



ENABLING DATA DRIVEN DEVELOPMENT FOR AUTONOMOUS DRIVING.

PROMISES OF AUTONOMOUS DRIVING TO CUSTOMERS AND SOCIETY.

HIGHER
SAFETY
MORE
COMFORT
HIGHER
FLEXIBILITY
MORE TIME

LESS EMISSIONS

LESS
ACCIDENTS

LESS TRAFFIC

NEW MOBILITY
CONCEPTS
VEHICLES BEING PART OF OUR
LIVING SPACE



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**CHALLENGE 1: COMPLEX FUNCTION
DEVELOPMENT**

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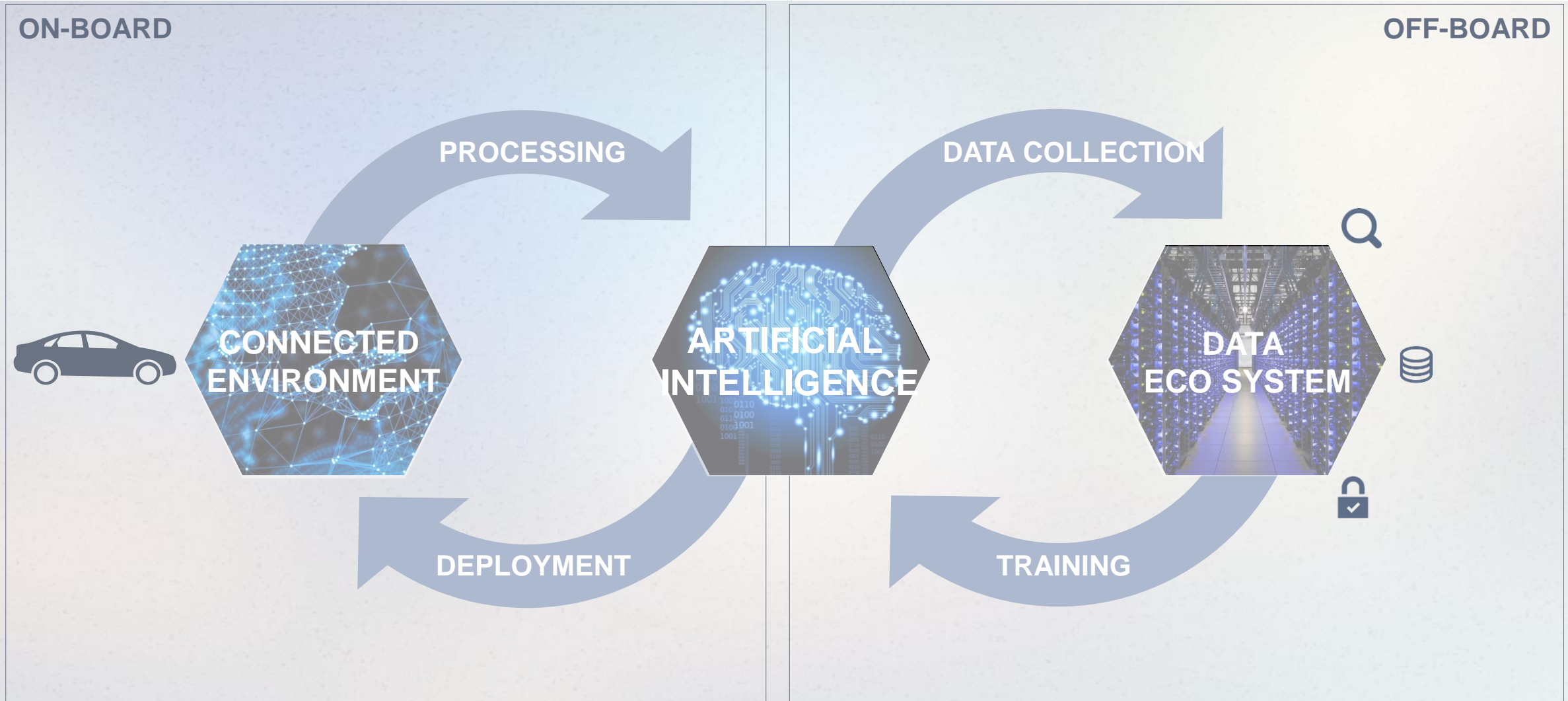
NEW MOBILITY
CONCEPTS
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CHALLENGE 1: COMPLEX FUNCTION
DEVELOPMENT
CHALLENGE 2: PROVE
SAFETY

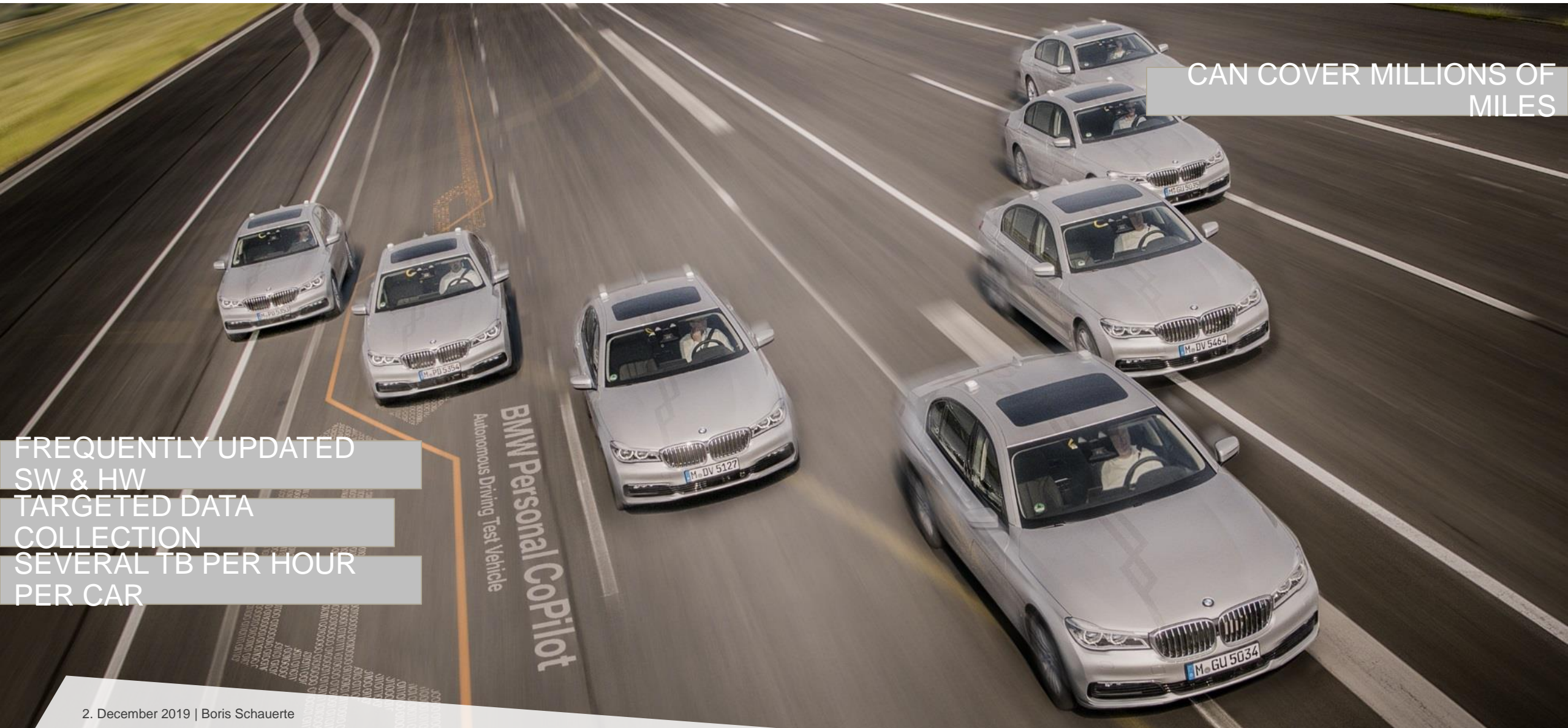
ARTIFICIAL INTELLIGENCE VALUE LOOP. AUTONOMOUS DRIVING.



ARTIFICIAL INTELLIGENCE VALUE LOOP. AUTONOMOUS DRIVING.



DEDICATED DATA COLLECTION AND TEST FLEET.



CAN COVER MILLIONS OF MILES

FREQUENTLY UPDATED
SW & HW
TARGETED DATA
COLLECTION
SEVERAL TB PER HOUR
PER CAR

BMW Personal CoPilot
Autonomous Driving Test Vehicle

CUSTOMER FLEET DATA COLLECTION.

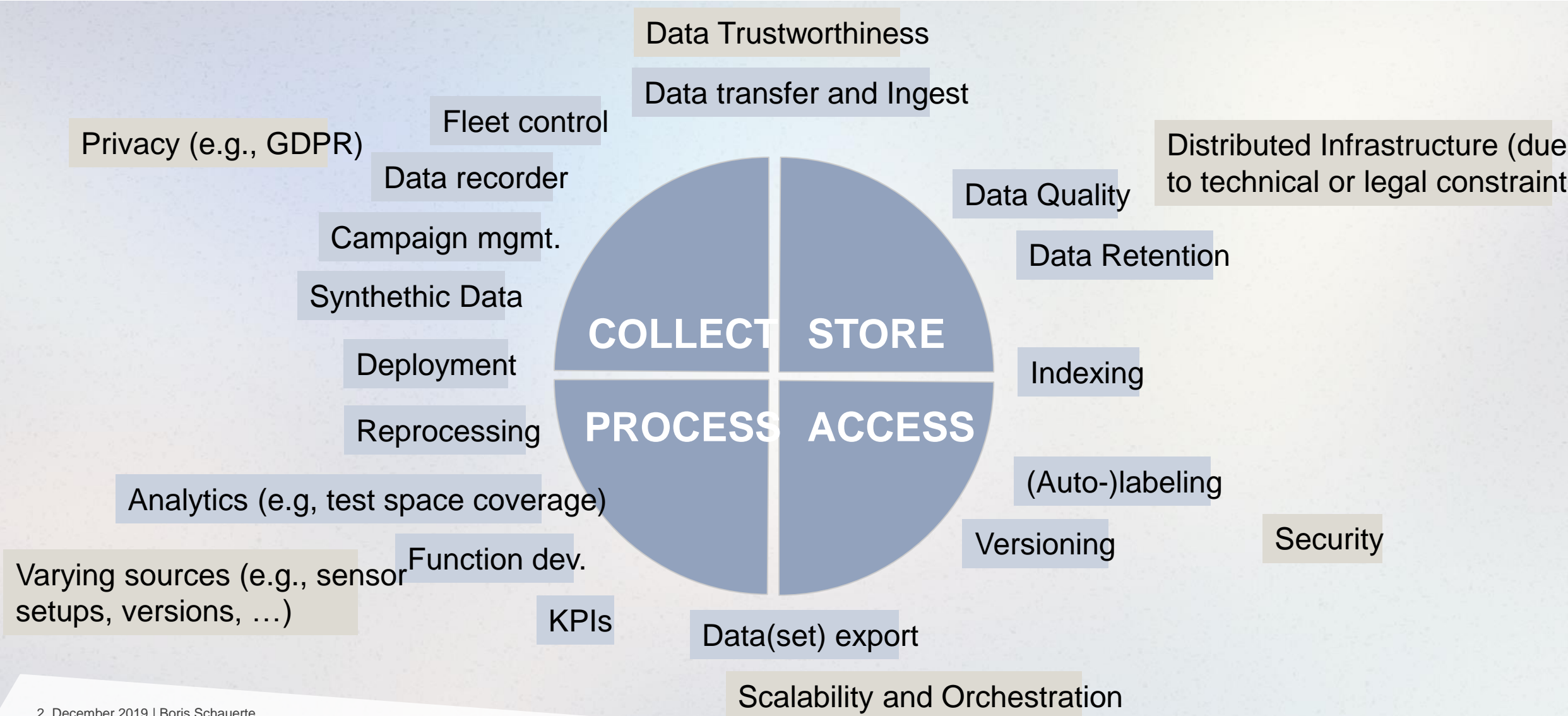
CAN COLLECT BILLIONS OF MILES



STABLE SW & HW
TARGETED DATA
COLLECTION
SEVERAL MB PER
HOUR



DATA LANDSCAPE.



BUILDING A AUTONOMOUS DRIVING DATA FACTORY.

INTRODUCTION & DATA SOURCES:

Data-driven development needs large amounts of data.

AUTOMATION & ARCHITECTURE:

Automated processes are necessary to handle the volume.

DATA FACTORY.

Data Collection & Preparation



Development Fleet



Customer Fleet

Data quality
assurance,
Data access
API

Raw Data

Ground truth
generation
Data clearing & post
processing

Labeling & Indexing
Classify sequences

DATA FACTORY.

Data Collection & Preparation



Development Fleet



Customer Fleet

Data quality assurance,
Data access API

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Ground truth generation

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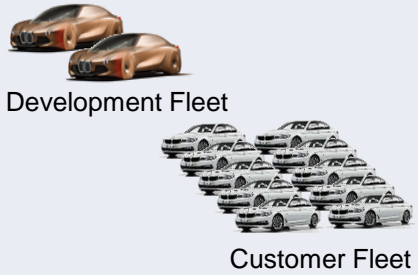
Labeling & Indexing
Classify sequences

Post-Processed Data

Evaluation Framework
Evaluation of safety, performance, comfort, test coverage etc.

DATA FACTORY.

Data Collection & Preparation



Data quality assurance,
Data access API

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Simulation

Environment Simulation

Traffic Models

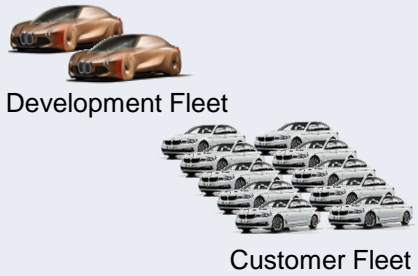
Sensor Models

Vehicle Model

Bus Simulation

DATA FACTORY.

Data Collection & Preparation



Data quality assurance,
Data access API

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Ground truth generation
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Scenario Descriptions

Simulation

Environment Simulation

Traffic Models

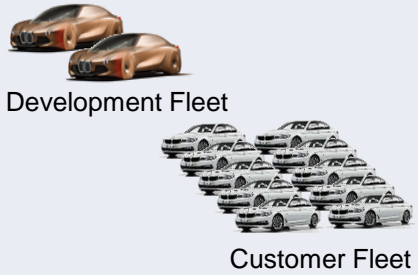
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Data Collection & Preparation



Data quality assurance,
Data access API

Raw Data

Ground truth generation
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Labeling & Indexing
Classify sequences

Post-Processed Data

Data, Simulation & Test Management

Traffic to Description
Derive (simulatable) scenario from post-processed data

Evaluation Framework
Evaluation of safety, performance, comfort, test coverage etc.

Scenario Descriptions

Simulation

Environment Simulation

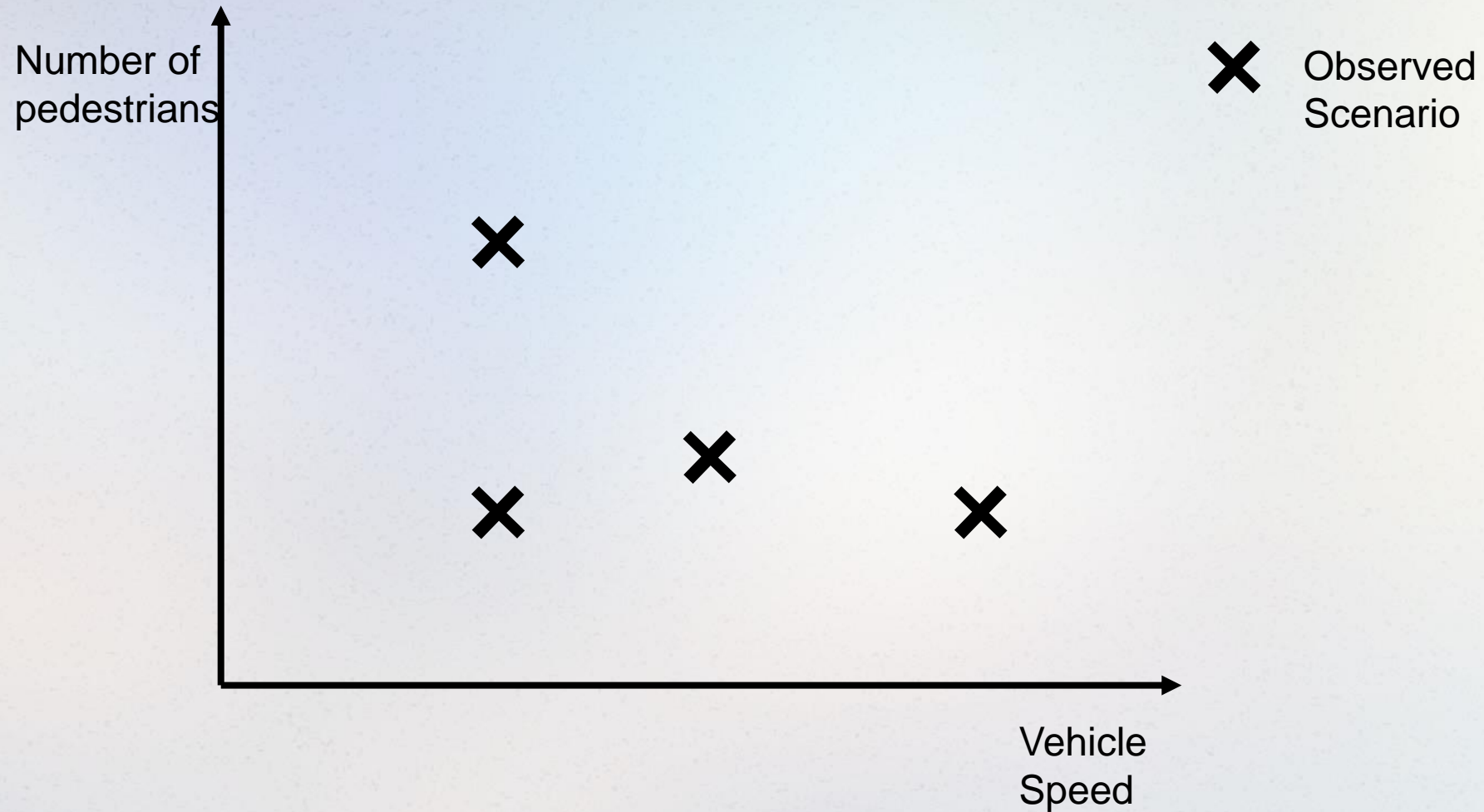
Traffic Models

Sensor Models

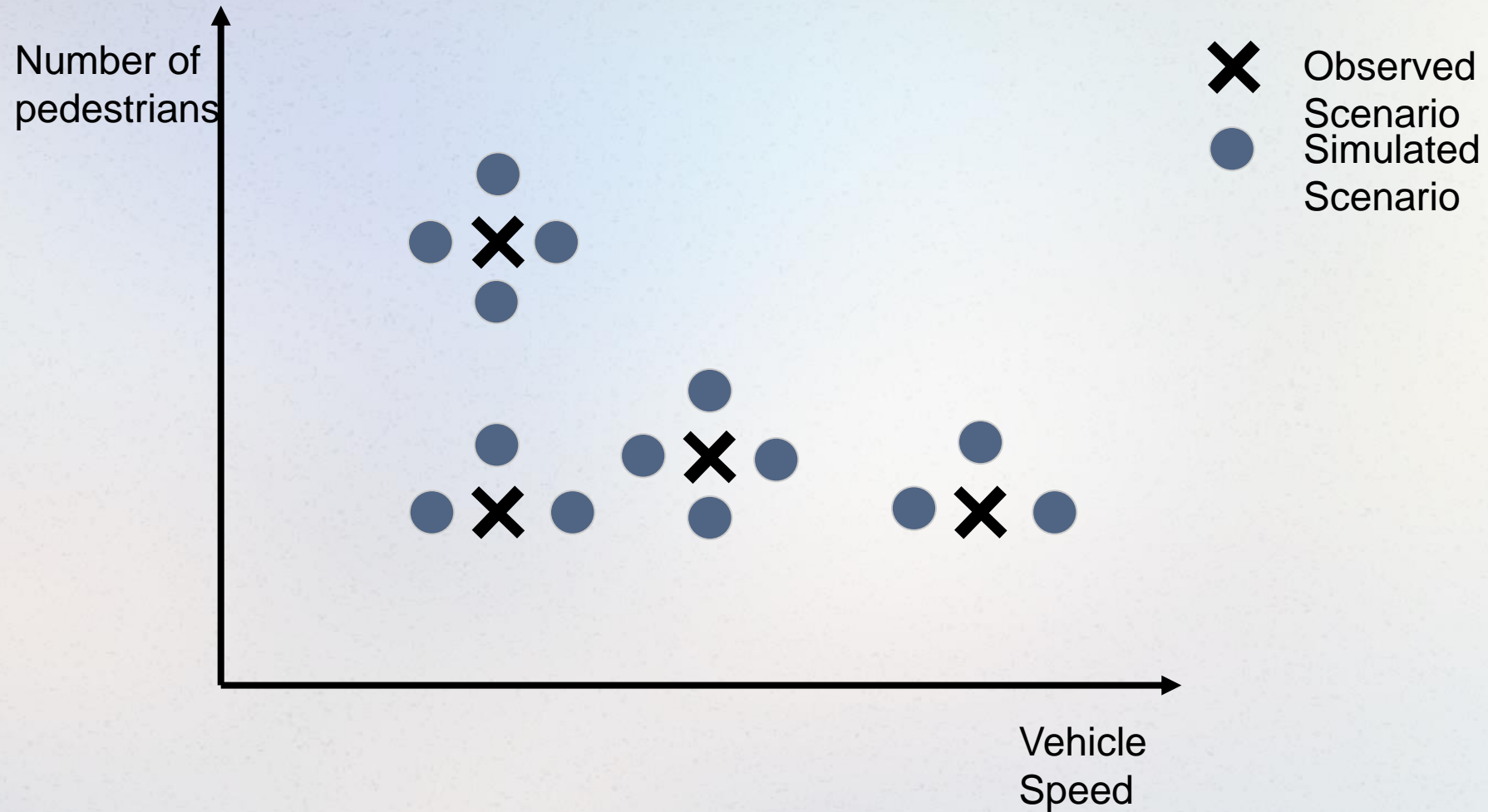
Vehicle Model

Bus Simulation

EXTENDING THE SCENARIO SPACE WITH SIMULATED DATA.



EXTENDING THE SCENARIO SPACE WITH SIMULATED DATA.

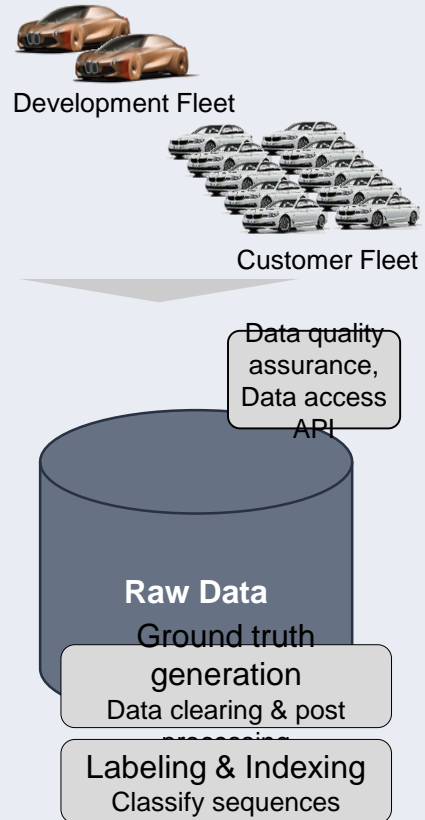


DATA VARIATION.



DATA FACTORY.

Data Collection & Preparation



Data, Simulation & Test Management

Scenario Extraction

Traffice to Description
Derive (simulatable) scenario from post-processed data

Scenario Variation

Auto. Scenario Variation

Scenario Evaluation

Evaluation Framework
Evaluation of safety, performance, comfort, test coverage etc.

Scenario Descriptions

Simulation

Environment Simulation

Traffic Models

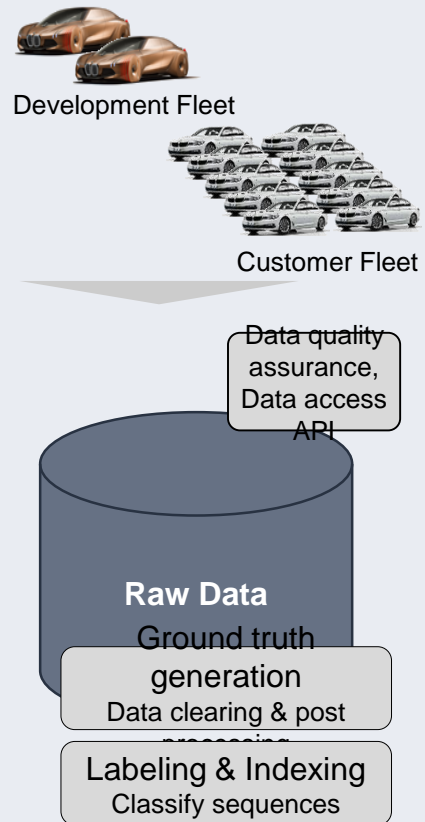
Sensor Models

Vehicle Model

Bus Simulation

DATA FACTORY.

Data Collection & Preparation



Data, Simulation & Test Management

Scenario Extraction

Traffice to Description
Derive (simulatable) scenario from post-processed data

Test Space Analytics
Derive model and statistics for scenarios

Scenario Evaluation

Evaluation Framework
Evaluation of safety, performance, comfort, test coverage etc.

Test Space Coverage
Statistical coverage of the test space

Scenario Variation

Auto. Scenario Variation

Test Space Exploration
Generate necessary parameter variations

Scenario Descriptions

Simulation

Environment Simulation

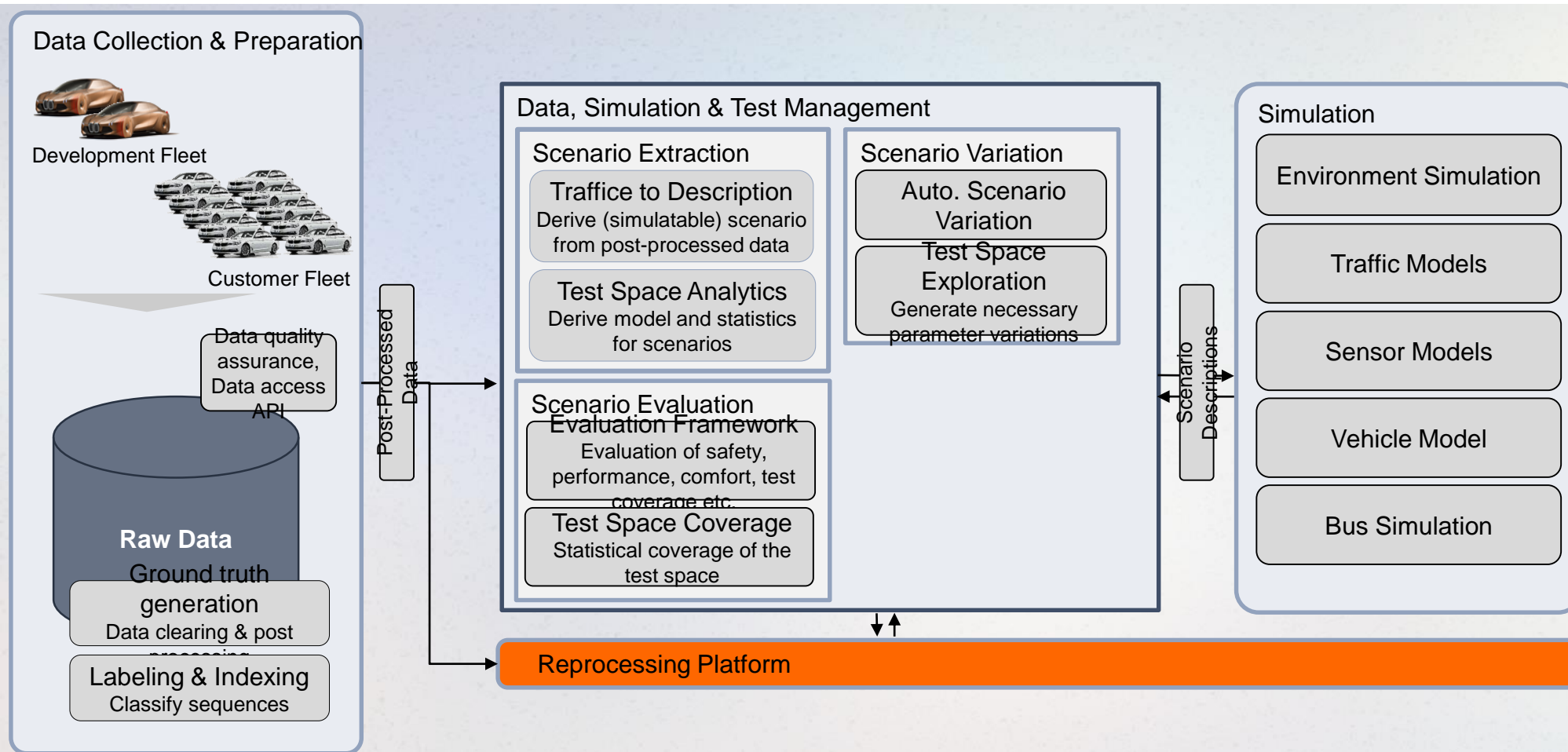
Traffic Models

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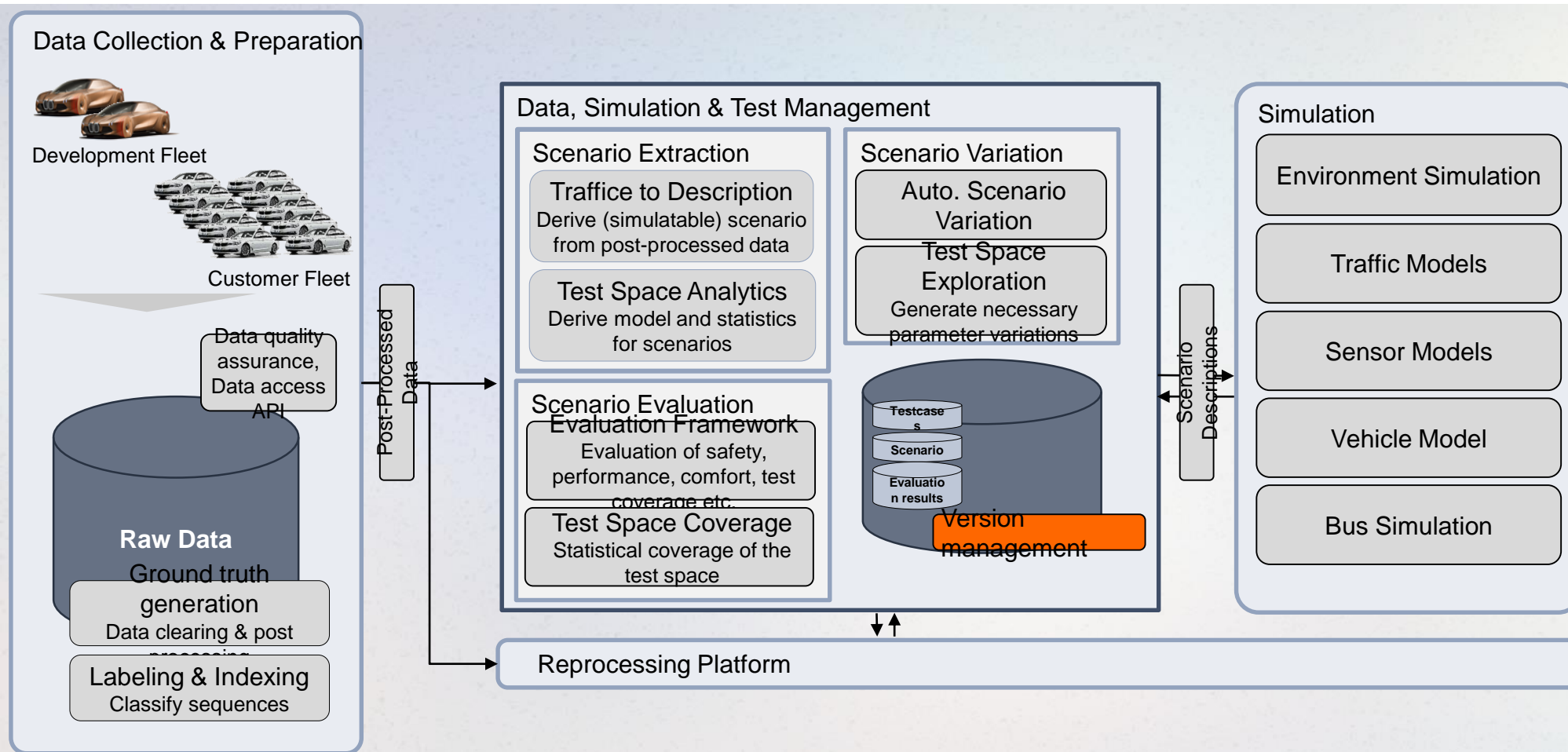
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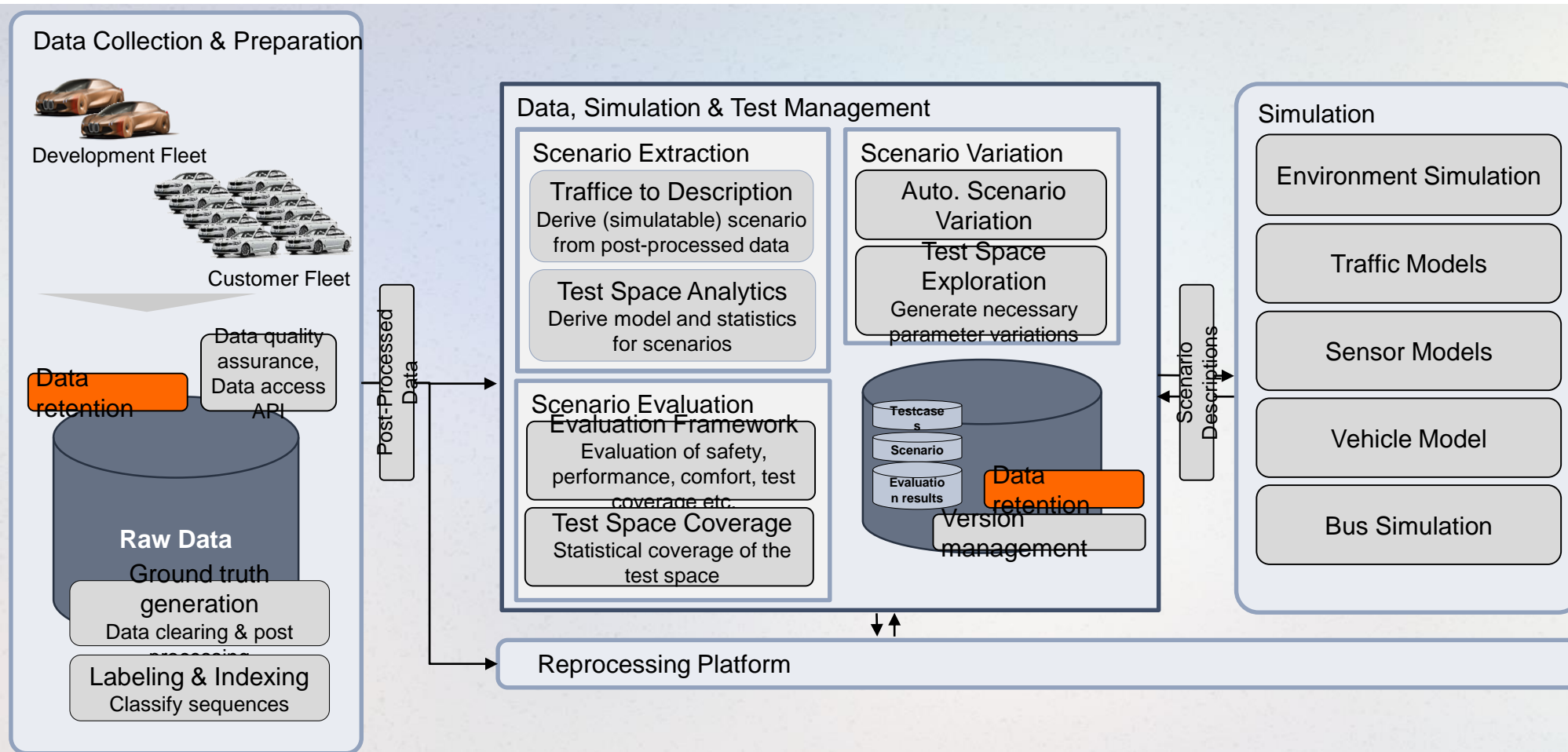
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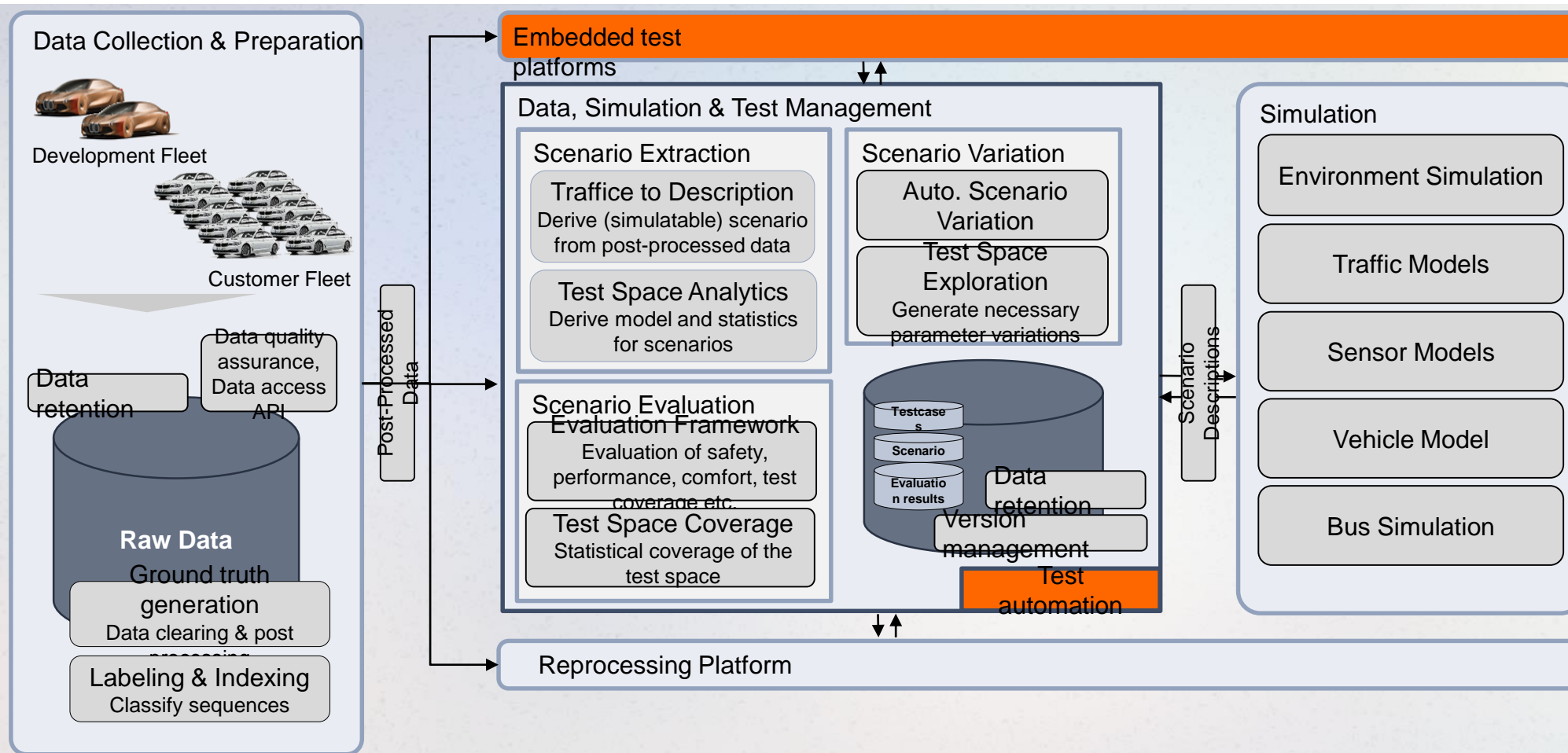
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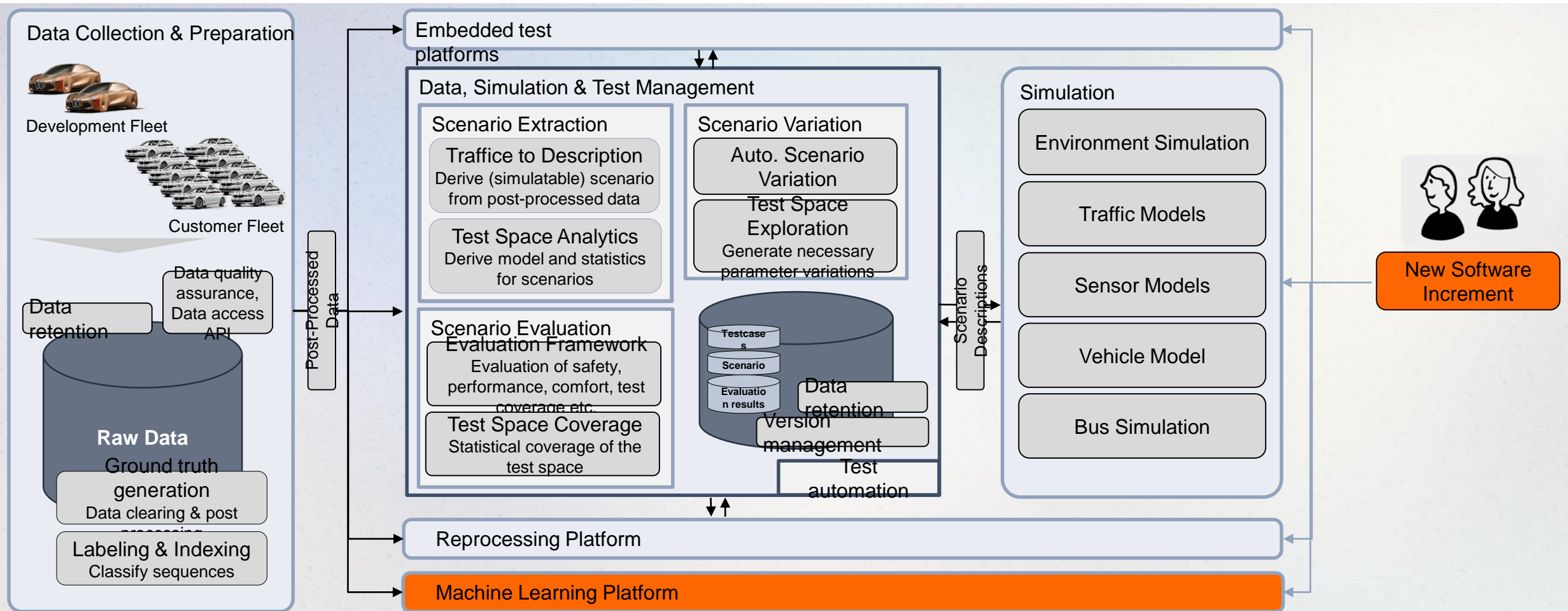
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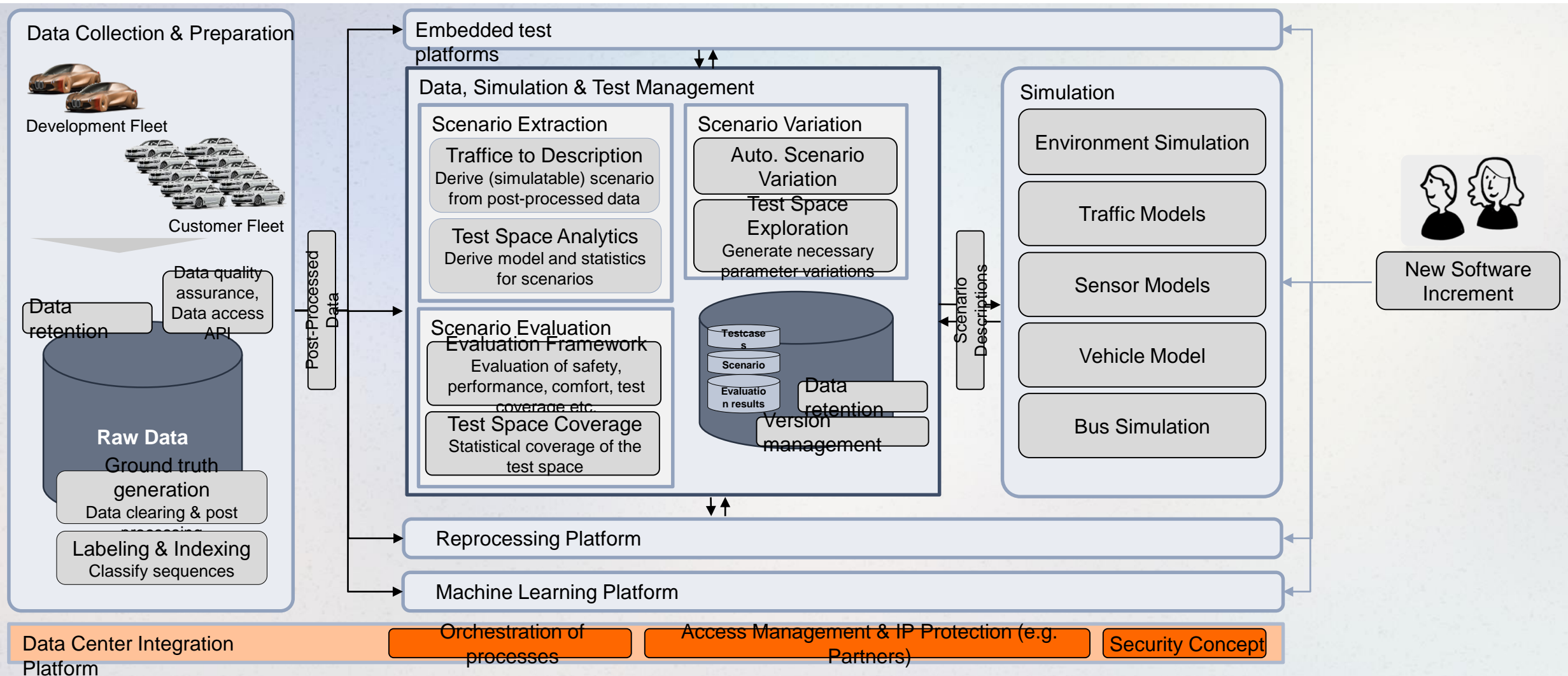
DATA FACTORY.



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DATA FACTORY.



THANK YOU FOR YOUR ATTENTION.

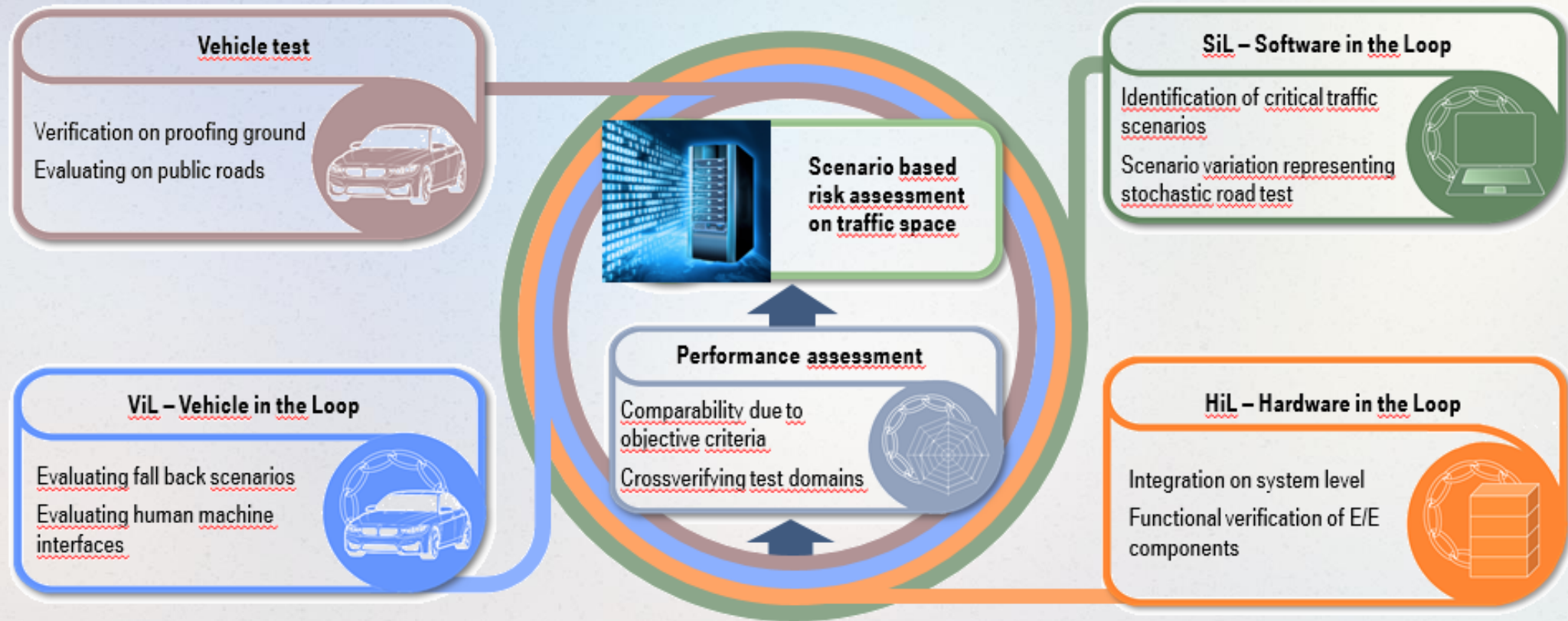
BORIS.SCHAUERTE@BMW.DE



Rolls-Royce
Motor Cars Limited



TEST LANDSCAPE.



WHAT IS ARTIFICIAL INTELLIGENCE?

THE AUTOMATION OF INTELLIGENT BEHAVIOR.

INFORMATION TECHNOLOGY [IT]

ARTIFICIAL INTELLIGENCE

MACHINE LEARNING

DEEP LEARNING

Knowledge representation

Perception and cognition

Planning and reasoning

...

Random forest

Neural networks

Support vector machine

...

Artificial neural nets

Deep neural nets

...

1950

EXPERT SYSTEMS
LEARNING SYSTEMS

rule based

1980

2010

SELF-

ARTIFICIAL INTELLIGENCE [AI] is a subdivision of computer science. AI describes a set of algorithm methodologies to solve complex optimization problems. Automates and supports decisions.

MACHINE LEARNING [ML] enables the recognition of patterns and correlations in data automatically as opposed to applying static rules and definitions. Allows the identification of formerly hidden semantics.

DEEP LEARNING [DL] describes a class of optimization methods loosely inspired by the structure of biological nervous systems. DL is able to produce results comparable to and in some cases superior to human experts, especially in the field of image recognition and natural language processing.

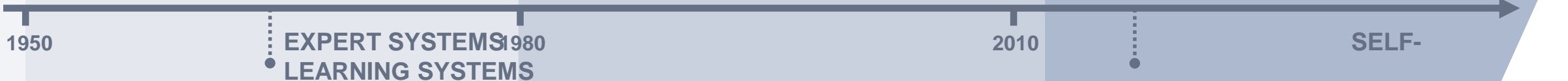
WHAT MADE THESE BREAKTHROUGHS POSSIBLE? ONE FACTOR, THE EMERGENCE OF ACCESS TO HIGH-QUALITY DATA.

INFORMATION TECHNOLOGY [IT]

ARTIFICIAL INTELLIGENCE

MACHINE LEARNING

DEEP LEARNING



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