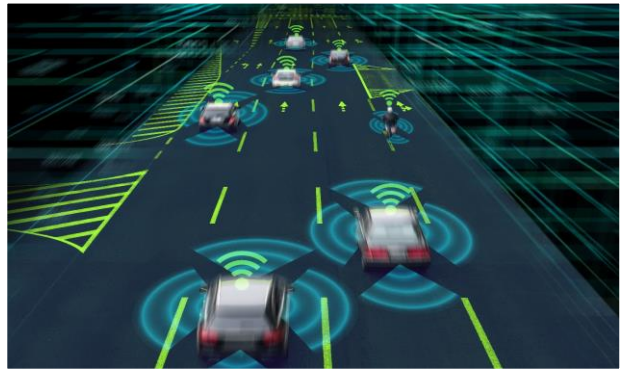
MathWorks
AUTOMOTIVE
CONFERENCE 2019

Trend in Automotive Industry and its challenge

Satoru Abe
Industry Marketing Manager
MathWorks Japan

Technology Megatrends Driving Automotive

1. Vehicle Electrification
2. Autonomous Driving
3. Connected Vehicles



Software everywhere

Software is reshaping the automotive industry

THE WALL STREET JOURNAL.

ESSAY

Why Software Is Eating The World

By Marc Andreessen

August 20, 2011

This week, Hewlett-Packard (where I am on the board) announced that it is exploring jettisoning its struggling PC business in favor of

Marc Andreessen
Founder of Netscape,
Renowned Venture capitalist

In the future every company will become a software company

Software is reshaping the automotive industry

Software Expertise Is Crucial for the Success of the Mobility Ecosystem

"Software is the oxygen for the mobility ecosystem"

More and more vehicles are being interconnected via software using Continental's technology. Whereas cars today require more than 100 million lines of software code for their functions, the amount of software required for future functions will increase tenfold. "In the coming years, sales with software will increase tenfold compared to

Source: Continental's 2019 Annual Shareholders' Meeting

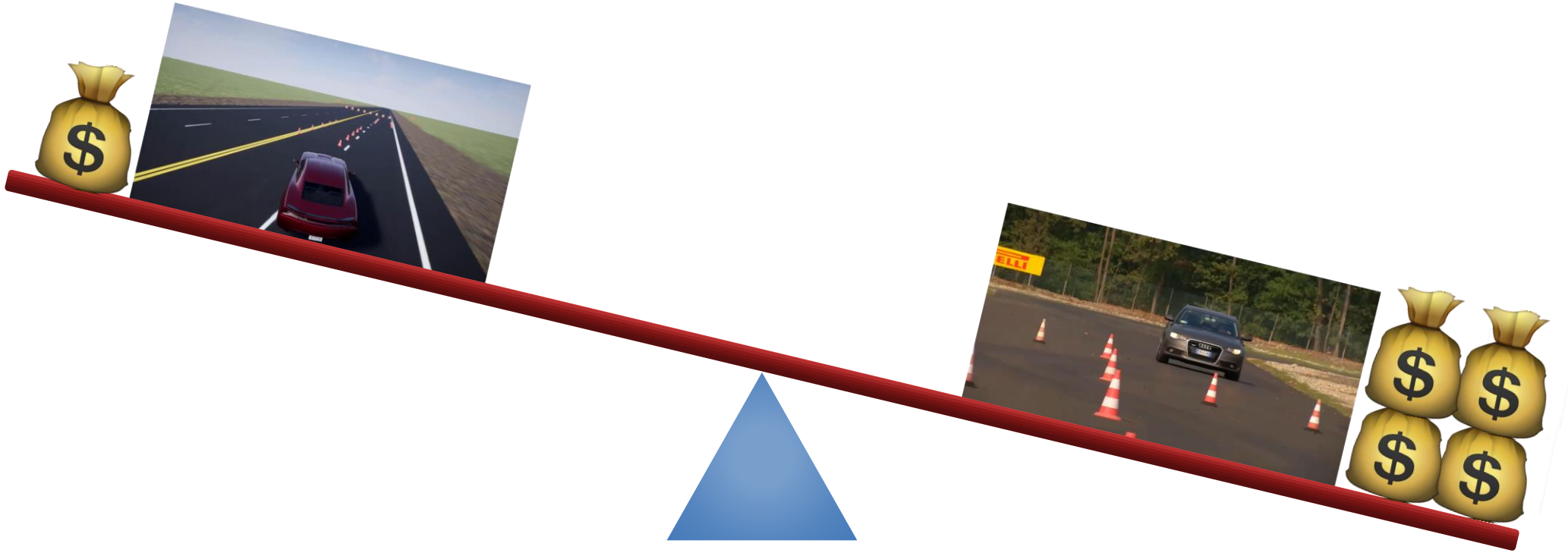
Software is reshaping the automotive industry

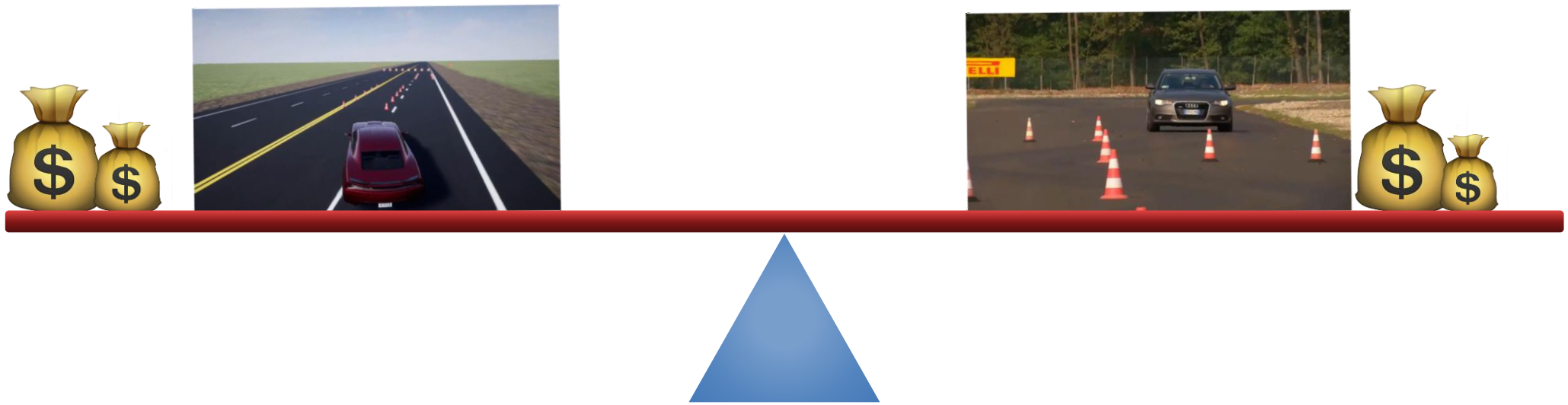
Augmenting control with machine learning (BMW)

One Pedal Driving (GM)

Autonomous driving (Voyage)

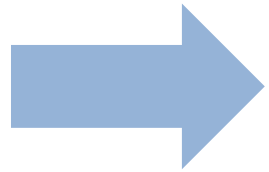
Models == Understanding





Impact of disruptive trends on us: what we see in the field

- Full vehicle simulation
  - System design and study
  - ADAS/AD virtual drive



Utilize simulation
with limited resources

Full vehicle simulation

- Click to
  - – Secon
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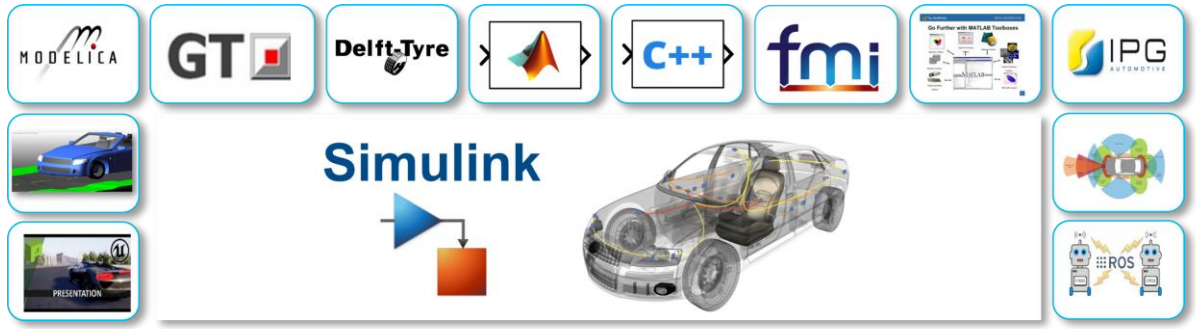
Simulation Integration: Analyses

Verification and Validation	Design Optimization	Sensitivity Analysis	Virtual Calibration

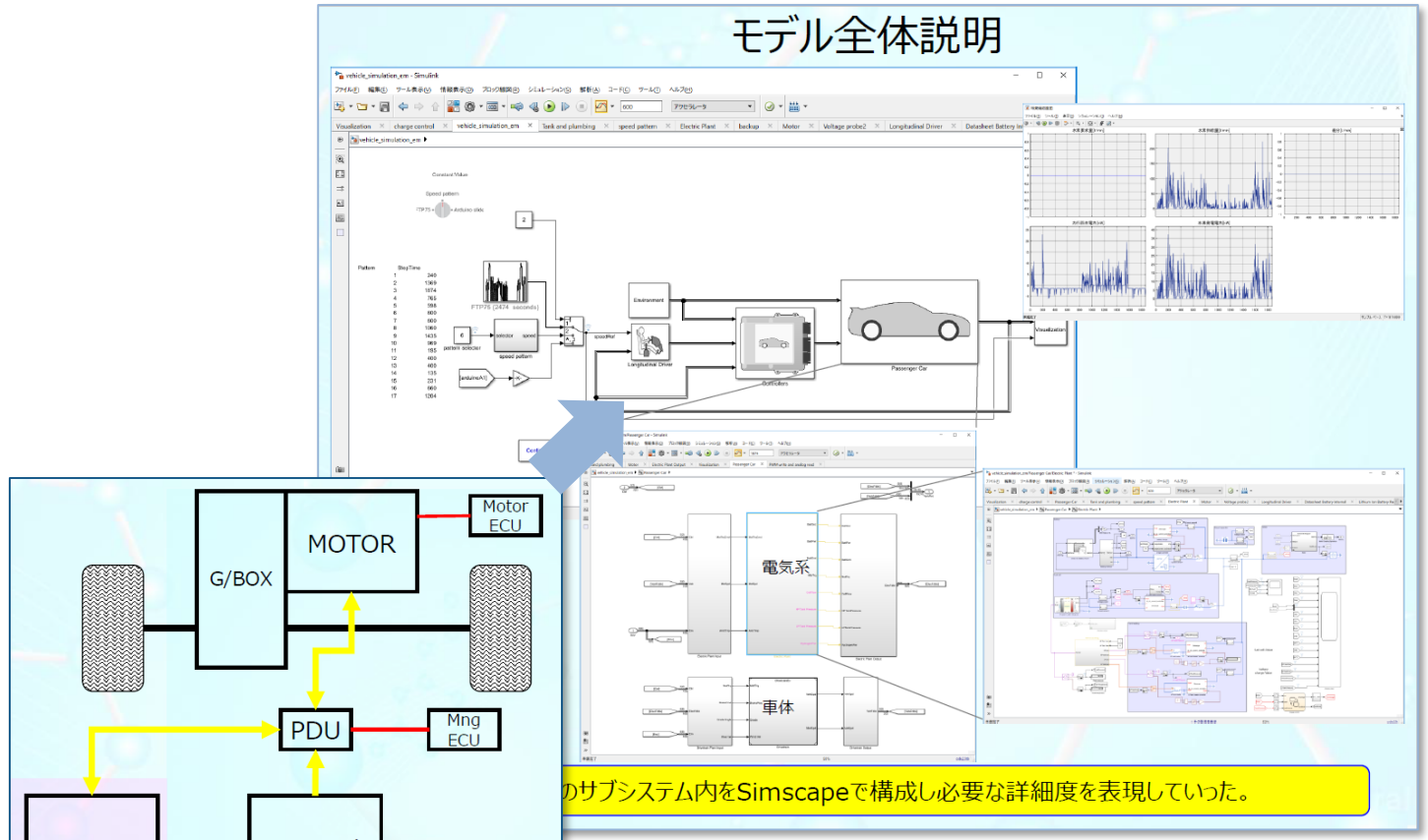
Fuel Economy	Performance	Energy Consumption	Drivability	Ride & Handling



Atsumitech evaluated FCV system with MathWorks tools

FCV Hydrogen tank with electric components development

- Trade-off study for Hydrogen amount with various driving scenario
- Evaluate the required hydrogen amount while transient changes in pressure and temperature of the hydrogen tank
- Evaluate the effect of energy management, especially efficient use of hydrogen



Source : MathWorks Automotive Conference Japan 2018

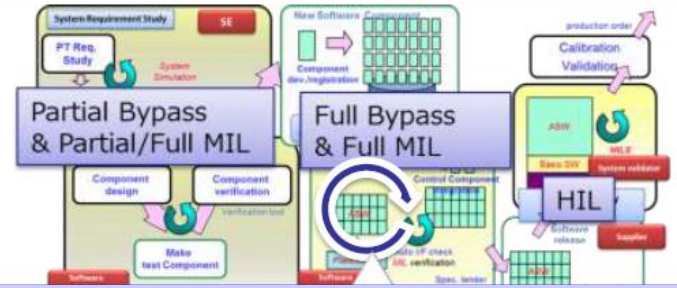
Nissan deployed common plant models in the process

- Common Plant model in system requirement study, component and software integration test, and software quality verification
- Test cases are also commonalized through the process
- Fast simulation speed with high accuracy is the key
- Integrated with existing plant model with Powertrain Blockset

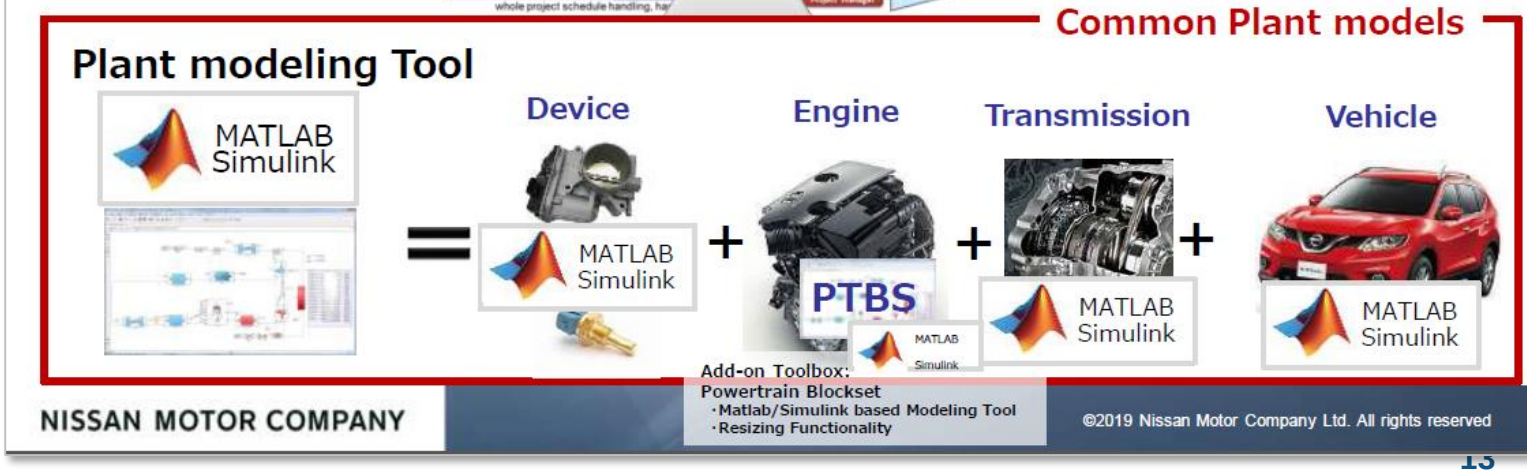
Common plant model

To verify the control algorithm, it is important to evaluate software accurately and quickly
→ **Lightweight and high-precision model**

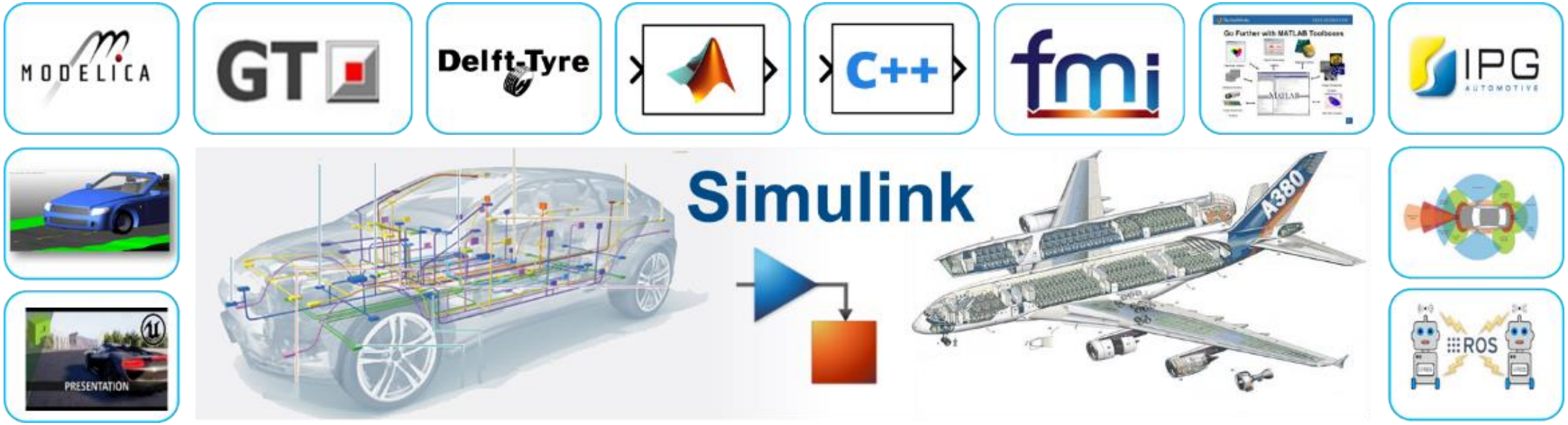
- Devices, Transmission and low fidelity vehicle model built with Simulink
- Powertrain Blockset is used for Engine model



Plant model is commonly used for RCP, MIL and HIL



Simulink is Simulation Platform



152 Interfaces to 3rd Party
Modeling and Simulation Tools
(as of March 2019)

MathWorks Partner

Impact of disruptive trends on us: what we see in the field

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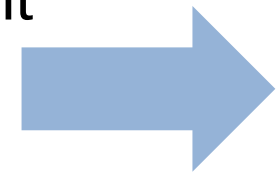
Utilize simulation with limited resources

- Scaling up embedded software development
  - Agile development
  - System Architecture



New approach to the new challenge

Agile Values

Individuals & Interactions over **Process and Tools**

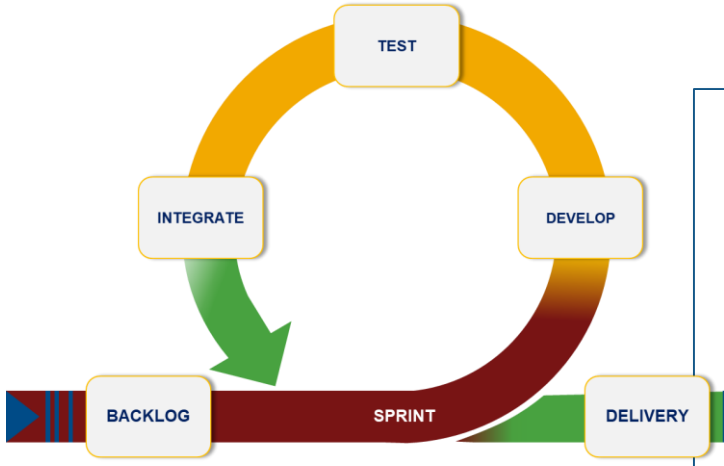
Customer Collaboration over **Contract Negotiation**

Working Software over **Comprehensive Documentation**

Responding to Change over **Following a Plan**

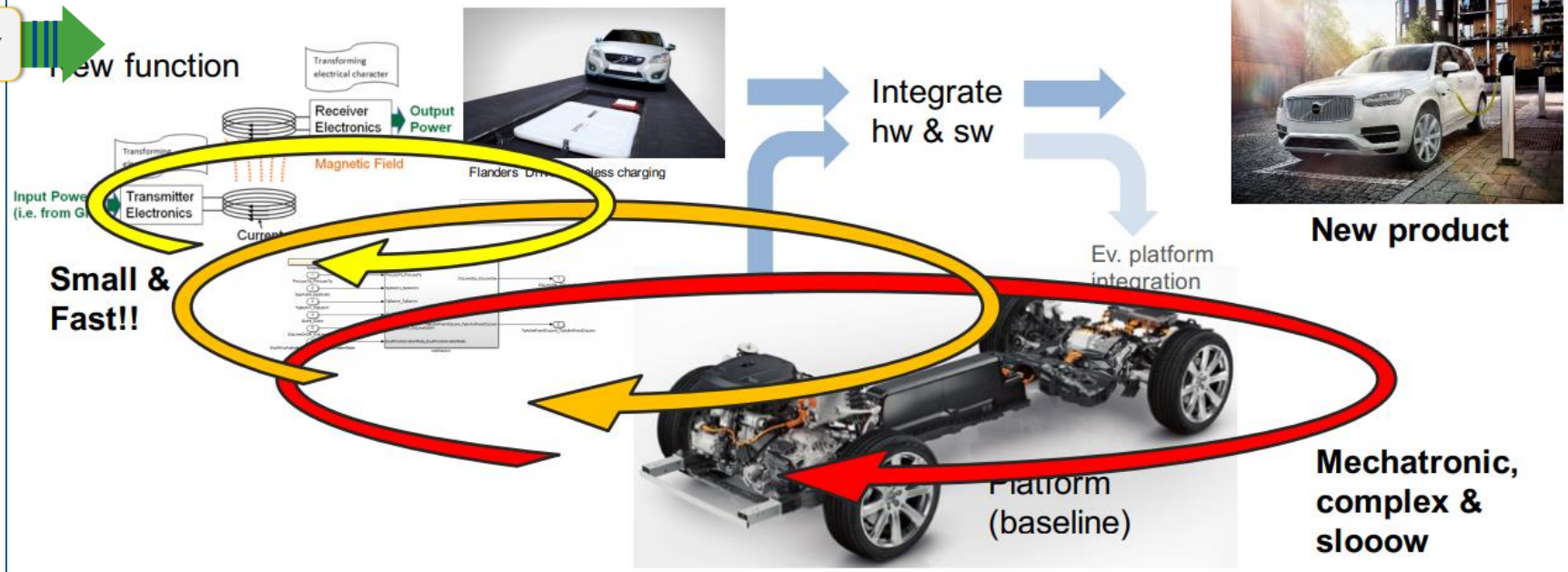
"While there is value in the items on the right, we value the items on the left more."

Volvo cars conducts agile development with Model-Based Design



From planning to experimentation!

This is a software business trend, but we see it as well. Time is valuable and requirements change rapidly.



MAC 2015, Multi-Domain Simulation for Electrical Propulsion Systems at Volvo Cars, Jonn Lantz, jonn.lantz@volvocars.com

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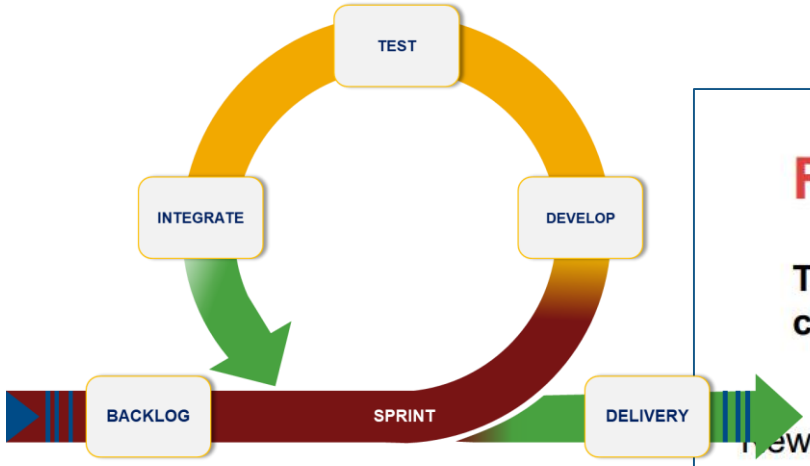
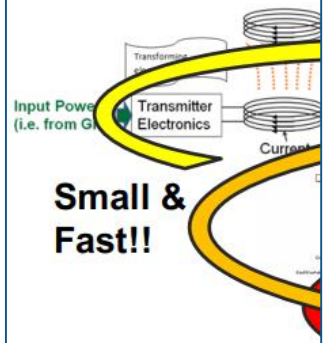
Volvo cars conducts agile development with Model-Based Design



From planning to experimentation!

This is a soft
change rapi

ew function



Small &
Fast!!

MAC 2015, Multi-Dom

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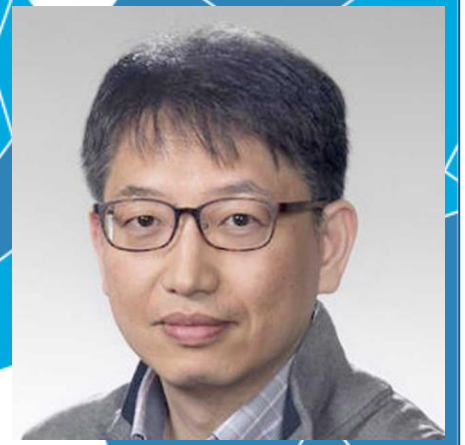
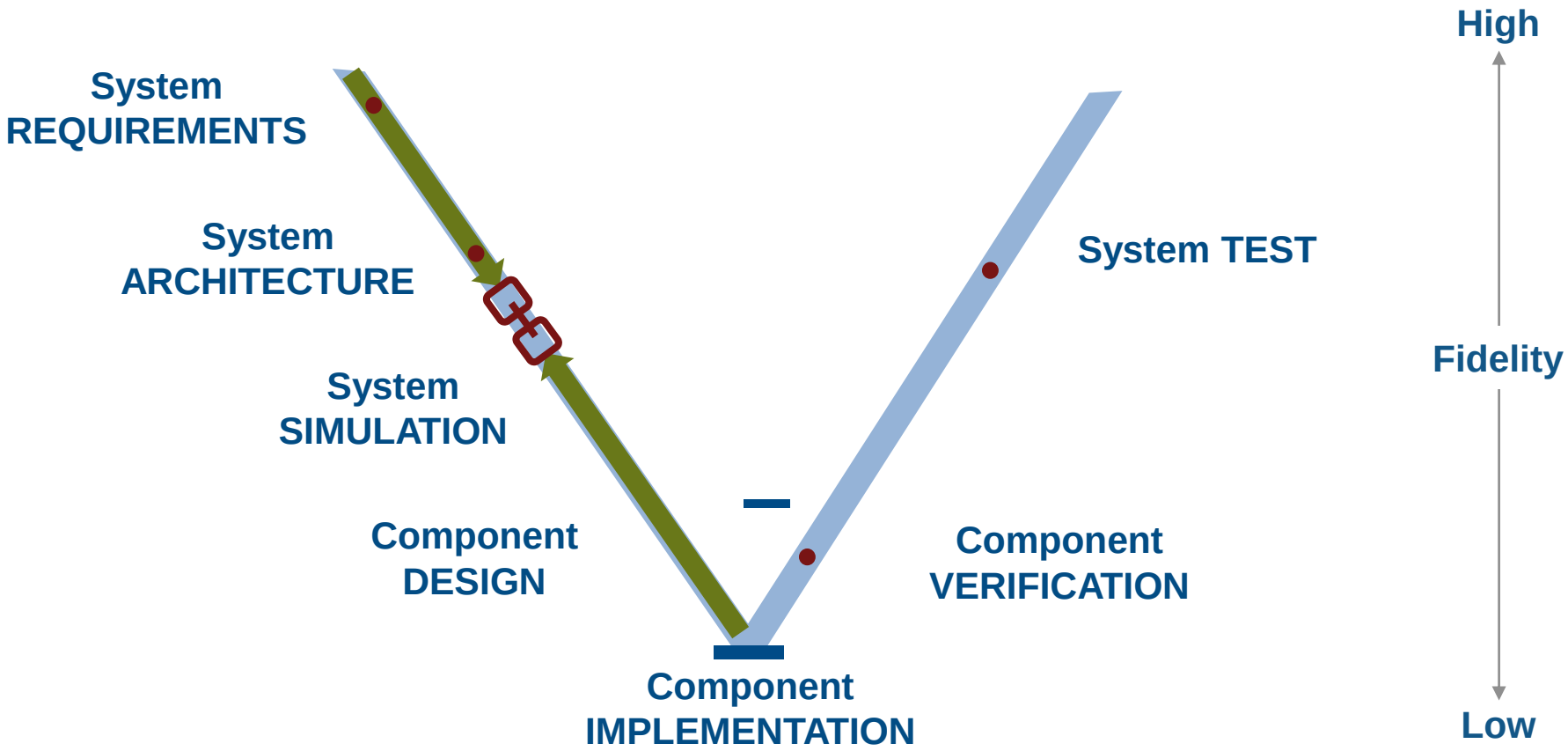
Agile 개발 방법과 모델기반 설계

이영준

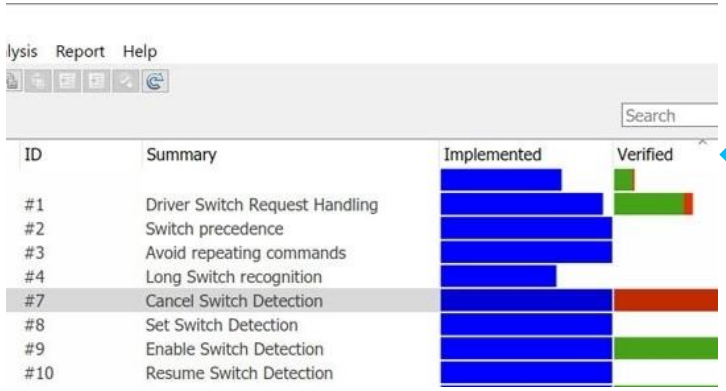


Linking top-down and bottom-up workflows

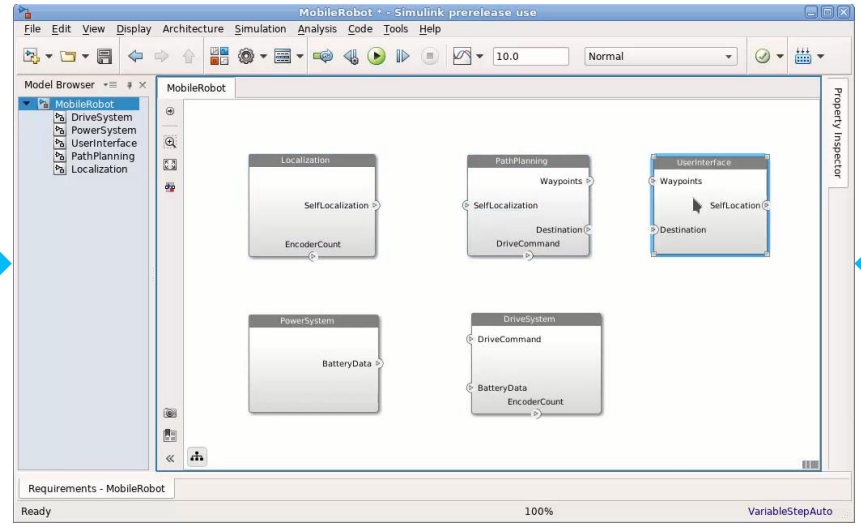


Systems engineering

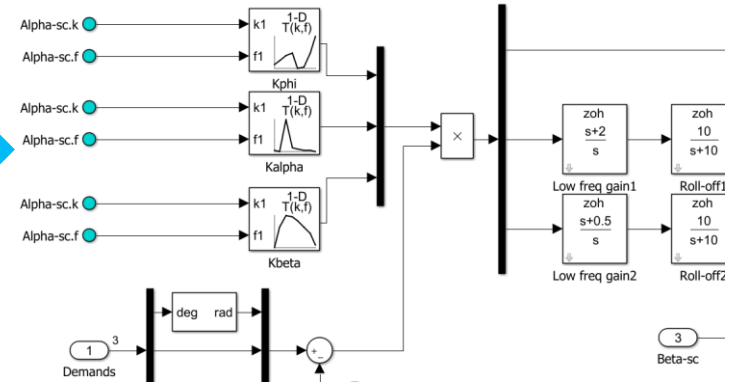
Requirements



System Composer



Components



Systems engineering

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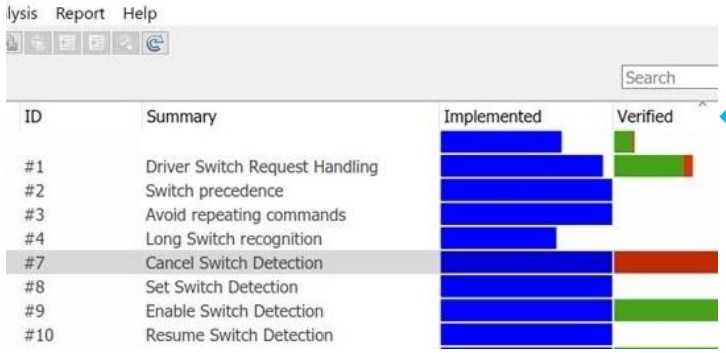

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Utilize simulation with limited resources

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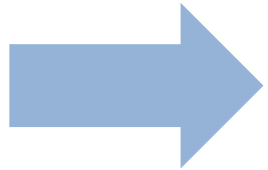
New approach to the new challenge

- Leveraging streaming and stored data
  - Data utilization in Model-Based Design workflow
  - Digital service for new businesses

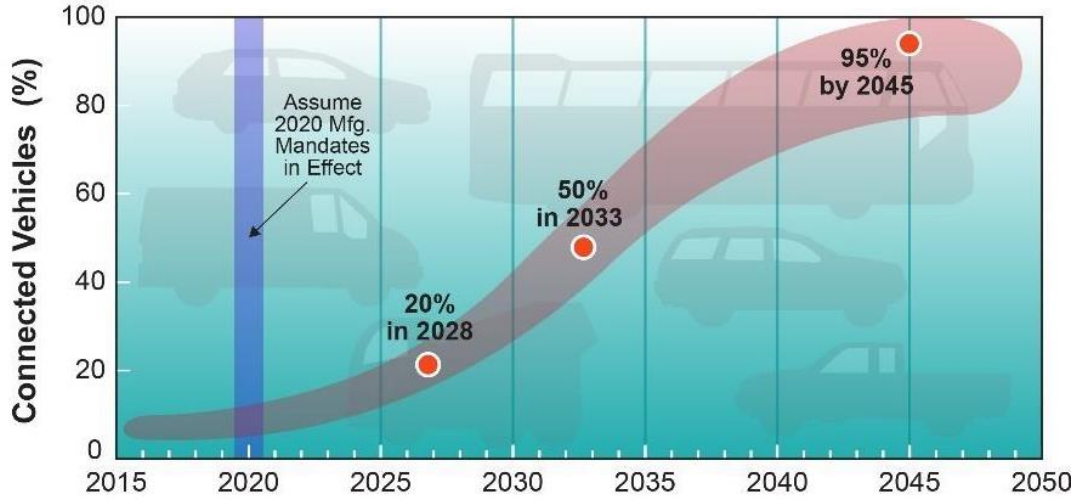


Accelerate development and develop new business

Why Data, Why Now?

- Exponential rise in data intake

Connected vehicles will each generate data every 100 milliseconds while being driven, resulting in more than 10 Petabytes by 2020; Pilot (<3000 vehicles) >18Terabytes per month being collected



- Commoditization of computing
  - Cost of storage drives towards zero
  - Cloud enables massive parallel computing
  - GPU offers computing power at density

- Machine learning and deep learning are maturing
  - MATLAB makes them accessible to engineers

Volkswagen Data Lab develops driver recognition algorithms with MATLAB

Develop technology building block for tailoring car features and services to individual

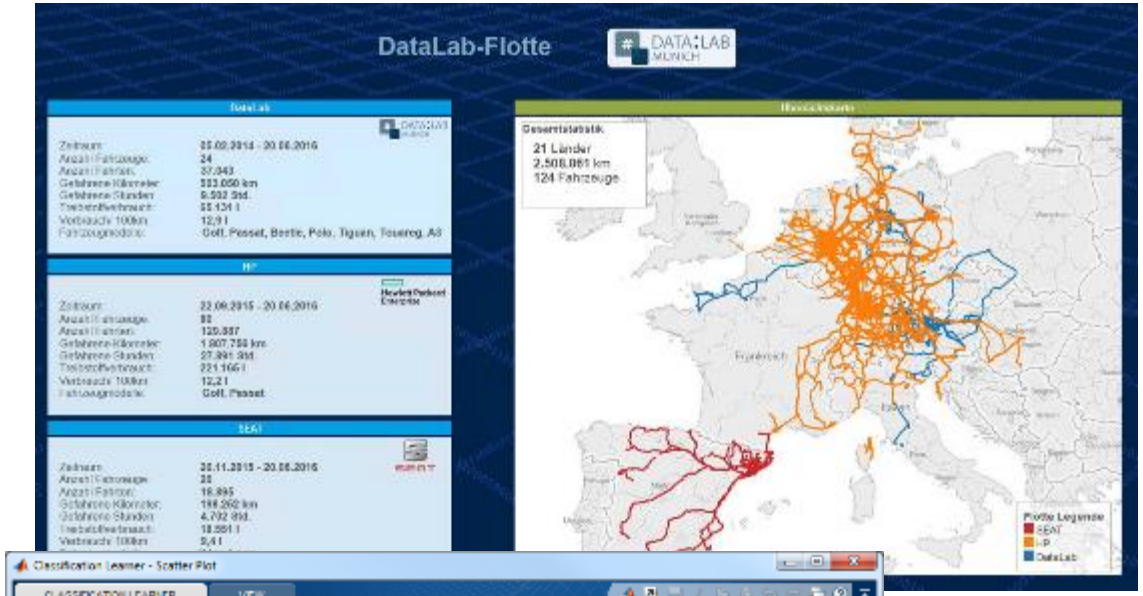
- Need to identify individual drivers based on their driving behavior using collected data

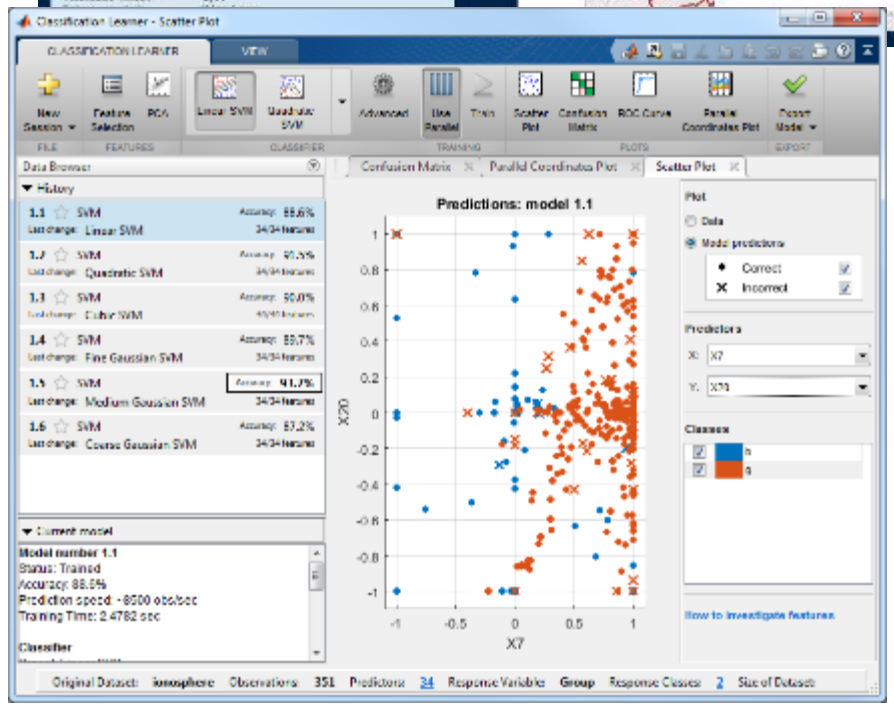
Challenges

- Accuracy despite low training data
- Robustness despite environmental conditions
- Computing time

Data sources

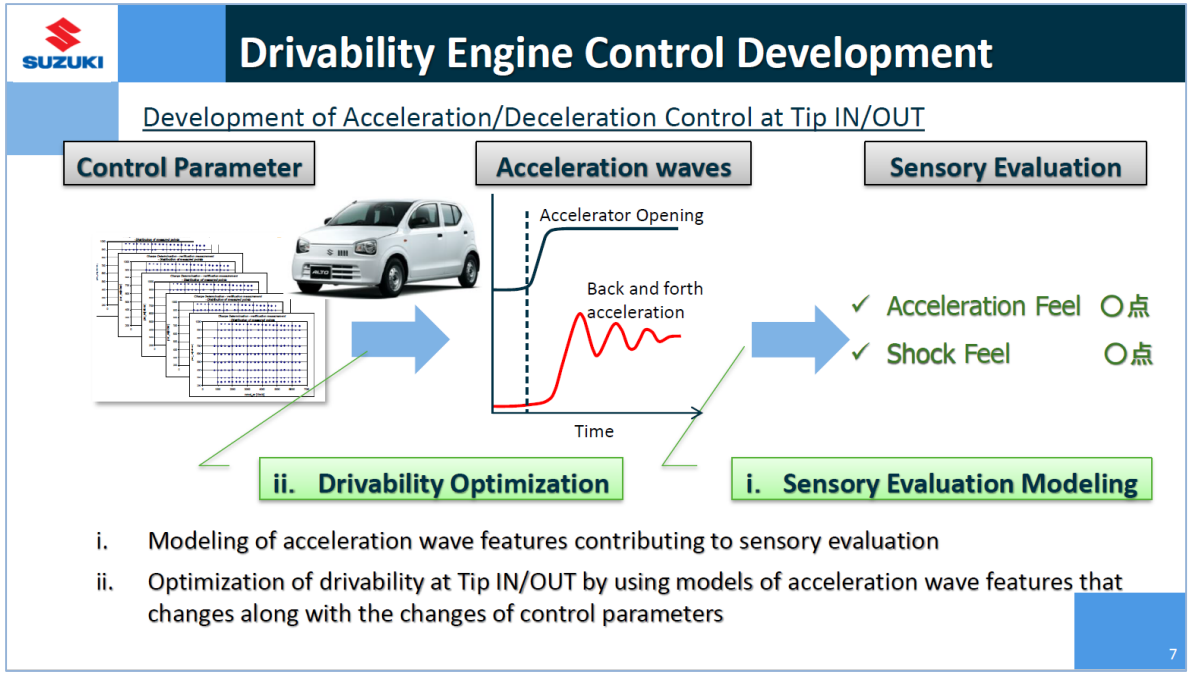
- Logged CAN bus data and travel record

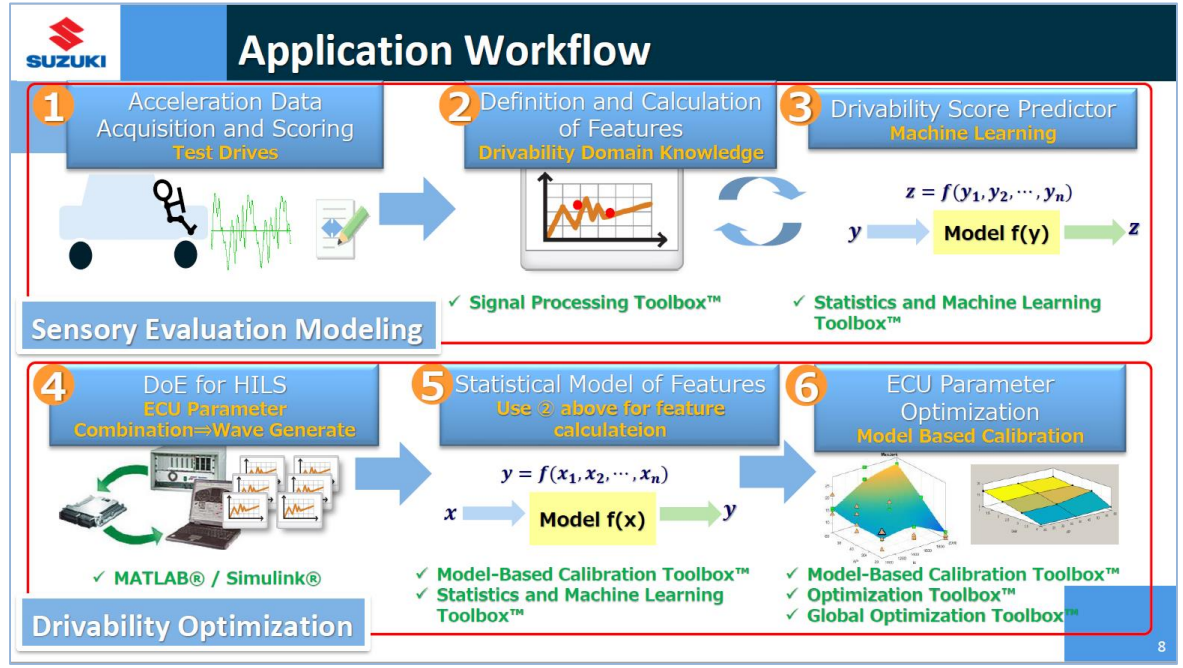




Source: „MATLAB EXPO Germany, June 27, 2017, Munich Germany

Suzuki motors developed drivability assessment framework with Machine Learning





- Extract features from longitudinal acceleration timeseries of driving behavior and build predictive model for drivability score calculation using Machine Learning
- Optimize vehicle drivability performance by optimizing calibration parameters with Model-Based Calibration approach

Machine learning adoption in new fields

BMW Uses Machine Learning to Detect Oversteering

Challenge
Develop automated software for detecting oversteering, an unsafe condition in which rear tires lose their grip during a turn

Solution
Use MATLAB to develop, train, and evaluate a variety of supervised machine learning classifier types, including KNN, SVM, and decision trees

Results
- Oversteering identified with greater than 98% accuracy
- Multiple machine learning classifiers trained automatically
- Code generated and deployed to an ECU for real-time, in-vehicle testing

A BMW M4 oversteering on a test track.

"Working in MATLAB, we developed a supervis machine learning model as a proof of concept. having little previous experience with machine learning, in just three weeks we completed a w ECU prototype capable of detecting oversteeri over 98% accuracy."
- Tobias Freudling, BMW Group

Link to article

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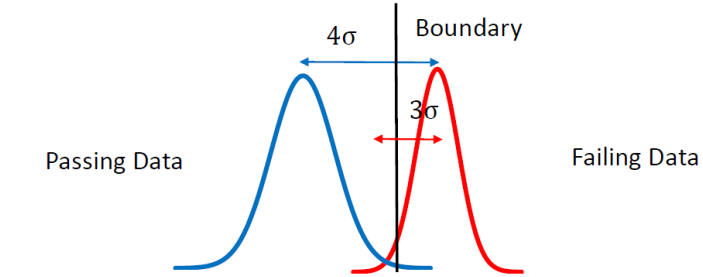
Machine Learning for OBD
Background: On-Board Diagnostics & Boundary

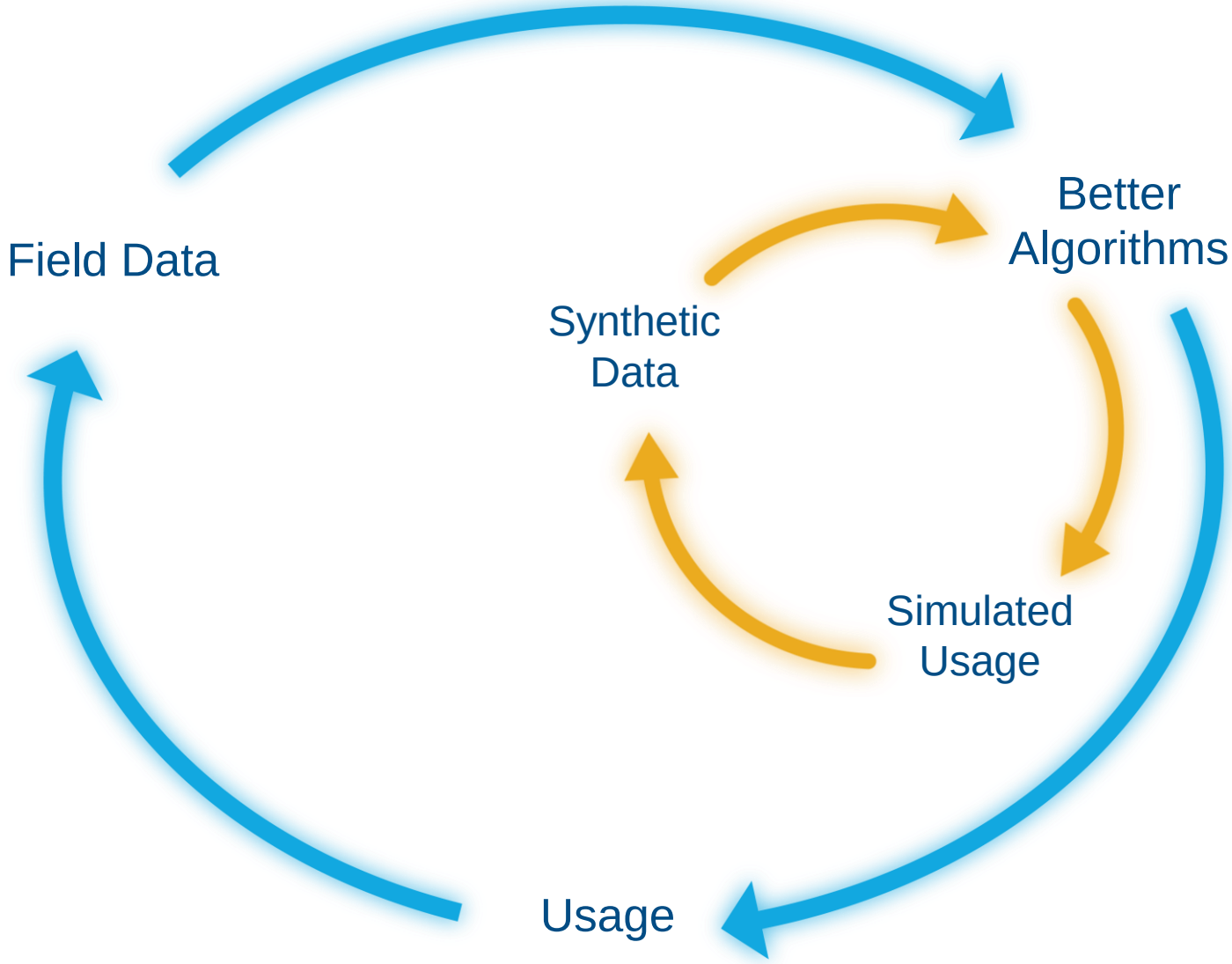
- Separation is needed to minimize:
  - False failure
  - False pass
- Diagnostic should run consistently on
  - The certification test cycle: FTP75
  - In the field: In Use Monitoring Performance Ratio (IUMPR)



3 Diesel Gasoline Systems | Gullitti DGS-EC/EAP1-NA | 5/4/2017

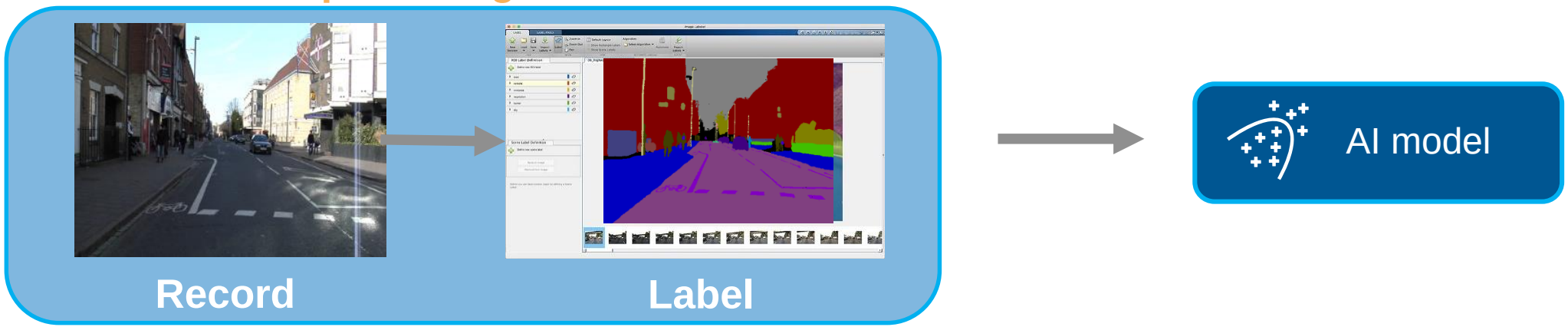
BOSCH

Data utilization in Model-Based Design workflow



One example of leveraging simulation for data synthesis

Traditional deep learning workflow



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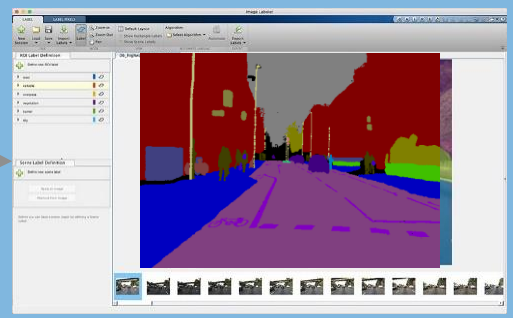
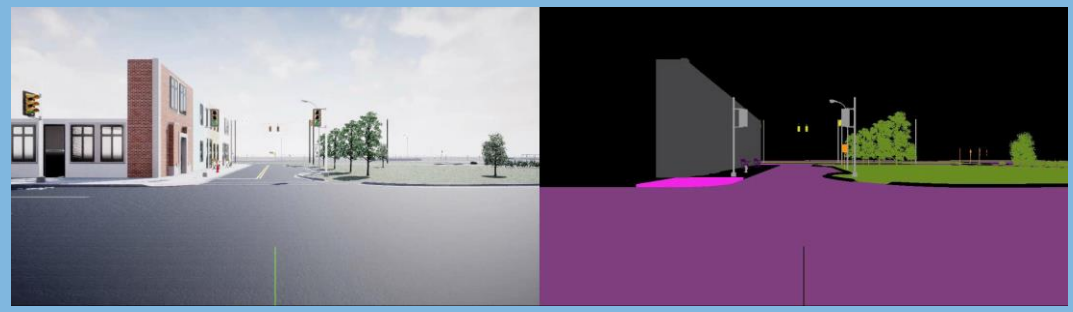


Record

Label

AI model

Simulation-based workflow



Simulate

Auto-label

NIO

MathWorks

Leveraging MATLAB-Simulink in Building Battery State-of-Health Estimo Pipelines for Electric Vehicles

Nilesh Kulkarni, Director, Artificial I
Matthew Daigle, Principal Scientist

In electric vehicles, understanding battery State-of-Health (SOH) is critical

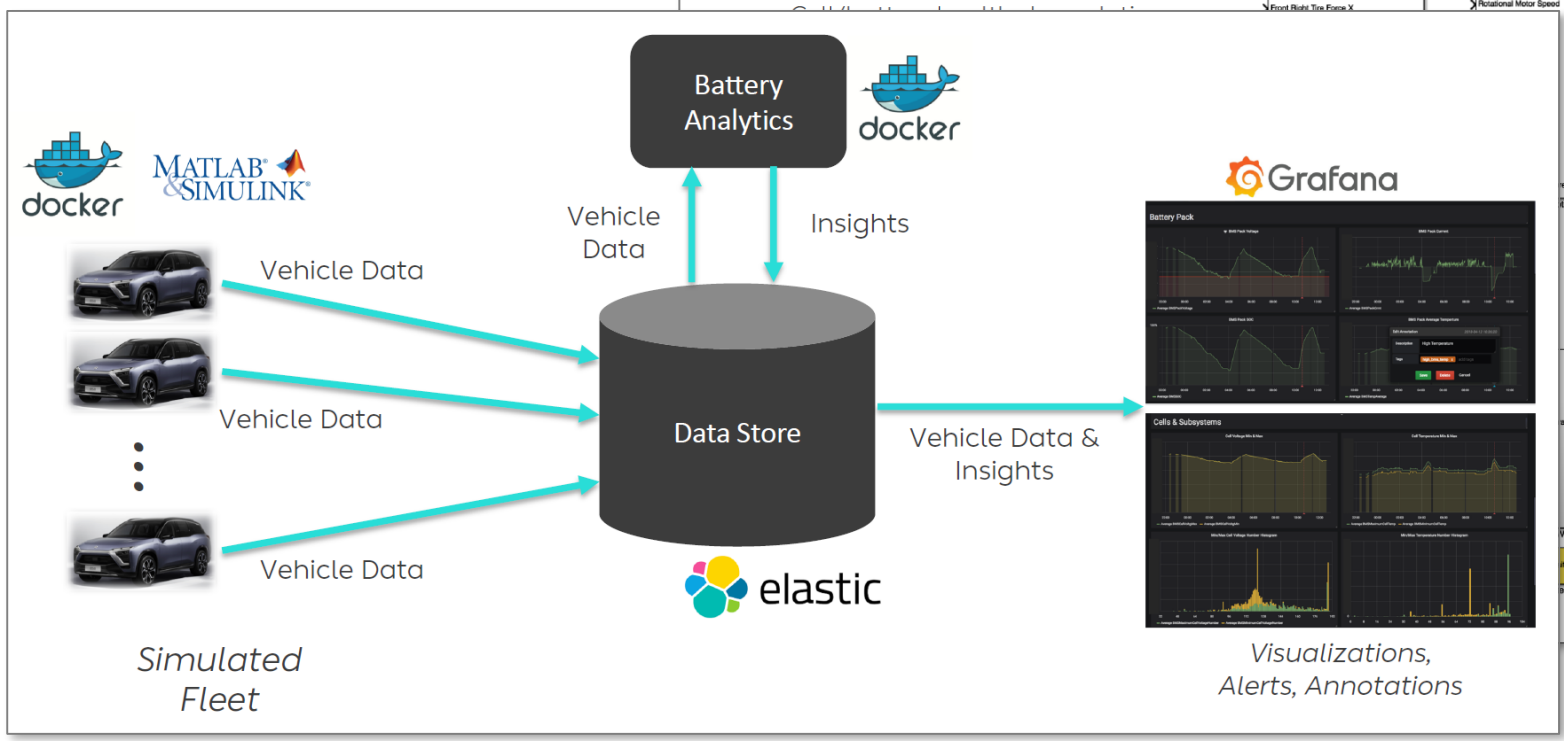
Challenges

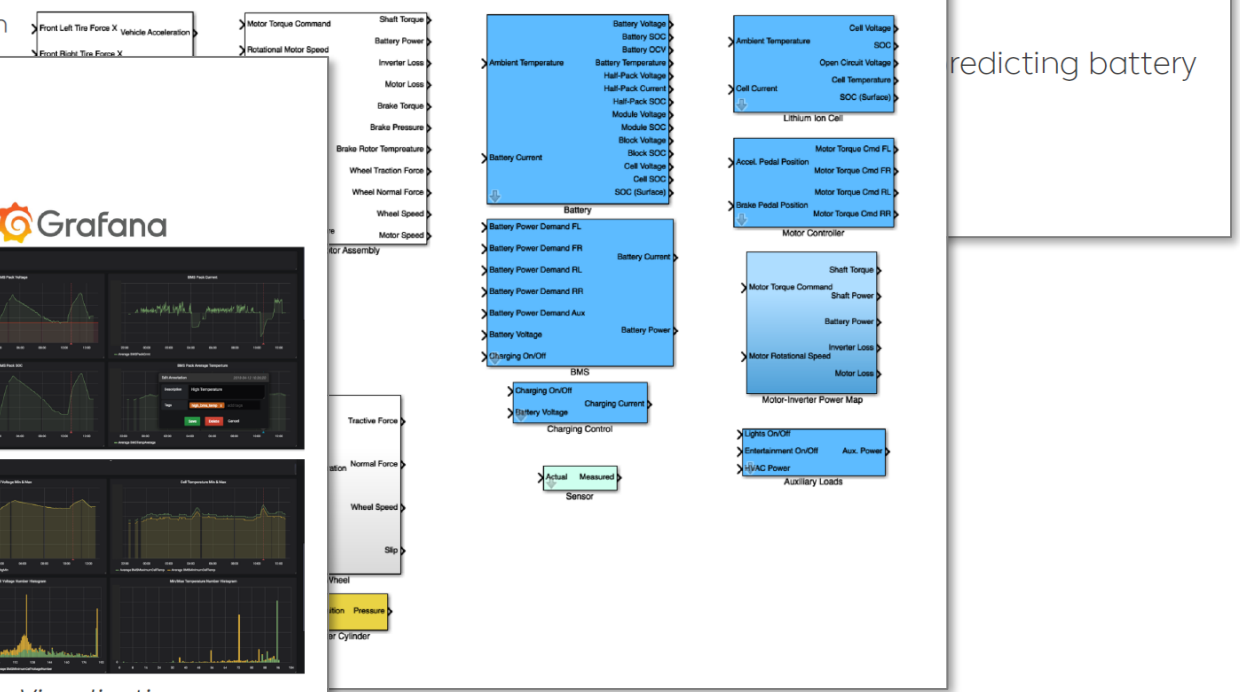
- In the product design phase, battery data is available only under laboratory and limited driving

redicting battery

Vehicle Simulation Summary

- Electrical
  - Cell models and battery configuration

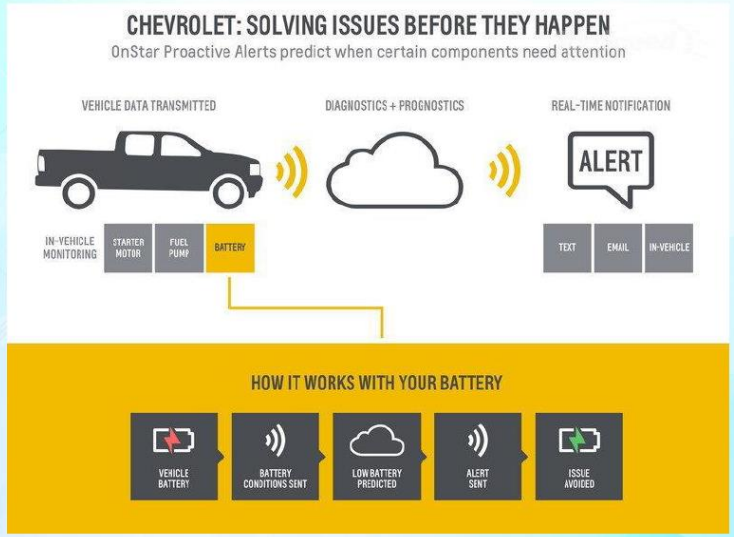




Large Scale Automotive Data Analytics: GM

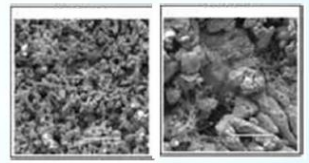
- OnStar™ Proactive Alert – A new customer care service
  - Alert before failure happens
  - Transform an emergency repair to planned maintenance
  - Enhance ownership experience - a delight to customers

VEHICLE PROGNOSIS

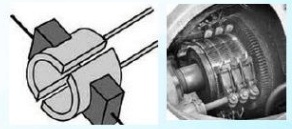


PROGNOSTIC ALGORITHM DEVELOPMENT

Physical-model based algorithm generation:
- Study failure modes - FMEA
- Model physics of failure
- Generate fault signatures and failure precursors
- Develop prognostics algorithm
- Validate concept on benches and test vehicles



Lead Acid Battery
(Plate Surface Scanning Electron Microscopy)



Electric Motor

MathWorks tools used for algorithm development and data analysis

Big-data based algorithm validation:
- Collect data from >1M vehicles
- Analyze warranty return parts
- Correlate algorithm outputs with engineering assessment
- Calibrate algorithm parameters

Impact of disruptive trends on us: what MathWorks is working

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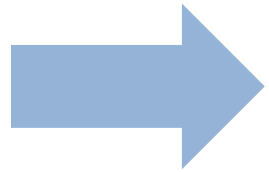
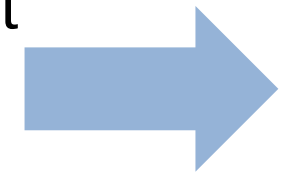


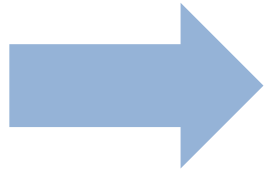
Simulink is simulation integration platform

- Scaling up embedded software development
  - Agile development
  - System Architecture



Utilize plant models
New capabilities, tools

- Leveraging streaming and stored data
  - Data utilization in Model-Based Design workflow
  - Digital service for new businesses



AI
MATLAB&Simulink integration
MATLAB scalability

Enjoy the conference