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AUT204

Autonomous driving simulation and validation on AWS

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Sr. Engineering Manager
Toyota

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AWS for Automotive Solution Areas

Software-Defined Vehicle

The vehicle is evolving into a software-defined digital platform and empowering the design and development teams to deliver on changing consumer value expectations

Connected Mobility

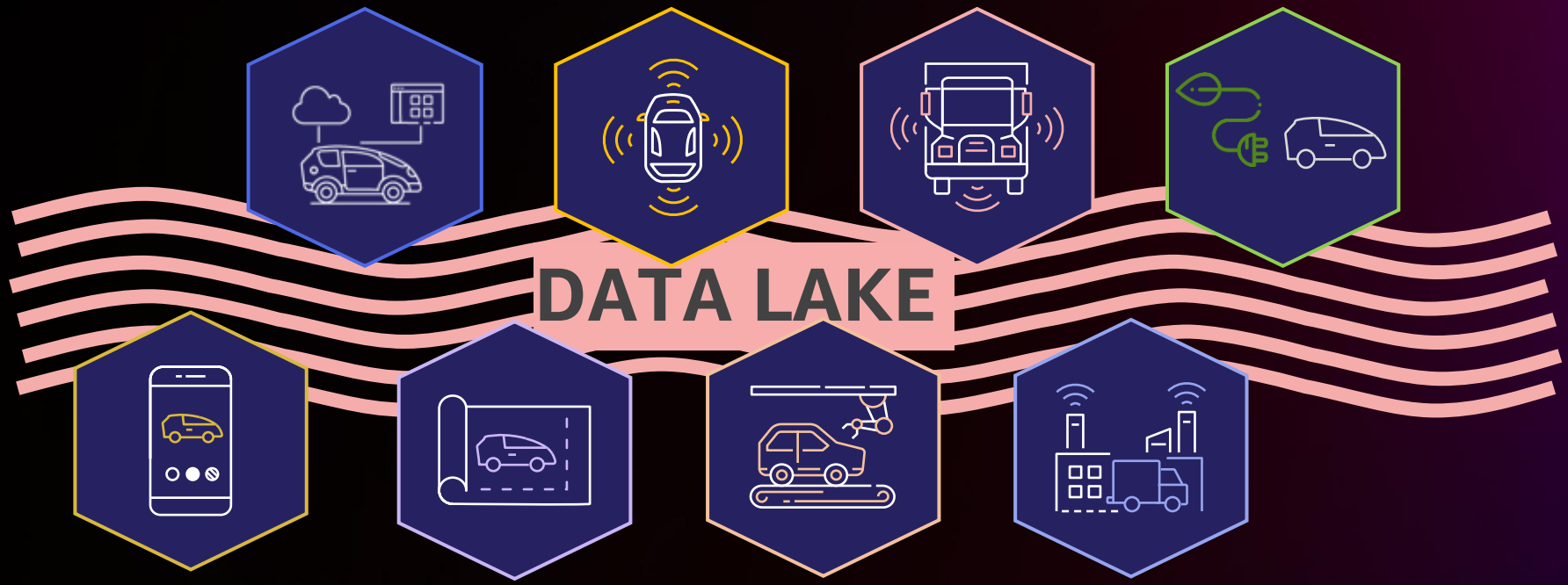
In a software-driven era, technology unlocks the power of your data to build intelligent, personalized features and revenue-generating mobility services

Autonomous Vehicle Development

Amazon's 20 years of experience with autonomous systems, robotics, and machine learning taught us how to accelerate our customers AV development with purpose-built AWS solutions

Sustainability

Enable customers to create and manage sustainable mobility and transform their enterprise to positively impact climate change



Digital Customer Engagement

Increase customer engagement with relevant marketing content, personalized digital experiences, and real-time data analysis

Product Engineering

Customers can use AWS and partner-enabled solutions to develop new and innovative products at a faster pace by collaborating with multiple suppliers and OEMs across a single platform

Manufacturing

Realize improved manufacturing operations and overall equipment effectiveness by enabling data-driven real-time decisions leveraging existing shop floor data and innovative technologies.

Supply chain

Gain end-to-end real-time visibility and insights beyond immediate suppliers to build a resilient, intelligent and cost-effective supply chain with unprecedented efficiency

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Voice of the Customer

- Products over self-serve building blocks
- AWS Services customized for Automotive Industry
- Enable partners on AWS

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AWS Value Proposition for Autonomous Driving

- Hyperscale Challenge
- Shift Left
- Community
- Cross-Platform

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AV Data-Driven Development

SiL Simulation

Data Collection, Data Ingest, and Data Enrichment

Data Labeling

Machine Learning for Model Development and Training

Validation & Testing



Autonomous Vehicle Data Lake



AD Development Workspace

AD Software Stack integrated into Hardware

HiL Simulation

Soft HiL

Qualification in the Vehicle Test Drive

Qualification on AD Platform

Qualification in Cloud

Terms

SiL = Software-in-loop	HiL = Hardware-in-loop

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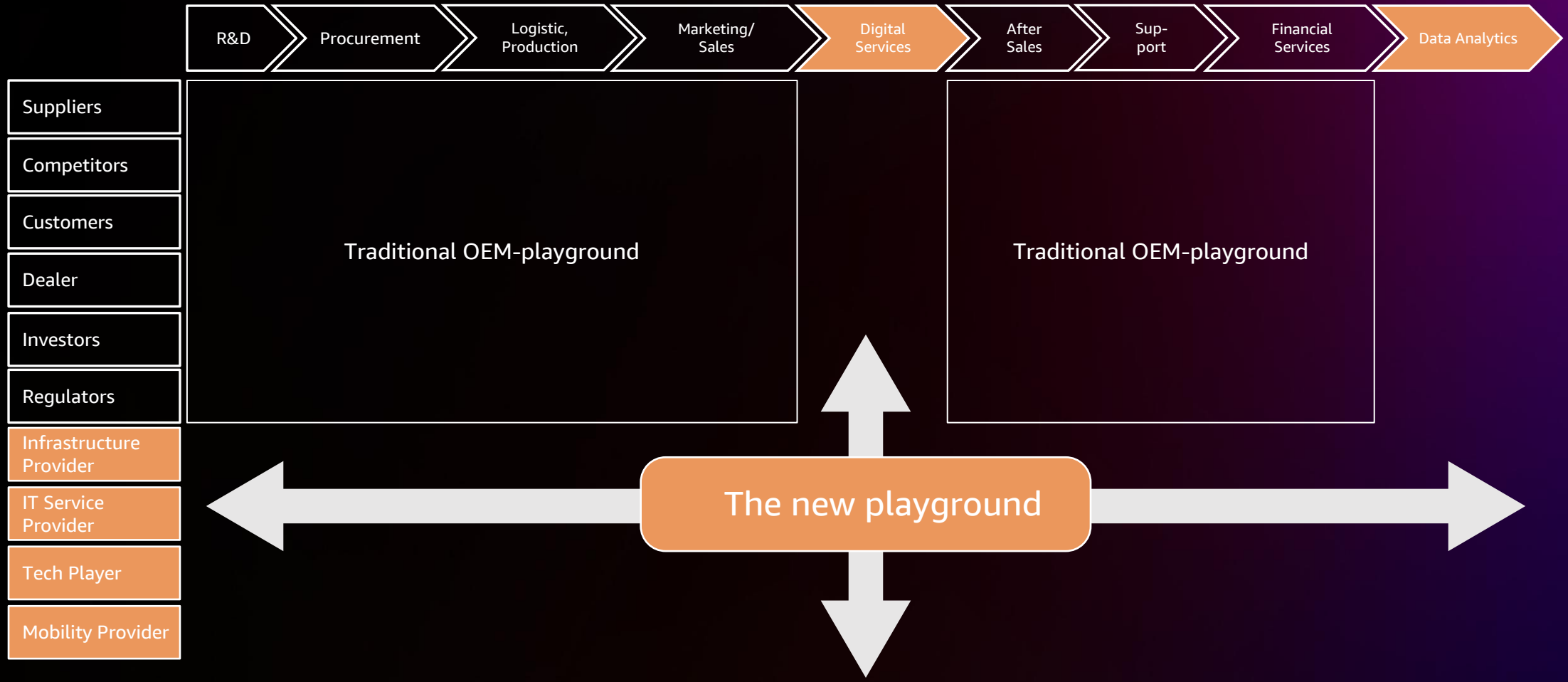
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Our iconic past and future



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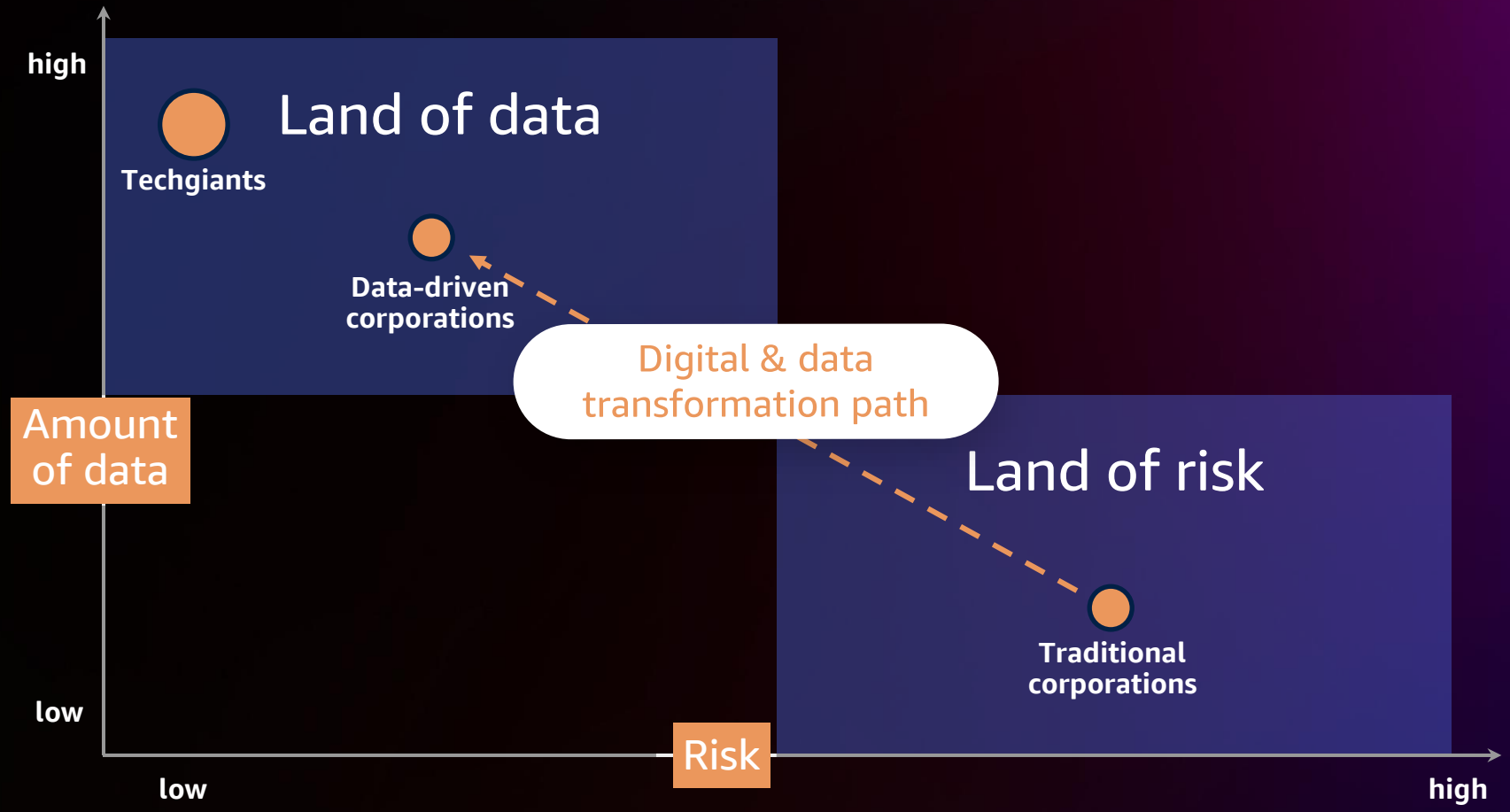
The new automotive value chain



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Digital and data transformation





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Data-driven R&D at VW Commercial Vehicles

Analytics

- Usage profiles
- Driving profiles

Data Logging

- Own test fleet
- Pilot customers

Vehicle analytics

Results

- Better vehicles
- Better services



Caddy



ID BUZZ



MOIA



T7



Amarok

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ID BUZZ AD



ID BUZZ



MOIA



T7



Amarok



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The ID. Buzz AD for MaaS & TaaS

- The ID. BUZZ AD is pointing the way to the future of mobility
- First fully autonomous vehicle in the Volkswagen Group
- Test in Germany started in 2021
- First offer for customers from 2025 with MOIA
  (our ride-hailing service in Germany)





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Monitoring and validation of SDS

Quality & **safety** assurance are vital

Continuous processing of huge amounts of data for **monitoring** and **validation** of self-driving systems (SDS)

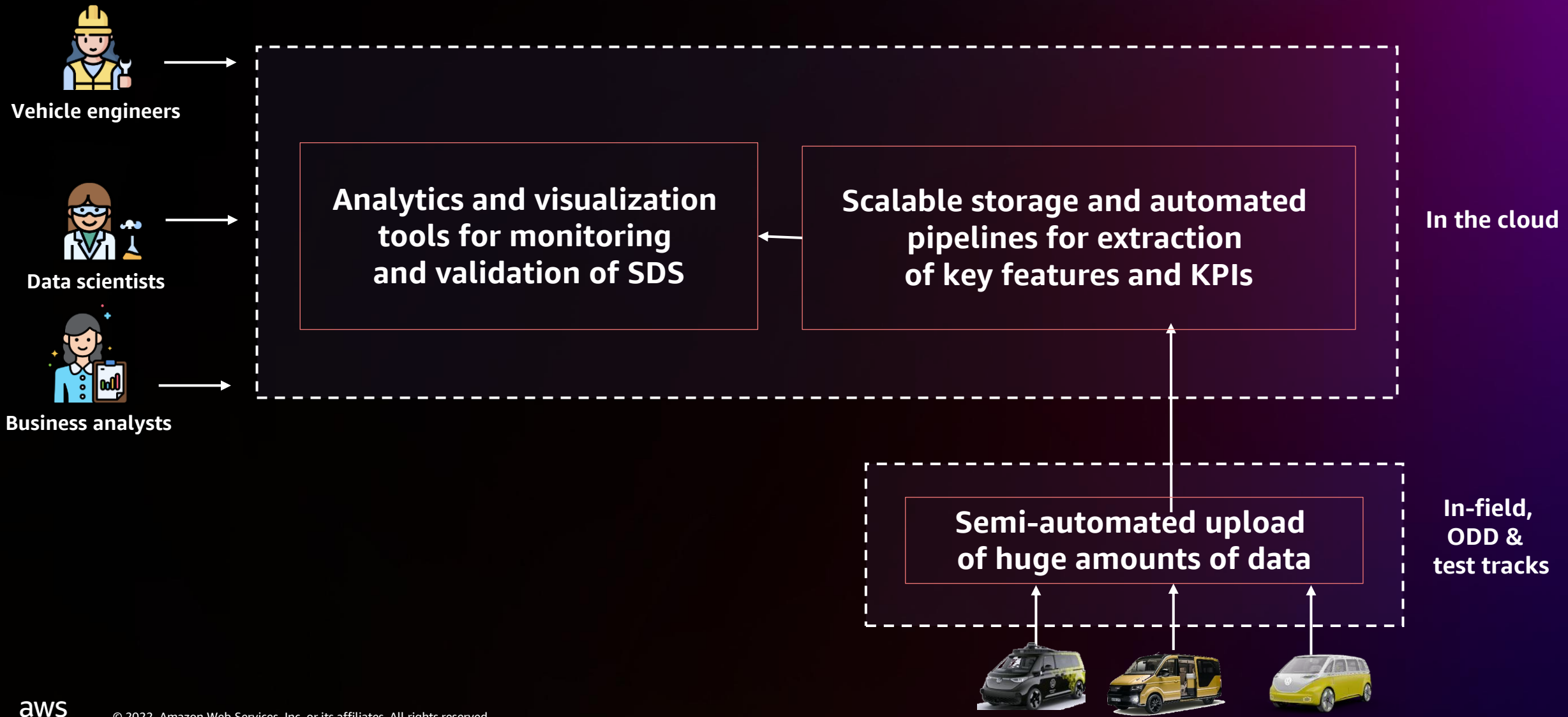
Insights are needed on **all decision levels**



ID BUZZ AD

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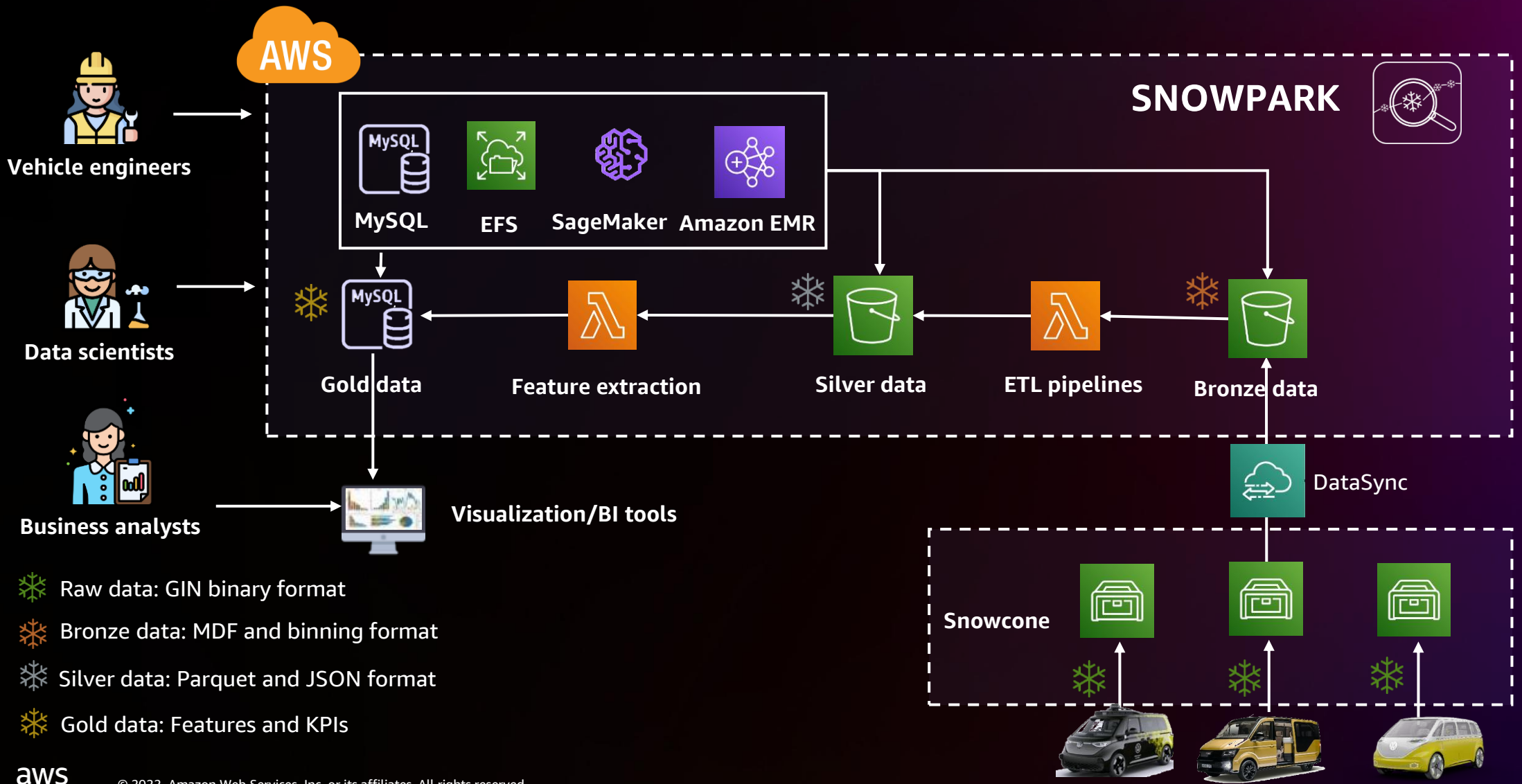
Data-driven development



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SNOWPARK for data-driven development

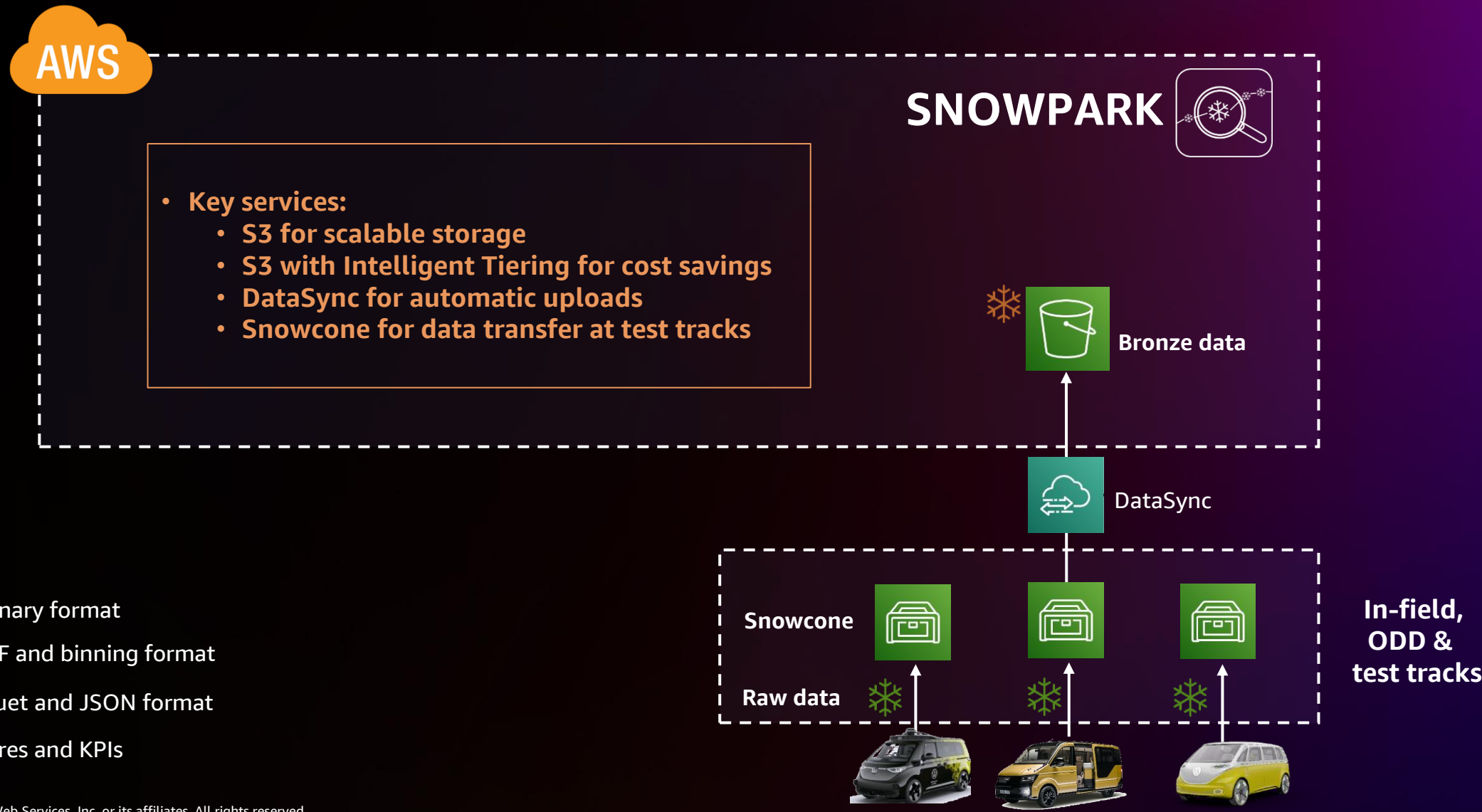


- Raw data: GIN binary format
- Bronze data: MDF and binning format
- Silver data: Parquet and JSON format
- Gold data: Features and KPIs

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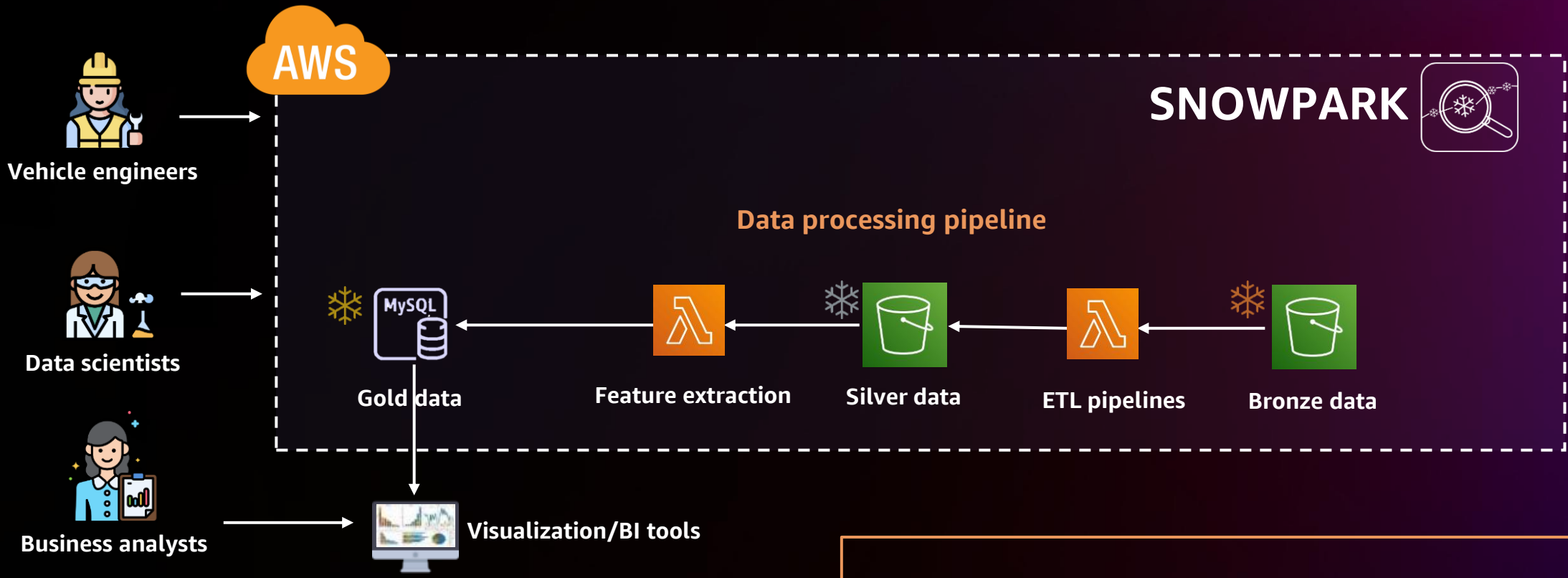
SNOWPARK for data-driven development



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SNOWPARK for data-driven development



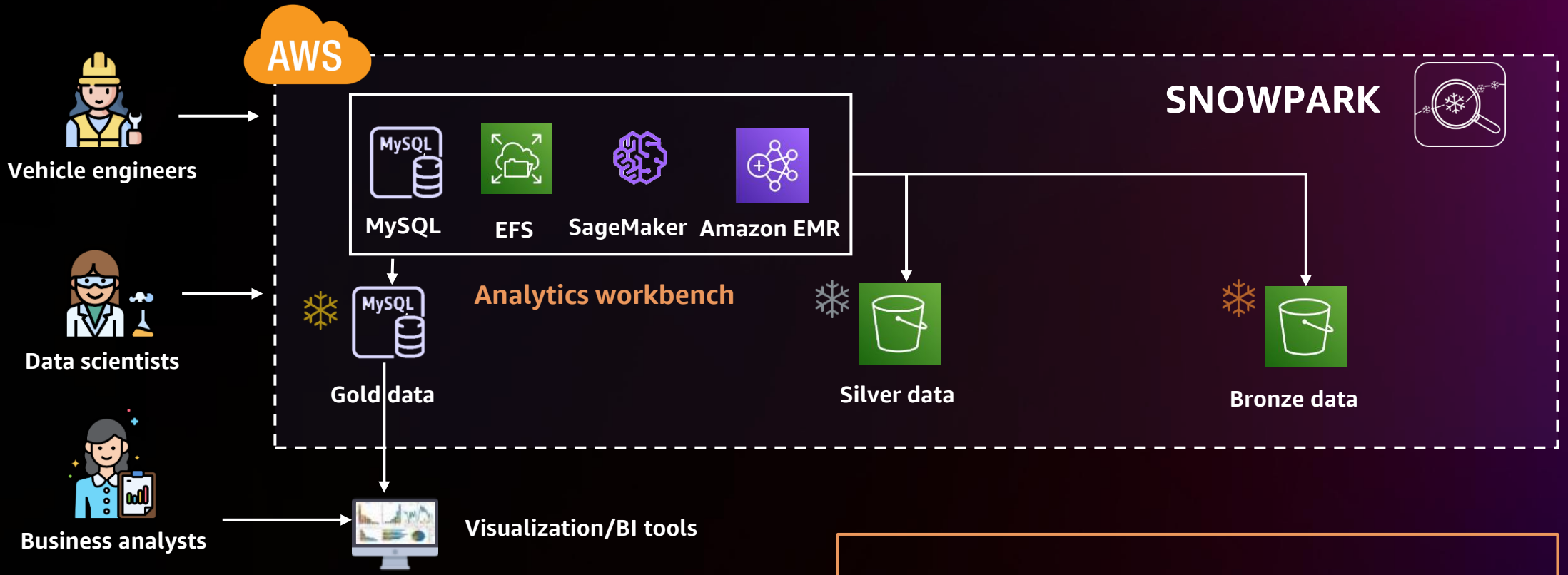
- Raw data: GIN binary format
- Bronze data: MDF and binning format
- Silver data: Parquet and JSON format
- Gold data: Features and KPIs

- **Key services:**
  - **Lambda functions and Amazon SQS as building blocks**
  - **Full automation using event triggers**
  - **CloudWatch for monitoring and alerting**

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SNOWPARK for data-driven development



- Raw data: GIN binary format
- Bronze data: MDF and binning format
- Silver data: Parquet and JSON format
- Gold data: Features and KPIs

- **Key services:**
  - **SageMaker for ML tasks**
  - **Amazon EMR for scalable analytics**
  - **Elastic File System (EFS) for sharing data**

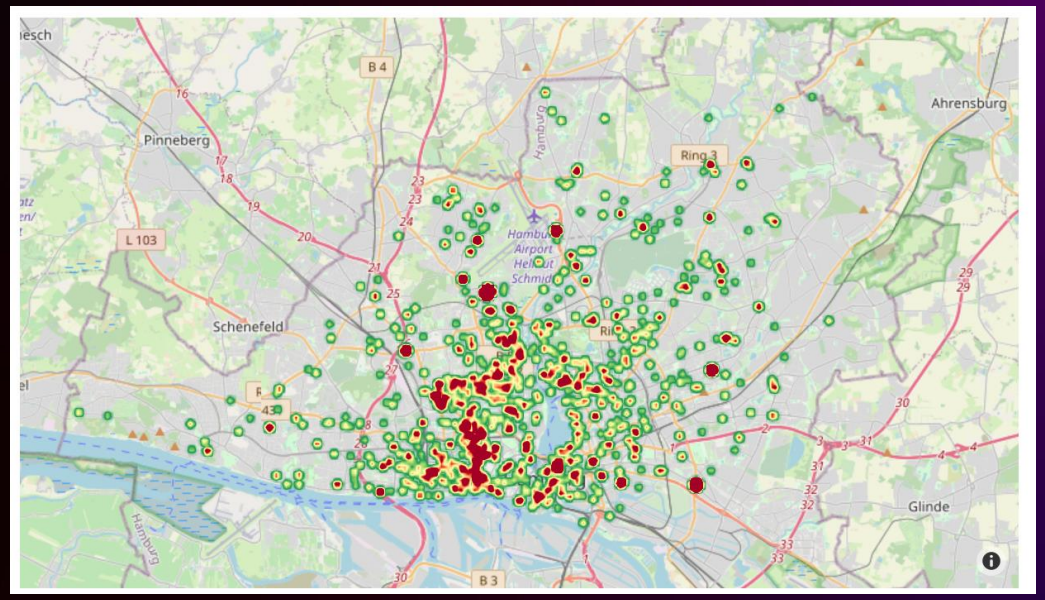
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Example: SDS monitoring and validation



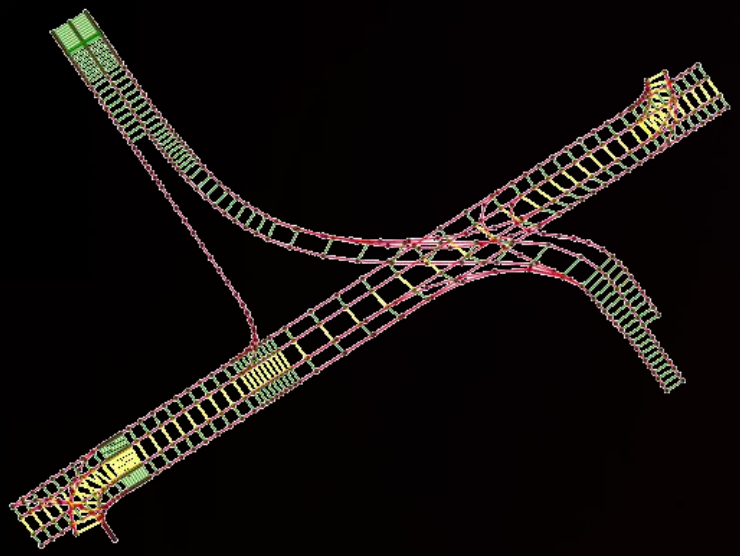
Reconstructions of driving situations using vehicle sensors data



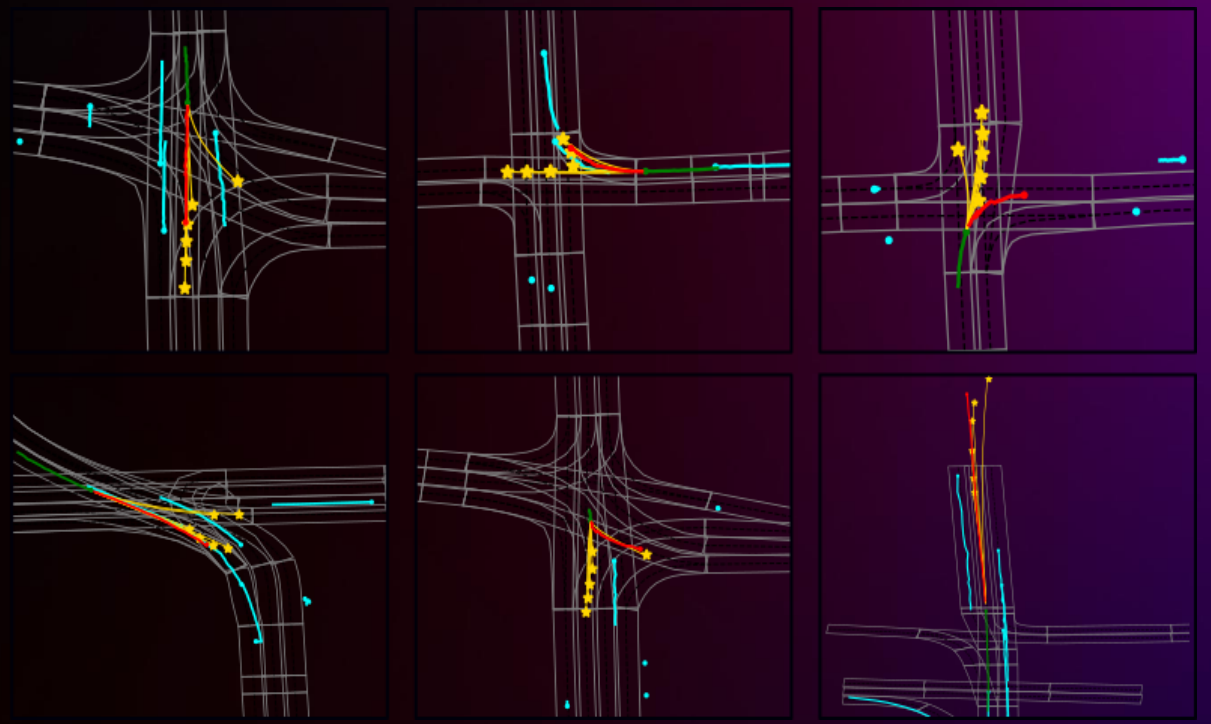
Monitoring of the ODD coverage (an illustrative plot as an example)

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Example: Motion prediction using graphormers



Graph representation of road networks



Evaluation of motion prediction models

Shimon Wonsak, Mohammad Al-Rifai, Michael Nolting and Wolfgang Nejdl, "*Multi-Modal Motion Prediction with Graphormers,*"
Published at the IEEE International Conference on Intelligent Transportation Systems, 2022

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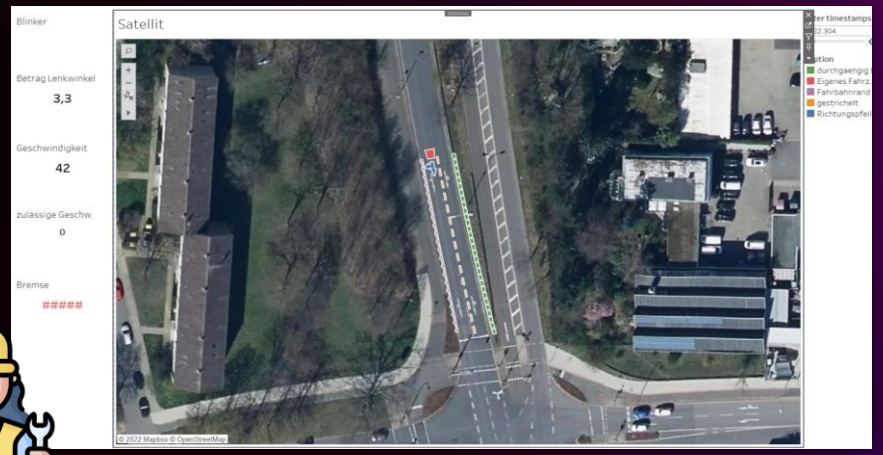
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Data democratization in the land of data



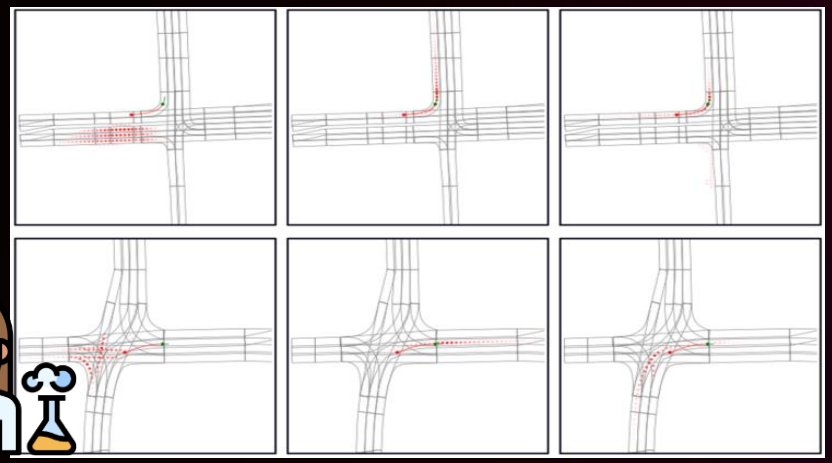


Business intelligence – Management decision level





Technical features – The engineering perspective





Data science – The algorithmic perspective

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Scale-Out Edge-to-Cloud DataOps for ADAS/AV programs in production

Tim Holman
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Toyota Motors North America

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Overview

- About TMNA R&D and IVS
- Big Picture/Challenges
- Solution Deployed
- Solution Benefits
- Lessons
- Conclusions

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About TMNA R&D and IVS



- Toyota Motors North America, R&D Pillar, Integrated Vehicle Systems Division
- Commonly referred to as IVS
- Multi-disciplinary team
- Mission: ***Mobility for All***
- Support the ADAS production cycle from research to production follow-up
- Lead development for Team Mate in North America

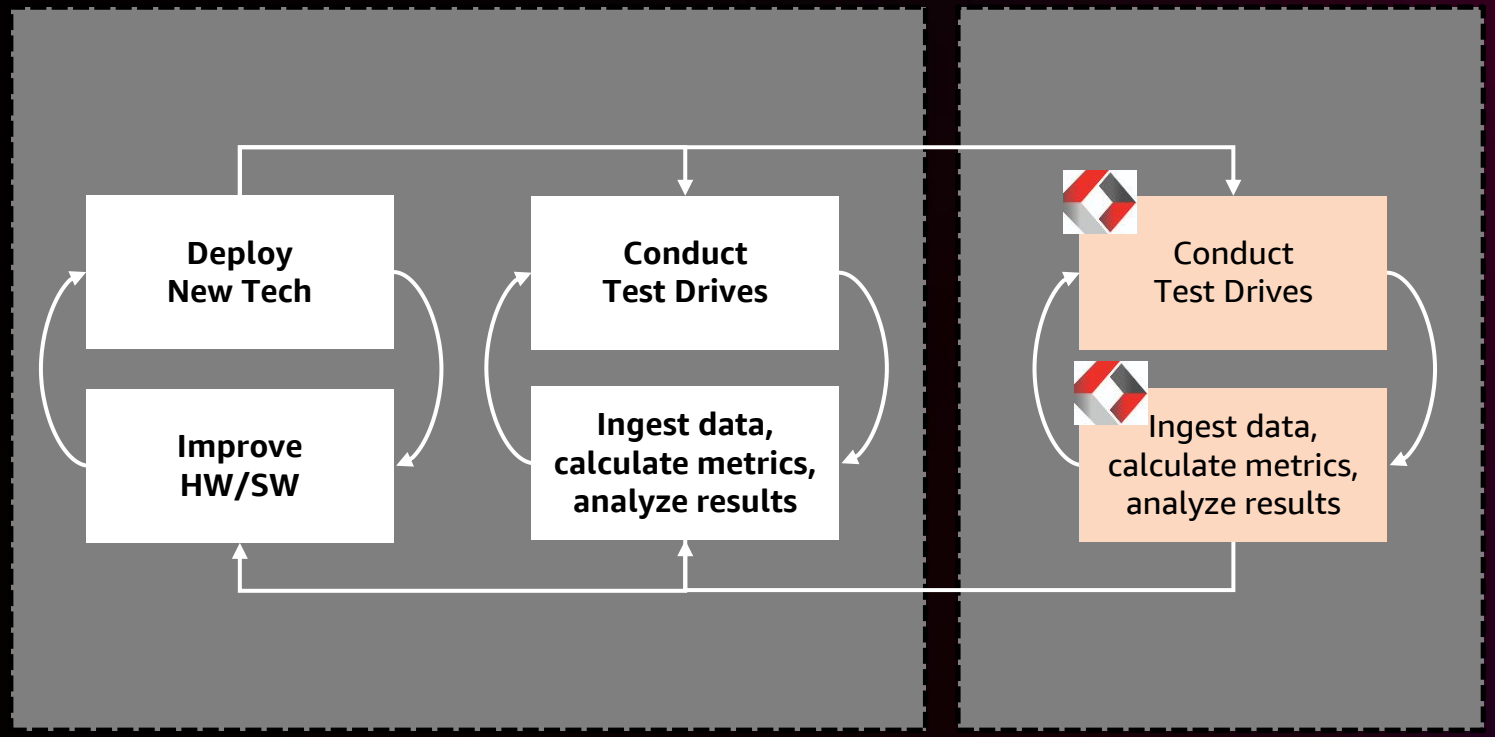
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Big Picture / Challenges

HW/SW DEV & R&D



ADAS Development Lifecycle



REGIONAL R&D

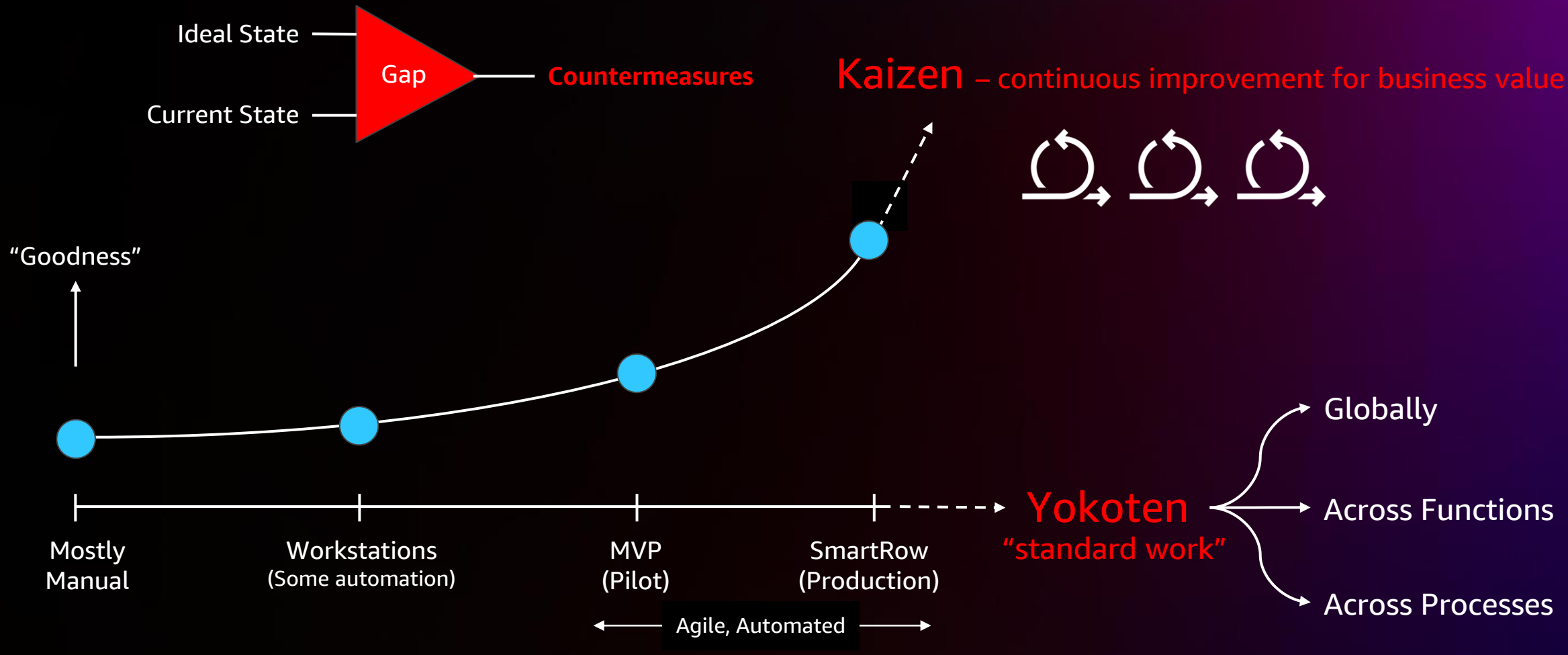


Challenges:

1. **ADAS Evaluation Growth [Scale]**
2. **Data Volume Growth [Scale]**
3. **Time to Analyze / Answer [Productivity][Operations]**
4. **Global Teams [SCALE][Collaboration]**

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TMNA Dev Process Improvement



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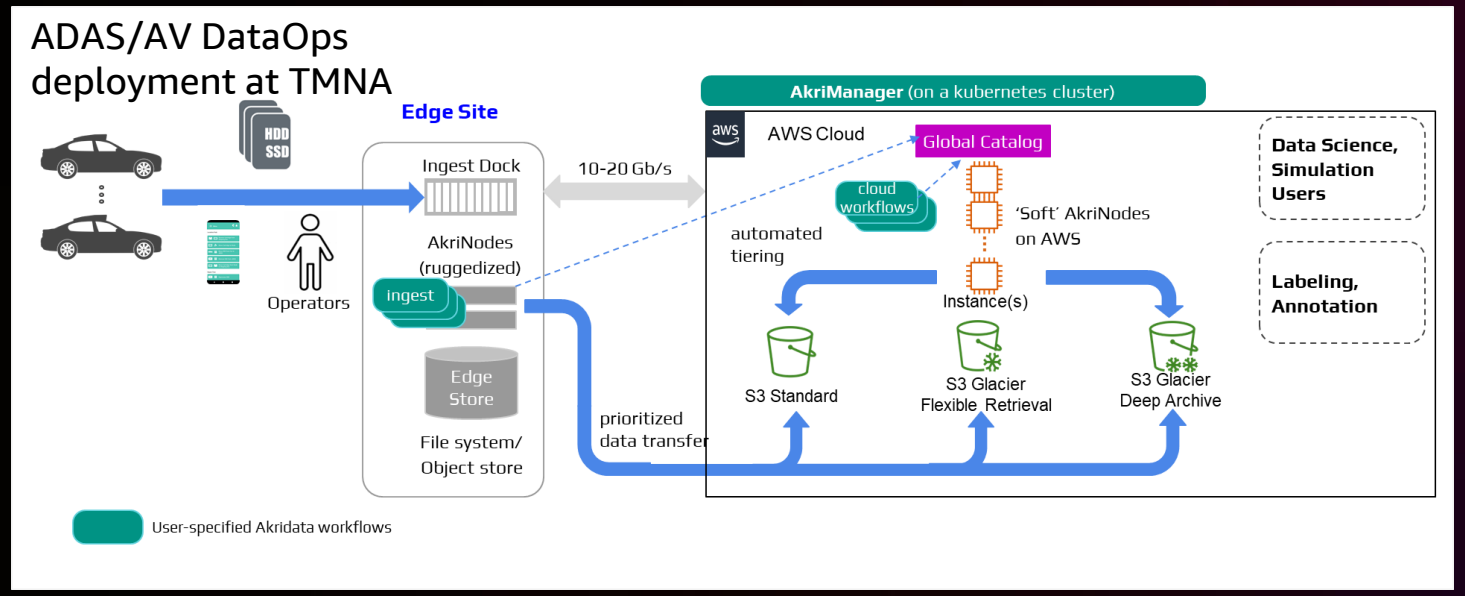
Solution Outline

① Edge-to-Cloud DataOps

- Engineering Efficiency gains for Development and V&V teams
- IT & Engineering Collaboration

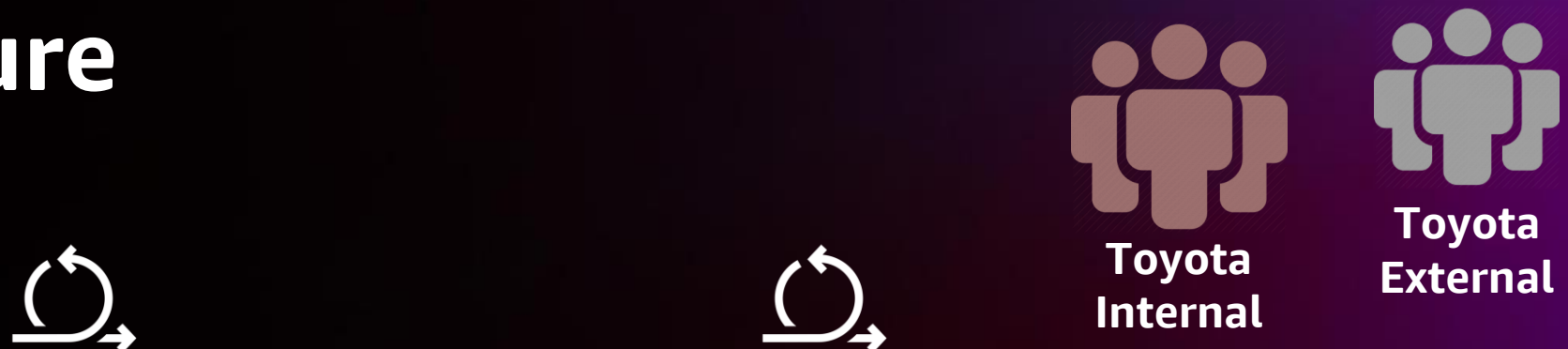
② Next-gen Infrastructure: Scale across multiple sites, multiple programs

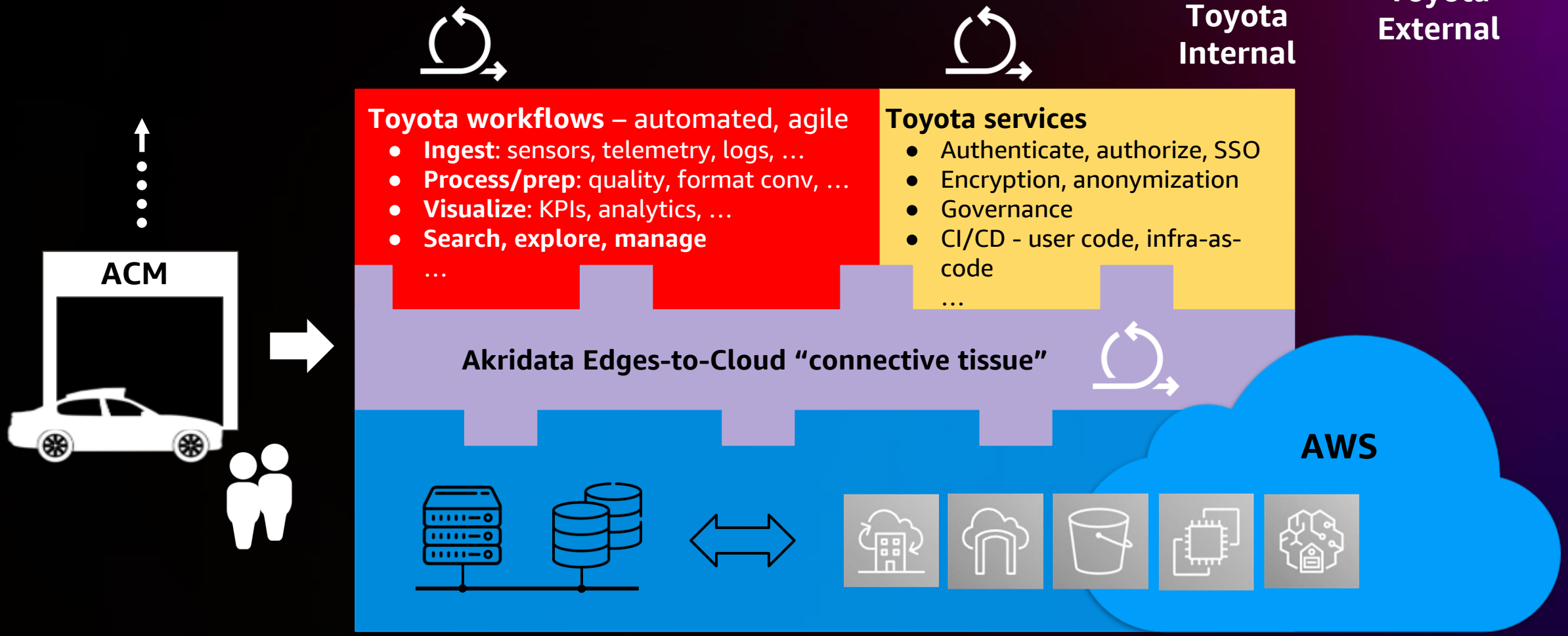
- Accelerate data access
- Promote hybrid dataflow
- Increase code reusability



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Solution Future





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Solution Benefits

1. [Kanban] Deployed a “pull” solution, with smart edge

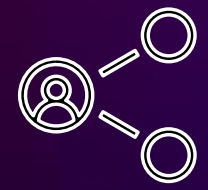
2. [Kaizen] Shortened time from ingest to analysis with continuous improvement

3. [Yokoten] Established a template for Smart edge sites to replicate and adapt

4. [Muda] Eliminated resource waste

Scale

TIME





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Lessons

① TPS principles applied to ADAS/AV and agile SW development

- *Customer First!*
- *Thinking Way* [Kanban, Kaizen, Yokoten, Eliminate Waste leading to Business Value]

② End-to-end view – vs optimizing subsystems

- Edge / Cloud infrastructure (scale up, scale out) with on-prem data centers
- Automate deployment & recovery w/ Centralize management

③ Plan for evolution of requirements – Design for Flexibility

- *Everything* evolves over project's Lifecyle (vehicles, sensors, data, infrastructure, tools)

④ Design in fundamental infrastructure needs

- Collaboration across global organization
- CI/CD, DevSecOps, Data Privacy

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Solution Partners

- **Akridata – Edge to AWS Data Pipelines and end-to-end Data Management**
  - Kunal Vasavada: kunal.vasavada@akridata.com
- **AWS – Cloud Services and Infrastructure**
  - Karthik Krishnan

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Thank you!

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