



Making Use of Connected Car Data

Reducing Warranty Costs and Improving Uptime

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Today's Presenters



Milan Zivadinovic

Master of Science

Lead Engineer
Data Science

Data Science expert for
engineering challenges

More than 7 years with AVL



Gerhard Schagerl

Master of Science

Product Line Manager
Data Intelligence

Market and customer focused
data business enthusiast

20 years in automotive industry

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Today's Agenda

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About AVL

2

Motivation

3

Project example

4

Summary

Facts and Figures



Global Footprint

Represented in 26 countries

45 Affiliates divided over 93 locations

45 Global Tech and Engineering Centers (including Resident Offices)

1948

Founded

11,000

Employees Worldwide

12%

Of Turnover Invested in Inhouse R&D

70+

Years of Experience

65%

Engineers and Scientists

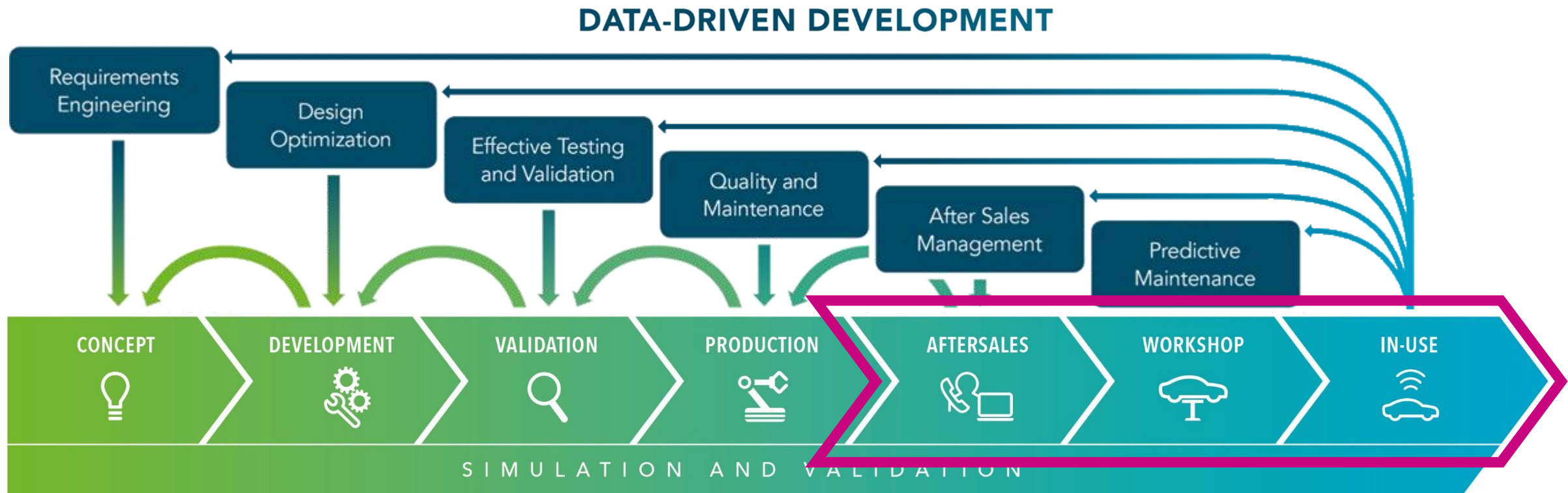
2,500

Granted Patents in Force

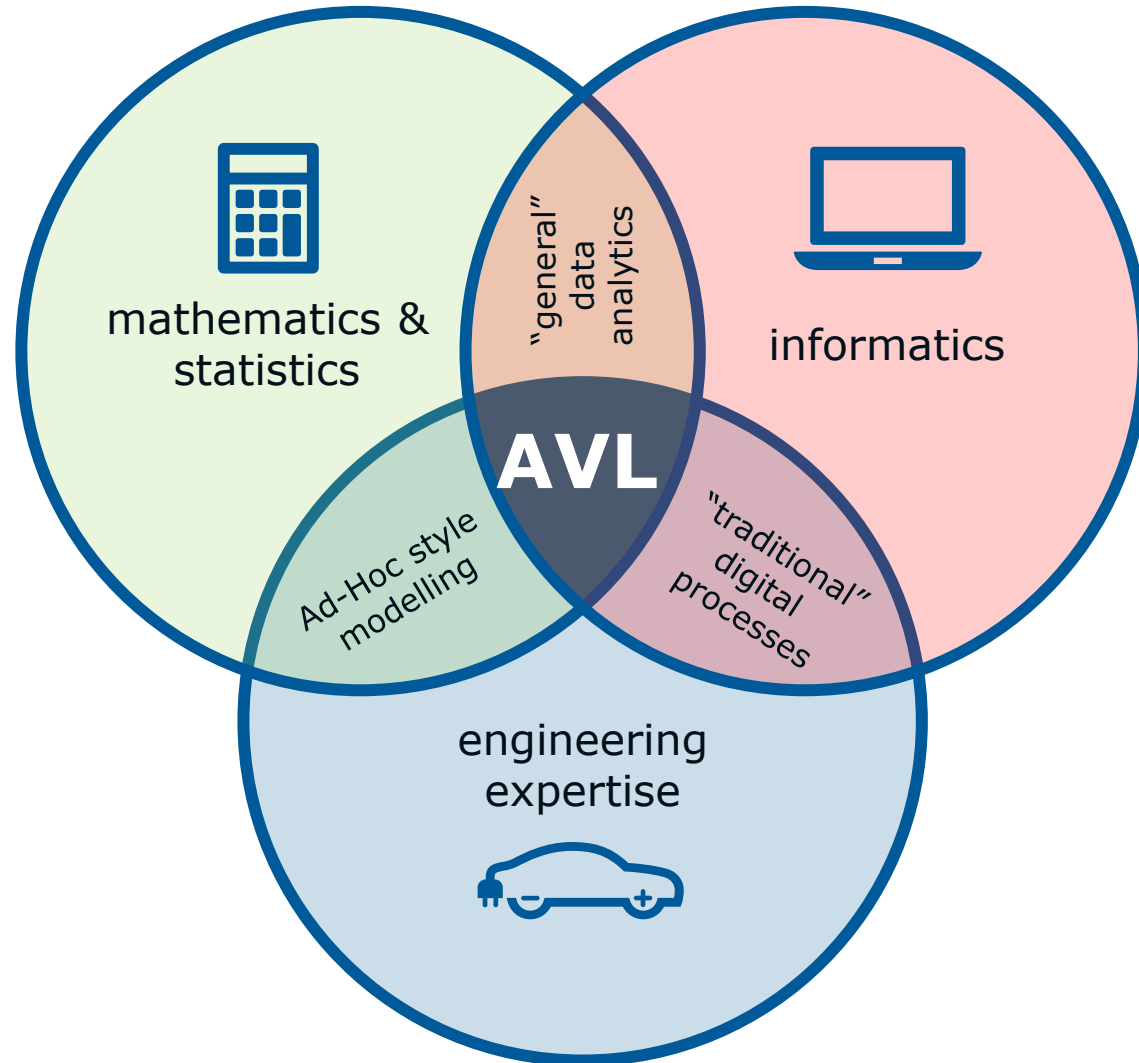
97%

Export Quota

Data Intelligence across the Product Life Cycle



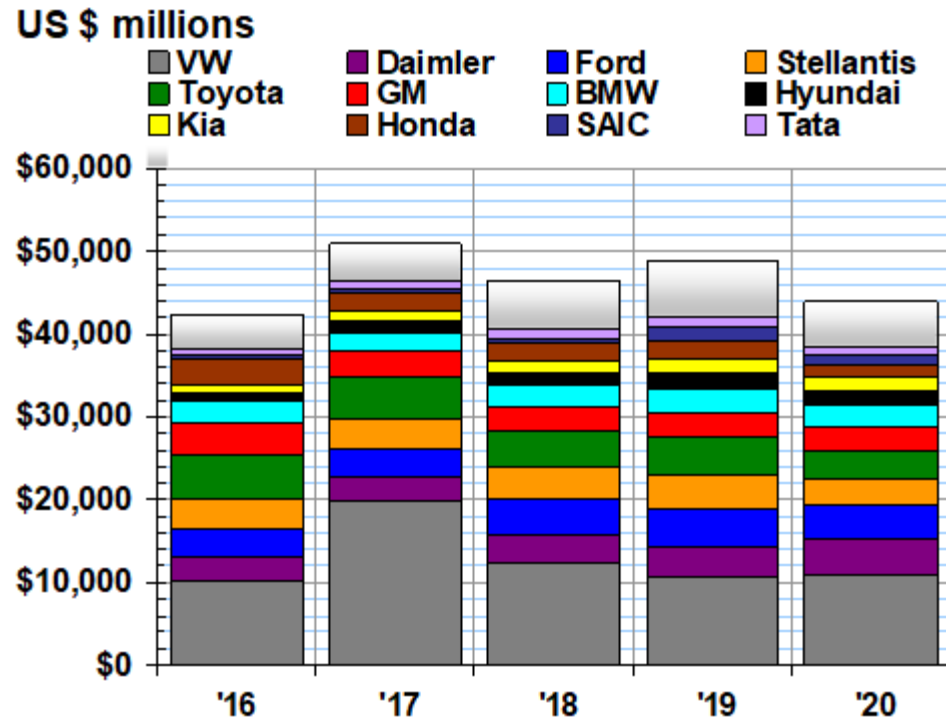
Required Competences



Motivation

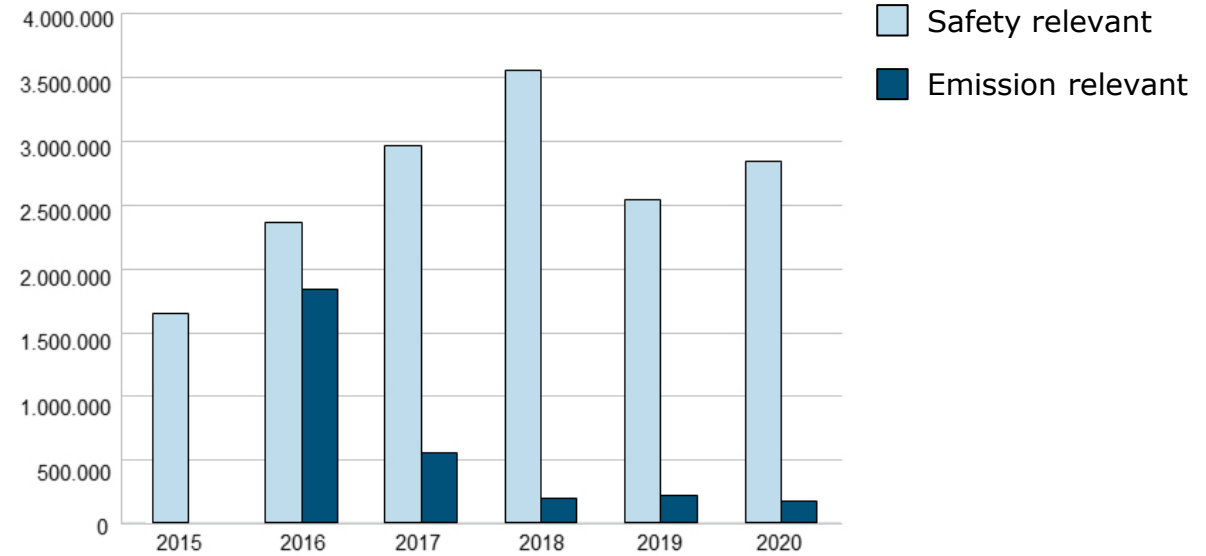
- General **growth in data volume** due to rising trend for vehicle in-use connectivity solutions
- **Increased complexity** of systems lead to complex cause-effect chains
- Growing quality & reliability **expectations** by customers
- **Availability of machine learning** and data mining **technologies**

Warranty Claims Lead to Billion Dollar Expenses Every Year



Source: WarrantyWeek

Recall Actions - affected vehicles in Germany



Source: Kraftfahrt-Bundesamt

Warranty claims in the automotive industry have a huge potential for cost savings.

How to select the right Use Case?

Impact of Use Case on Vehicle/Machine Uptime



Operational Guidance

- Ignore messages (hazard/warning lights)
- Overrev
- Shifting behavior
- Ignore service intervals
- Corner case load conditions (e.g., long idling, high load on cold engine, extreme loading, etc.)
- Ad-blue consumption



Predictive Service

- Forecasting mileage (or operating hours) based on service plan
- Flexible service intervals based on usage (for planned maintenance, e.g., tires, filters, brakes, spark plug, gearbox oil, engine oil, timing belt, etc.)



Health State Prediction

- Catalyst ageing/efficiency
- DPF loading
- Component remaining useful lifetime prediction (e.g., clutch, auxiliary battery, mounting)
- HV Battery SOH
- Low coolant level
- High sulfur in fuel
- Fuel in oil

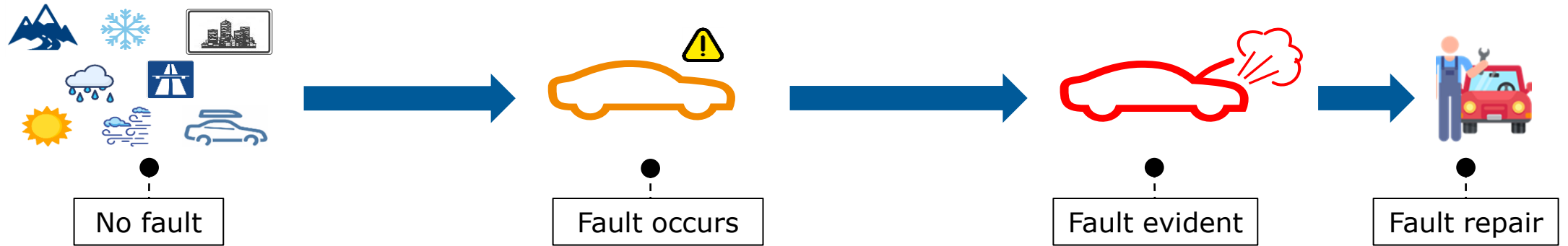


Predictive Failure Prevention

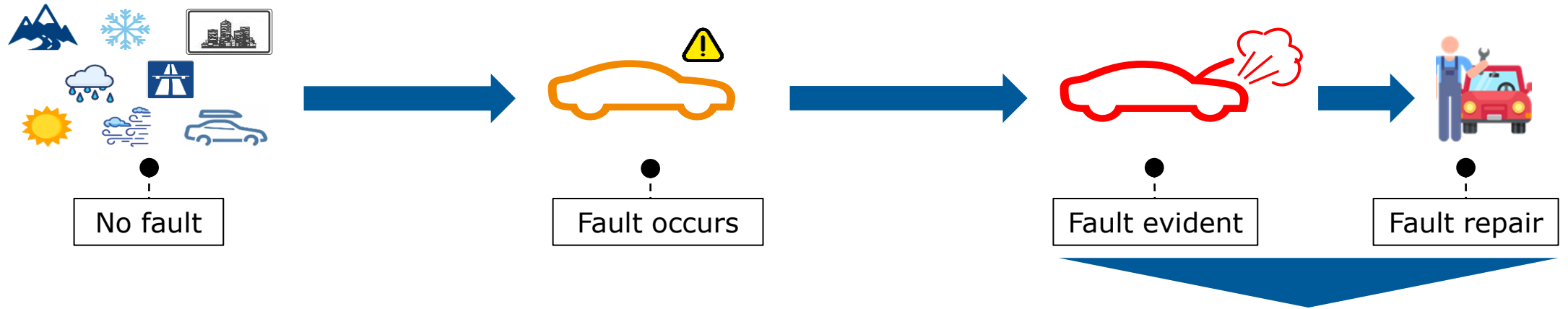
- Observation based risk prediction for single failure modes (for selective technical actions)
- MIL prevention
 - Predictive alert system (e.g., limp home mode)
 - False positive prevention
- Survival analysis

Impact on Uptime

Observation- & Effect based Approach Comparison

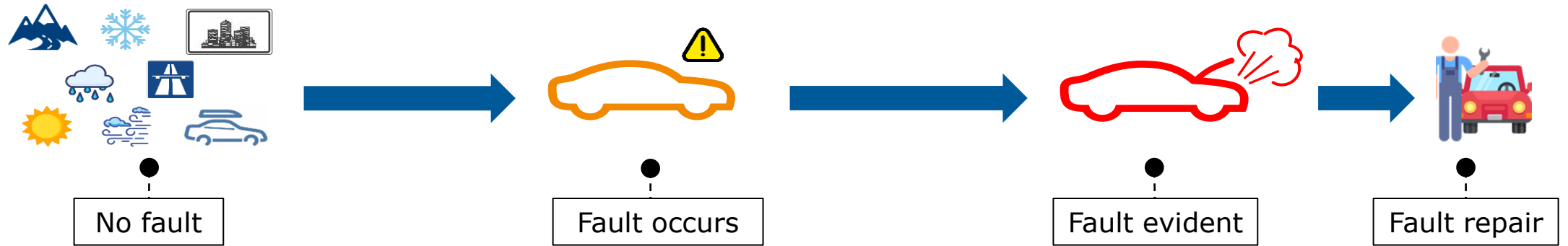


Observation- & Effect based Approach Comparison



- x Roadside breakdown
- x Customer dissatisfaction
- x Reputation
- x Consequential damages
- x ...

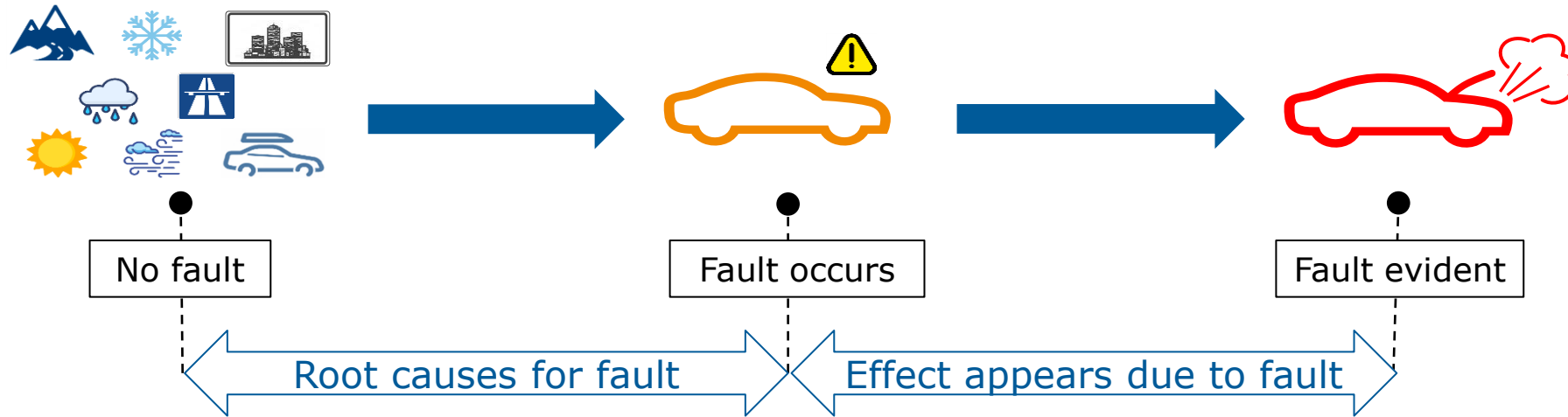
Observation- & Effect based Approach Comparison



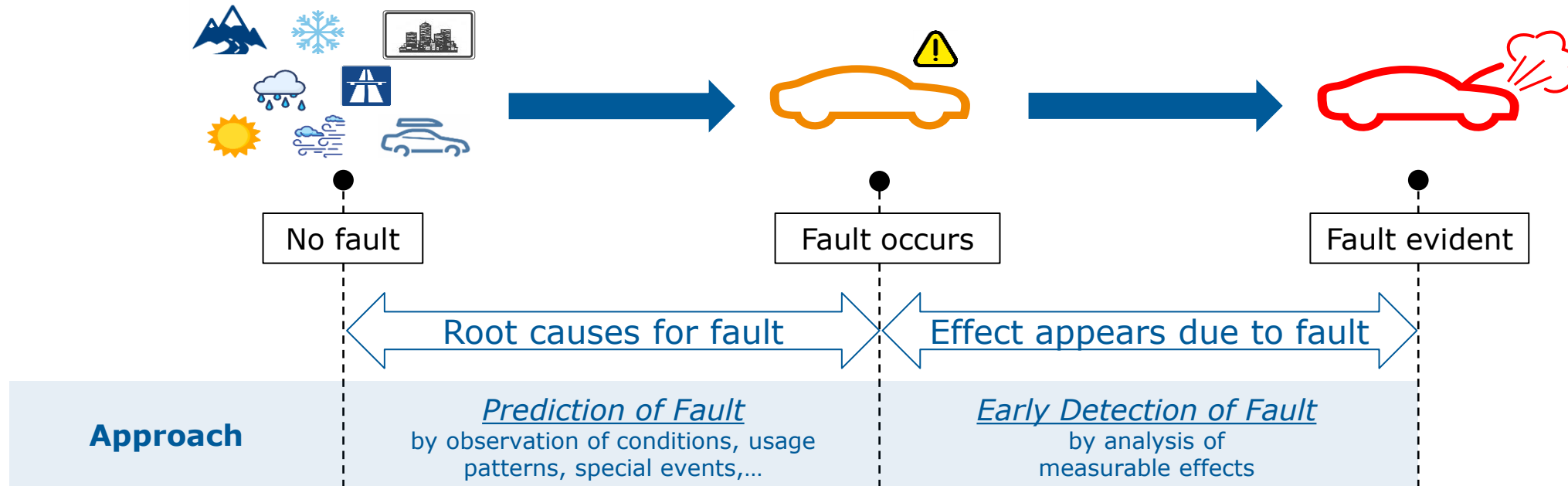
- ✓ ~~Roadside breakdown~~
- ✓ ~~Customer dissatisfaction~~
- ✓ ~~Reputation~~
- ✓ ~~Consequential damages~~
- ✓ ...

...to be avoided...

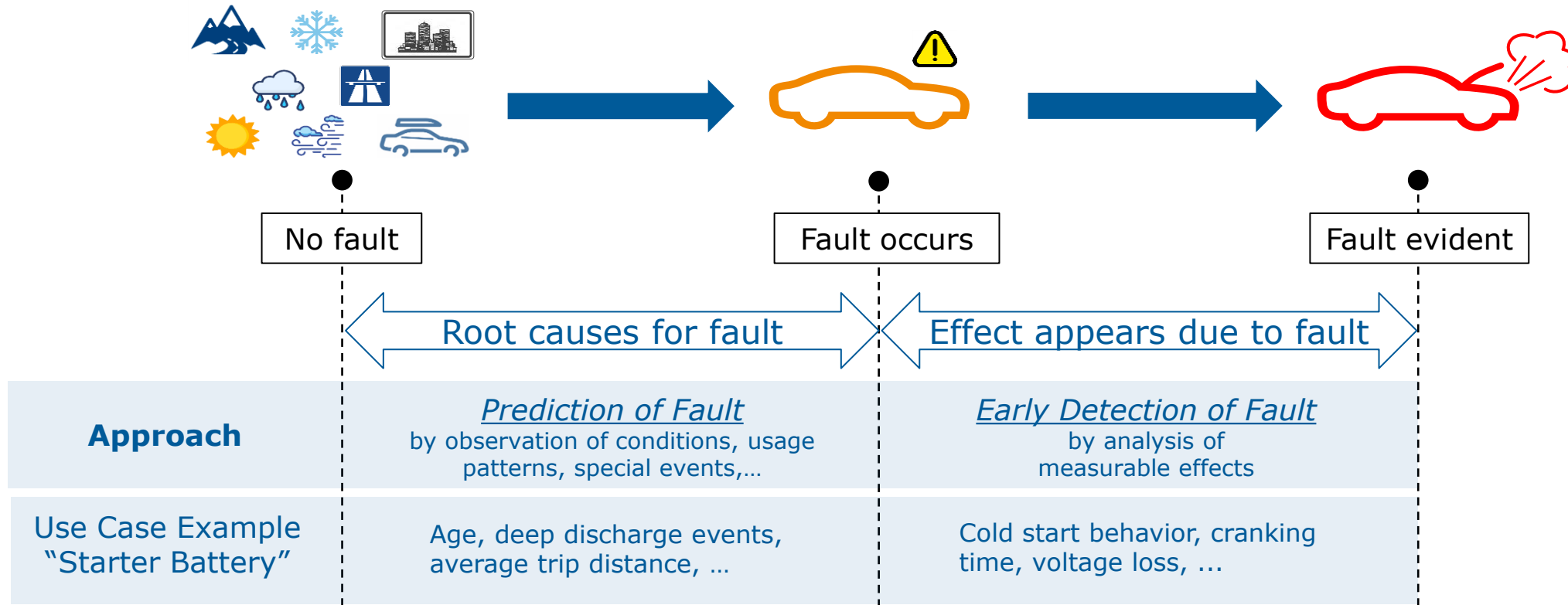
Observation- & Effect based Approach Comparison



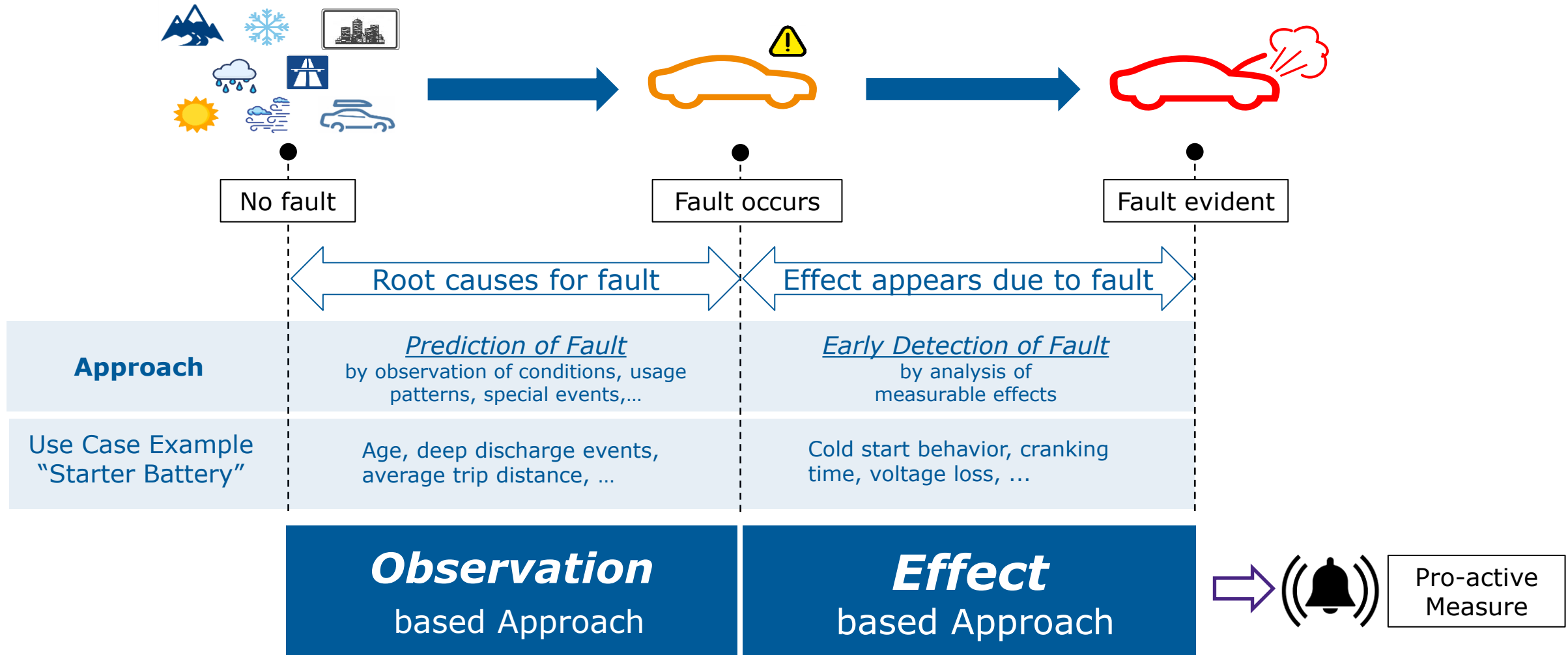
Observation- & Effect based Approach Comparison



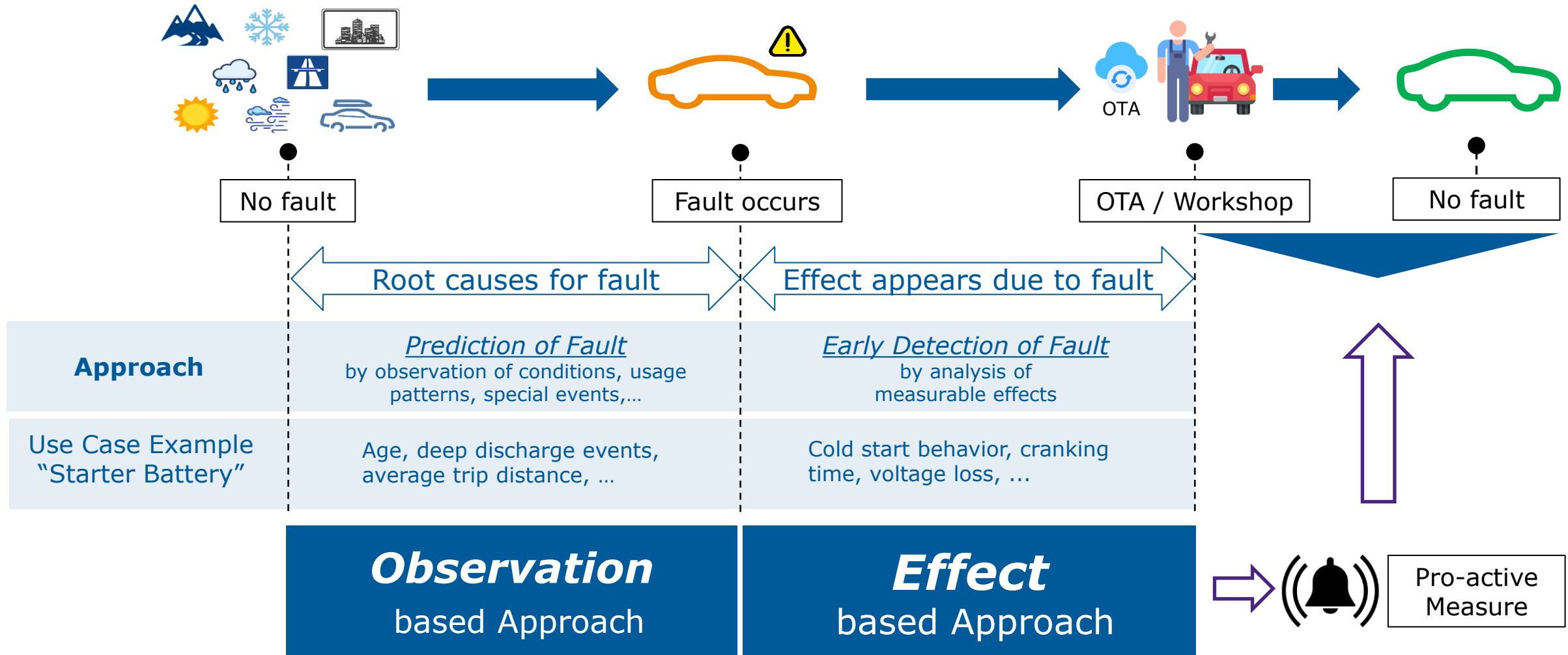
Observation- & Effect based Approach Comparison



Observation- & Effect based Approach Comparison



Observation- & Effect based Approach Comparison





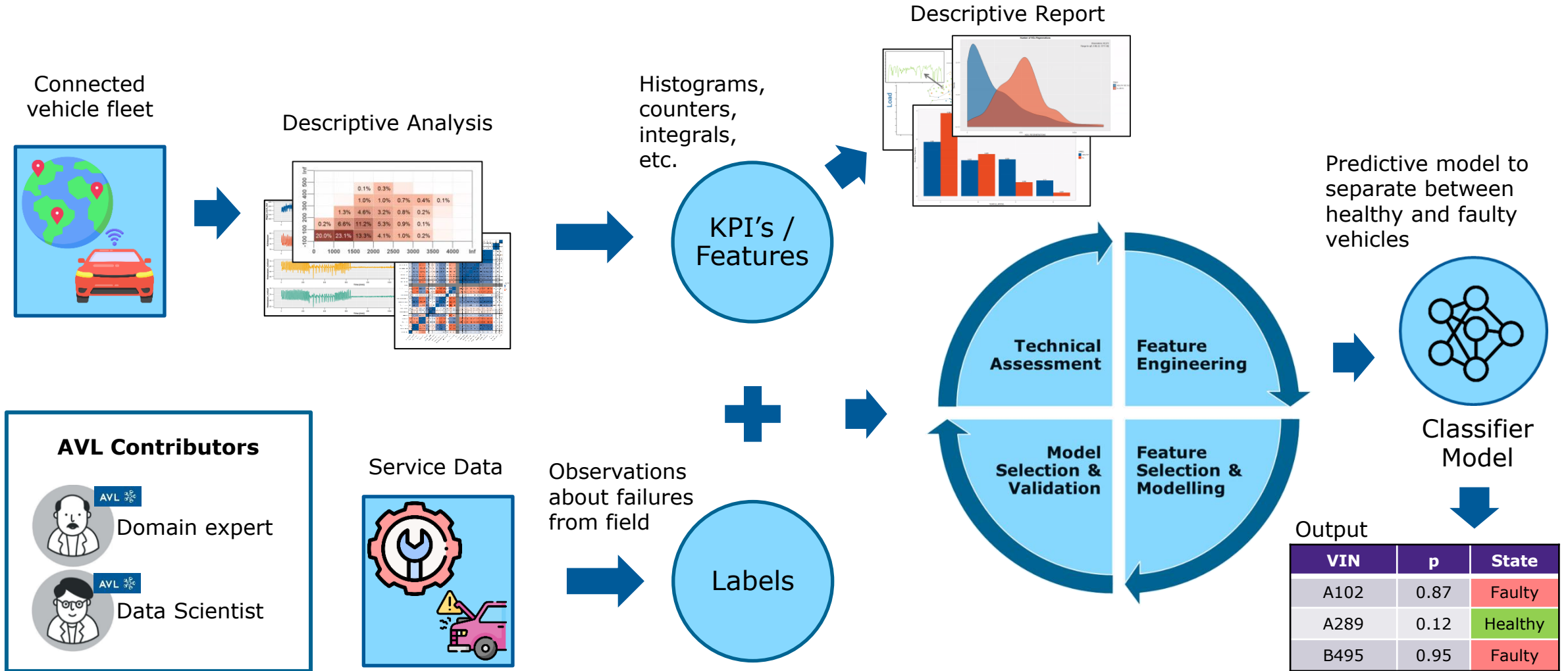
General Approach

Observation based Failure Prediction

Development Steps

Machine Learning Failure Prediction with Vehicle Fleet Data

Deliverable 1: Report



AVL Model Development Process

Deliverable 2:
Model

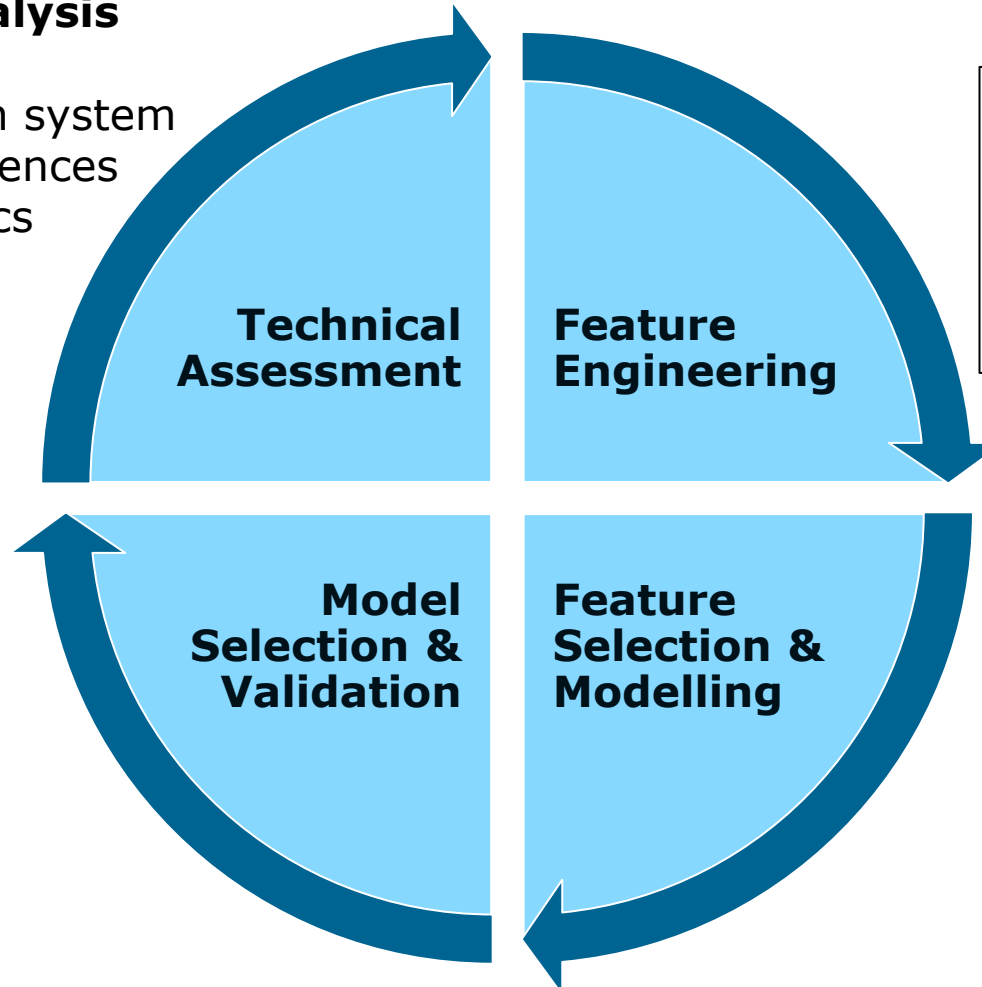
Problem definition



AVL Domain expert

System Analysis

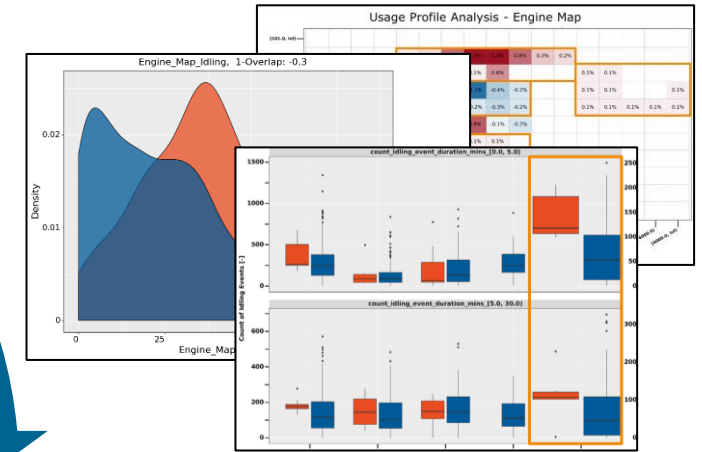
- Impact on system
- Main influences
- Diagnostics
- Detection strategy



How good is my model in operation?

- ✓ Physical expectations
- ✓ Right performance metrics
- ✓ Model quality
- ✓ Generalization
- ✓ Statistically significant

What are the main differences??



What is the best model for this use case?

- Feature ranking
- Different algorithms
- Hyperparameter tuning
- Cross validation

Data Scientist

AVL Model Development Process

Problem definition



System Analysis

- Impact on system
- Main influences
- Diagnostic
- Detection strategy

What are the main differences??



ARE WE DONE YET?

How good is my model for Operation?

- ✓ Physical expectations
- ✓ Right performance metrics
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is the best model for this case?


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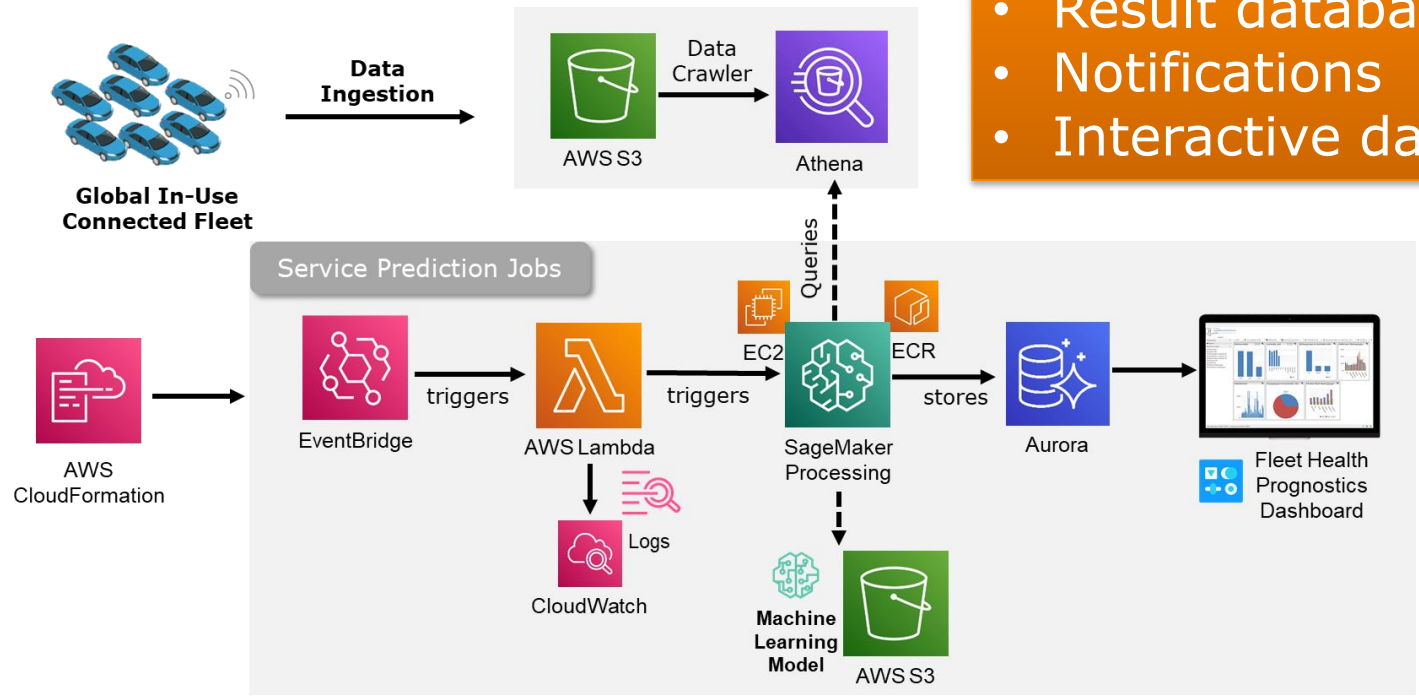
Deployment at Scale

From Data Science to Production

 **87%**
of data science
projects never make
it into production

Key Features: 

- Automatic processing
- Logging and monitoring
- Result database
- Notifications
- Interactive dashboards

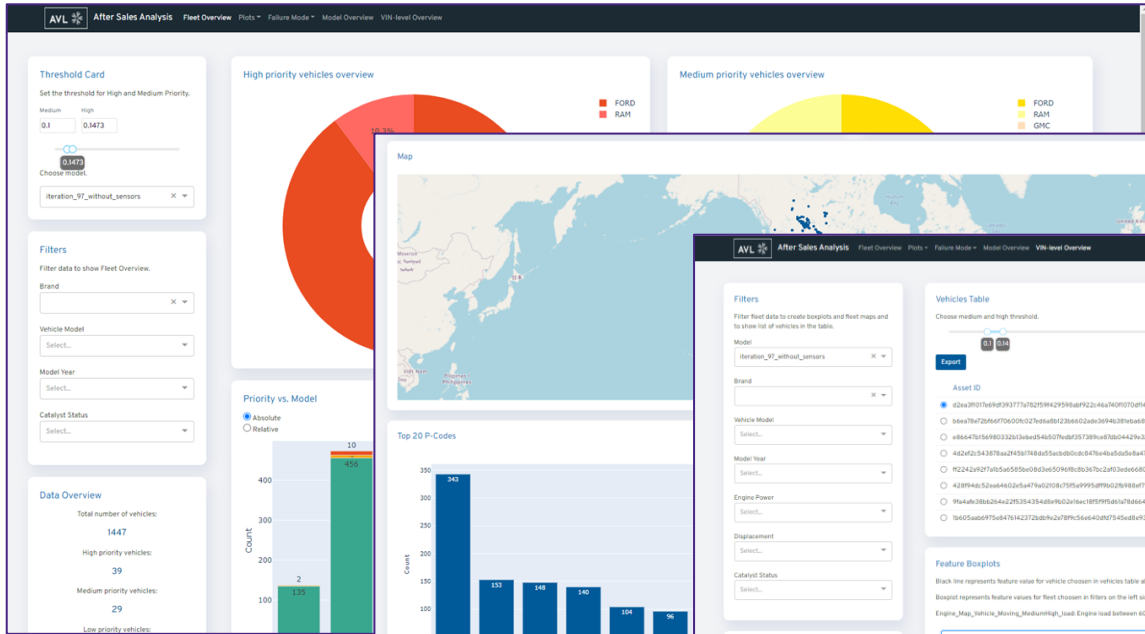


Exemplary Model Deployment in AWS

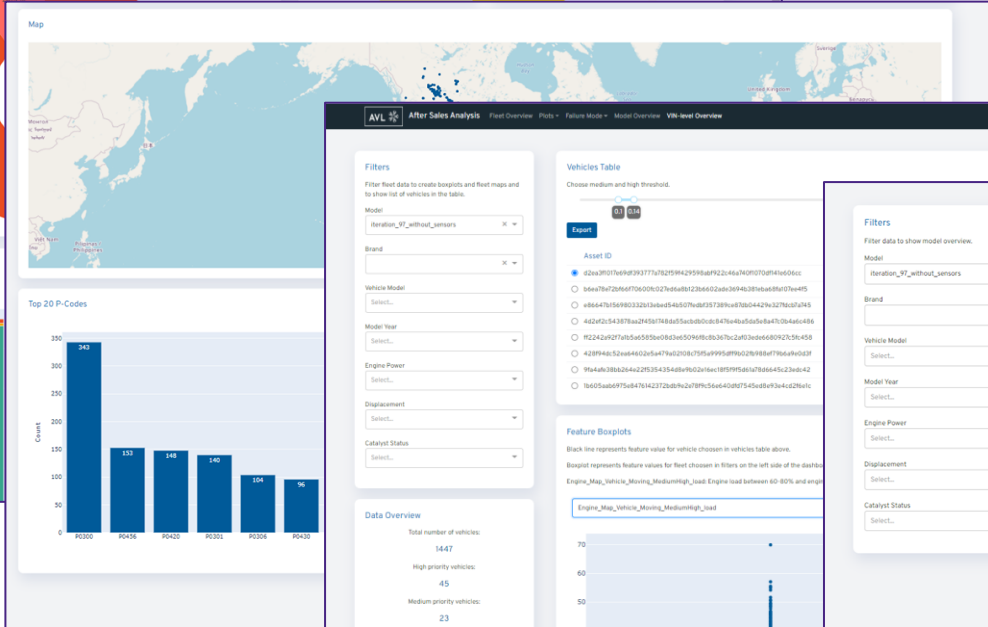
Visualization in Interactive Dashboard



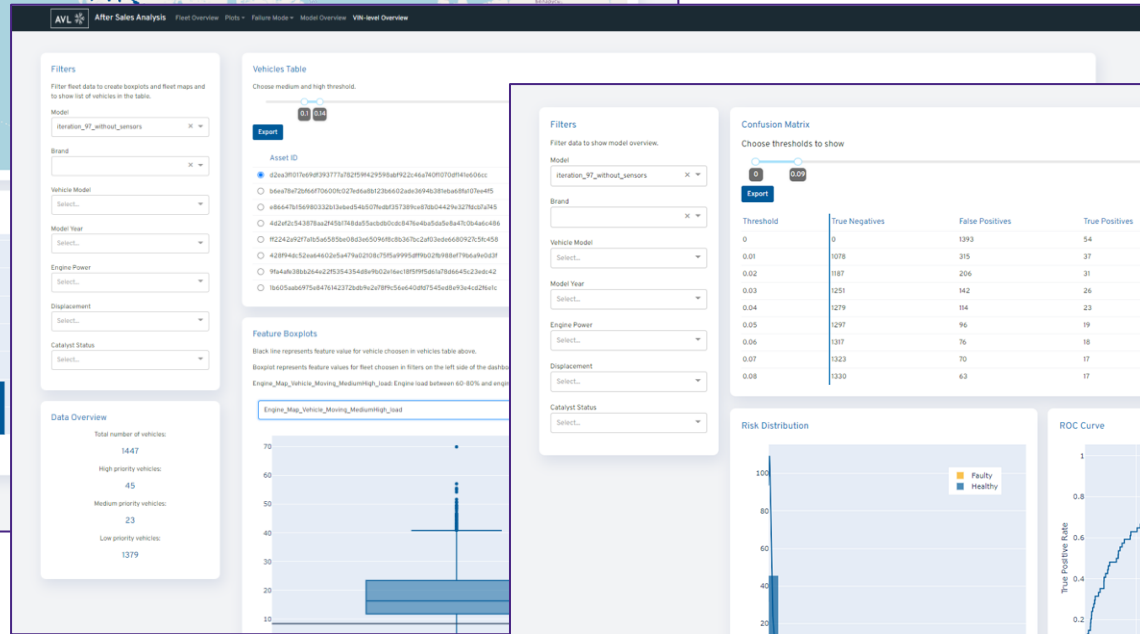
User friendly dashboards translate big data results into insights for after sales and engineering



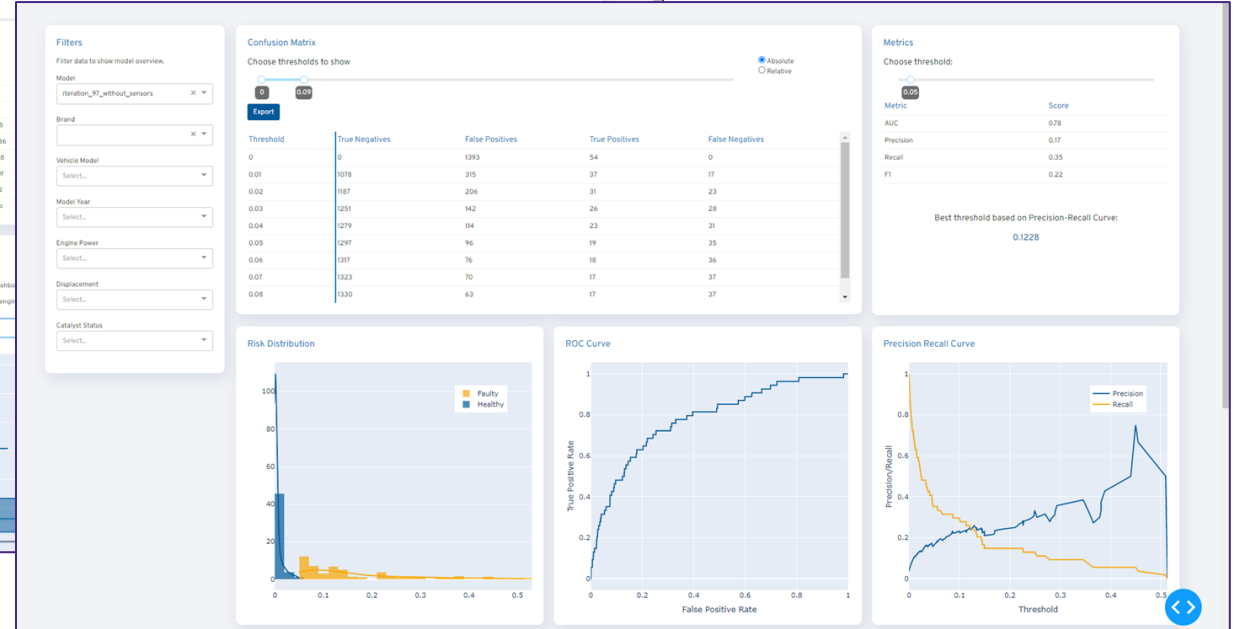
Fleet Overview



Fault Codes

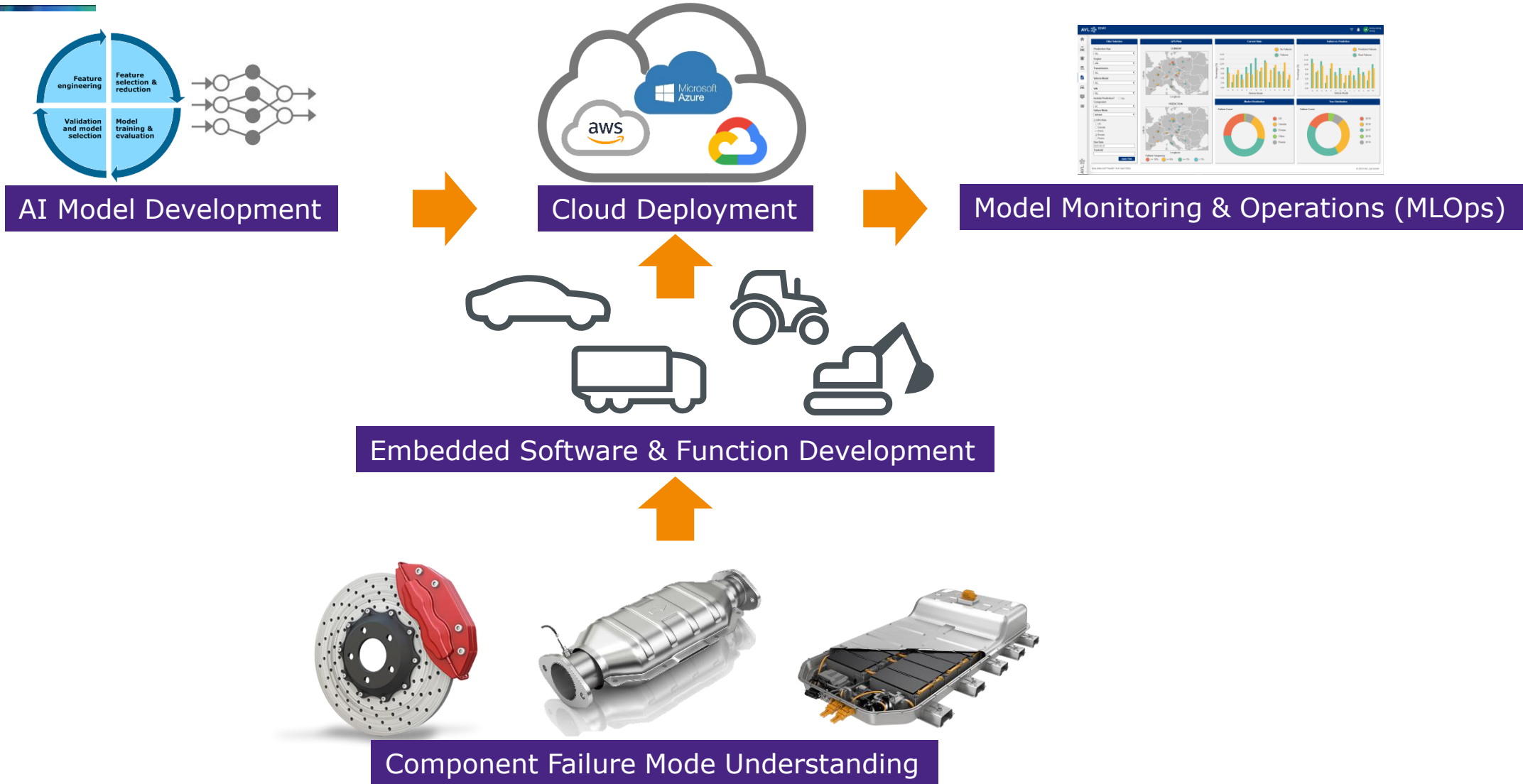


VIN-level Overview



Model Overview

AVL USP: End-to-End Solutions



AVL Fleet Health Prognostics

References


- **Methodology applied to various applications...**
 - Passenger Cars, Trucks
 - Tractors, Construction Equipment
 - Marine vessels and stationary systems

- **... and multiple use-cases**
 - Combustion engine and exhaust after treatment
 - Electrified powertrain components
 - Vehicle and chassis

- **Deployed and operated on global vehicle fleets**

- **Realised savings worth millions of Euros**

Customer: Global Agricultural OEM
Project: After Sales Issue Prediction – ML/MLOps in Cloud Infrastructure



Project description

Customer Benefits

- Risk estimation for selected technical issues in the field
 - Early warnings for high-risk machines
- Understanding of the main failure influencers
 - Feedback on component requirements to avoid issues for future applications
- Support technical actions & predict service intervals
- Reduce maintenance costs for end-customers

Challenges

- Working with huge amount of time-series data from the field
- Link between workshops and telemetry data
- Heterogenous data from different brands & dealers worldwide
- Complex powertrain systems

AVL Tasks & Deliverables

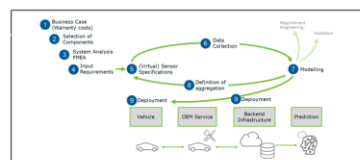
- Combine domain and data science expertise for a data-driven root-cause analysis
- Develop data analytics methods and processes
- Implement machine learning models for failure prediction
- Integrate and deploy scalable solutions into customers AWS environment
- Continuous monitoring and retraining of deployed models

Logos for AWS, Amazon Athena, Amazon SageMaker, Amazon S3, and AWS IoT are shown at the bottom.

Customer: Asian OEM
Project: Prognostics Features

Challenge

- Life time of wear parts and consumables is very dependent on usage and ambient conditions
- Replacement of components is always too late or too soon
- Handling warranty and goodwill actions missing the data driven decision process
- Identify safety relevant issues ahead of time



Approach


- Combine physics driven approach with data collected on validation fleets to create and calibrate fatigue models for specific components
- Create data aggregation algorithms to minimize data transfer from vehicle to cloud
- Implement the data aggregation on-board and implement fatigue models in the cloud back-end,
- Prediction of remaining life time for specific component on a spec

Business Value

- Enable Failure Prediction immediately with SOP
- Reduce maintenance costs
- Reduce road side brake downs

AVL Data Intelligence | 27 April 2022

Customer: Premium German OEM
Project: Predictive Analytics and Maintenance for After Sales



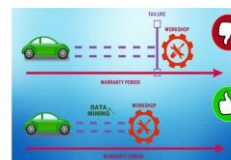
Project description

Project description

- Predictive Analytics & Maintenance for After Sales
- Reduction of service measures for warranty issues
- Insights into vehicles in the field (e.g., condition, patterns, quality problems,...)
- Optimization of logistic planning with the use of complex statistical methods and machine learning technologies

Targets / AVL Tasks

- Analysis of the technical issue
- Data understanding using descriptive analytics
- Identification, extraction, processing and validation of the field data relevant for the analysis
- Creation, testing and validation of deep and machine learning models for failure prediction



Confidential / 13 | Gerhard Schagerl | Data Intelligence | 12 October 2021 | AVL

Benefits of Connected Car Data and Prognostics



IMPROVED UPTIME

Predictive Maintenance
Customer Satisfaction
Warranty Issues

WARRANTY COST SAVINGS

Selective Technical Actions
Reduced Time to Fix
Brand Reputation



PUSH BACK INFORMATION INTO DEVELOPMENT

Optimize Design and Validation based on data-driven root cause analysis

WORKSHOP IMPROVEMENTS

Predicting Logistics Processes
Spare Parts Consumption
Failure Pinpointing





Vehicle to Grid

Q&A

Let's stay in touch



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Thank you



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