional data** e.g. temperature, road conditions, typical driving behavior.
- **On cloud** computation for additional computational resources

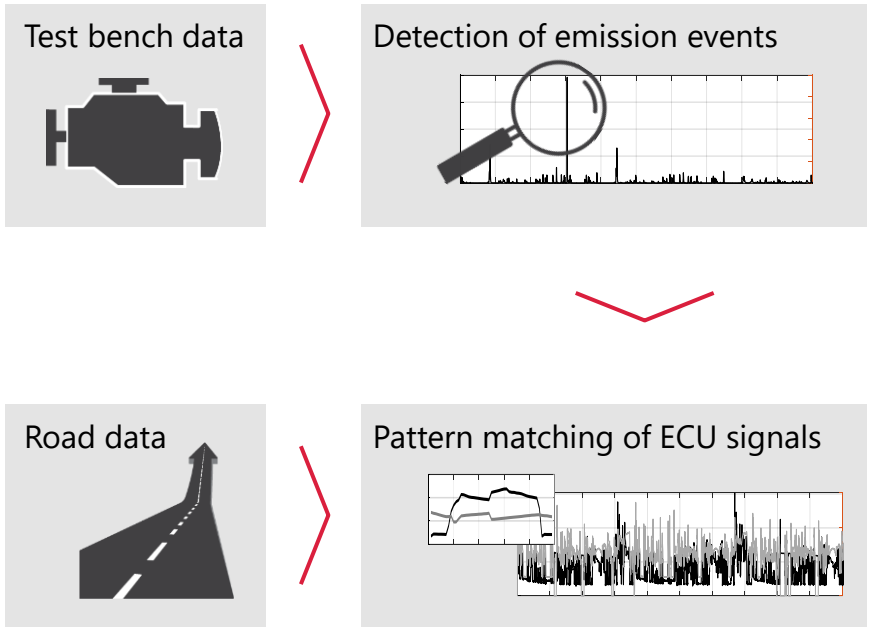
From on-board controller to advanced online controller



Intelligent Mobility & Software AI projects – 4

AUTOMATIC STATISTICAL EVALUATION OF EMISSION EVENTS FOR RDE CYCLES

FROM TEST BENCH DATA TO ROAD DATA



DATA SCIENCE FOR EVALUATION OF EMISSION EVENTS

Work scope

- Create emission critical RDE cycle with high relevance with respect to regular driving

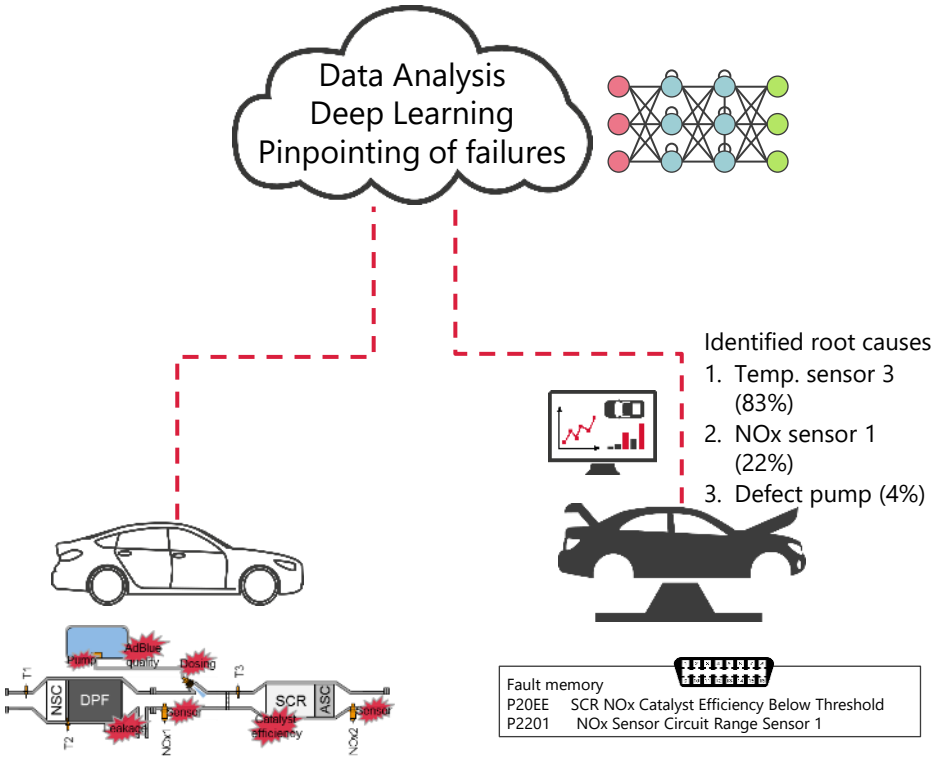
Solution

- Automatic detection of emission events
- Reveal structure in data by creation of data clusters with similar signal profiles
- Assessment of statistical relevance of events by identification of similar patterns in real world driving data
- Identification of conspicuous signals with anomalies in the signal profile

Intelligent Mobility & Software AI projects – 5
Prediction of Root Causes for Malfunctioning SCR System

PREDICTION OF ROOT CAUSES FOR MALFUNCTIONING SCR SYSTEM

VEHICLE TO CLOUD TO WORKSHOP



DEEP LEARNING FOR PINPOINTING OF ROOT CAUSES

Work scope

- SCR system malfunctions can trigger multiple fault code entries
- Assisted identification of actual failure causes at workshop

Solution

- Root cause analysis for pinpointing to actual failures
- Recurrent Neural Networks for identification of characteristic patterns in time series data
- Training with various simulated failure patterns for defective NOx sensors, overdosing, underdosing,… on different cycles (>1e6 data points)

SCR = Selective catalytic reduction

FEV Data Science and Artificial Intelligence Competence

FEV AI AND DEEP LEARNING COMPETENCE

EXPERIENCE AND EXPERTISE

Data Science Related Project Experience:

- 30+ OEM projects

Data Science Related General Experience:

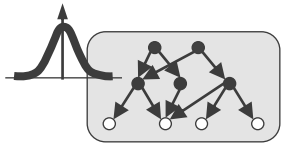
- 10+ years of experience in the development and implementation of Data Science, AI, Machine Learning, and Deep Learning applications
- 10+ years of experience from proof of concepts up to professional software and product development in the field of Data Science, AI, Machine Learning, and Deep Learning

Data Science Related IP:

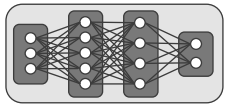
- 50+ patents and publications in the field of Data Science, AI, Machine Learning, and Deep Learning

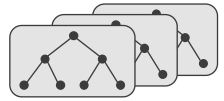
COMPETENCE PORTFOLIO

Data Science and AI Competence:



- Data Mining and Data Analysis
- Feature Extraction and Feature Analysis
- Unsupervised and supervised Machine Learning
- Deep Learning
- Reinforcement Learning
- Regression and Classification
- Optimization





Intelligent Mobility & Software AI projects

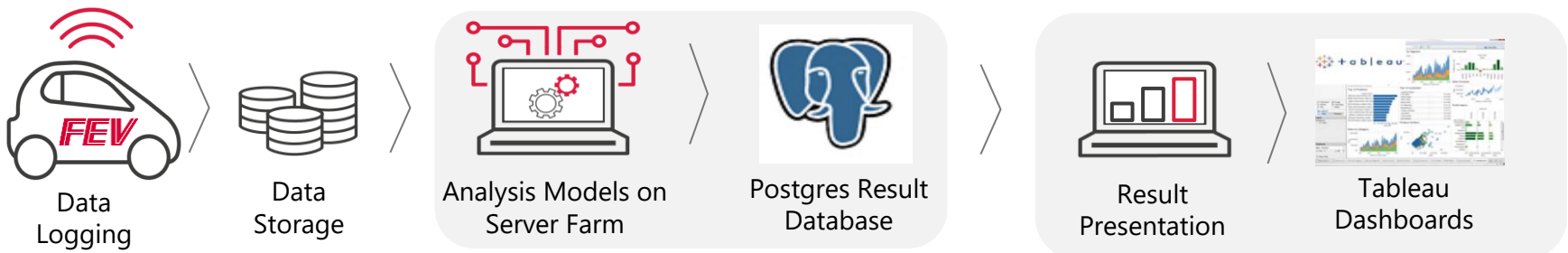
BIG DATA ANALYSIS FOR BATTERY ELECTRIC VEHICLES AND PLUGIN HYBRIDS

MOTIVATION

- More efficient usage of existing data (also from weekend drives etc.)
- Reduction of sources for human error
- Automatic evaluation of logger data without loss of information
- Possibility to extend analyses to multiple data sources (test bench data, further vehicles)

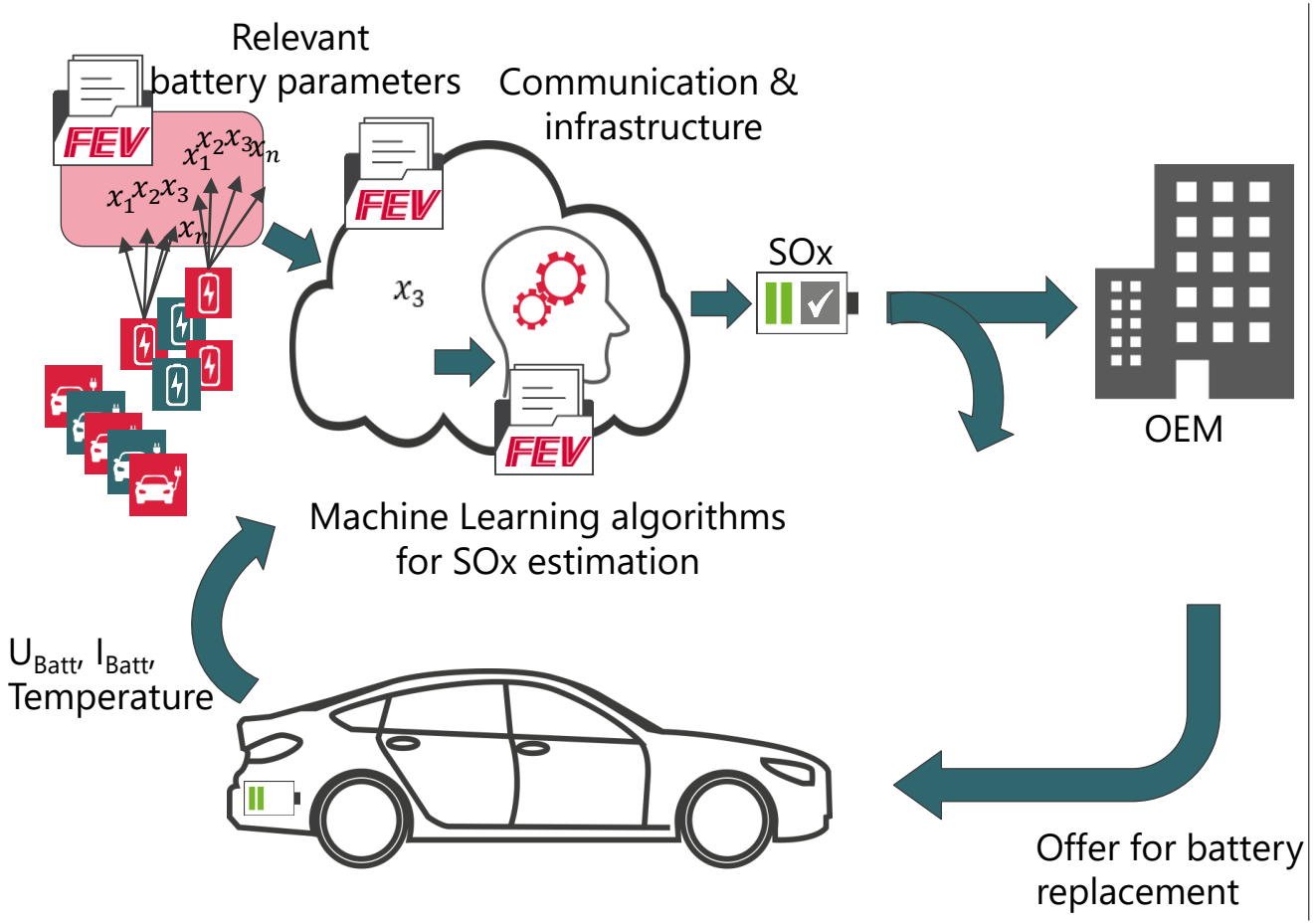
APPROACH

- Increase of robustness for testing and validation
- Targeted analysis with reliable statistical evaluations
- Multiplication of expert knowledge by applying it to large database



Intelligent Mobility & Software AI projects

MACHINE LEARNING AND OFF-BOARD COMPUTATION FOR BMS



- Assessment of different kinds of Machine Learning approaches for SOx prediction, e.g.
  - Neural networks
  - Support vector machines
- Assessment of different kinds of setups, e.g.
  - Direct modelling
  - Observer-correction approach
- Comparison of off-board and on-board solutions
- Analysis of backend toolchain
- Analysis of boundary conditions for FOTA functionality

Source: FEV

SOx = State Of (Charge, Health, …), BMS = Battery Management System, FOTA = Firmware Over-The-Air