AWS paving the way for the future of autonomous driving

Max Cavazzini – EMEA Automotive
cavazzin@amazon.com

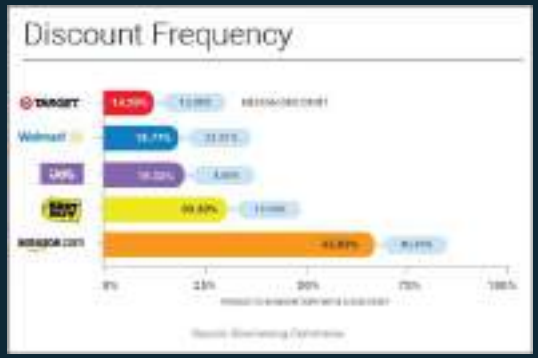
What do you know about amazon.com?

Unprecedented Scale

Hyper Speed

Relentless innovation

Customer Obsession



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Information Classification: General

What do you know about Amazon Web Services?

Applying amazon.com concepts to IT Infrastructure

Unprecedented
scale

22 regions
69 availability zones
3 new regions in H1 2020

Hyper
speed

Infinite IT resources available in minutes

Relentless
innovation

1957 new capabilities in 2018

Customer
obsession

Reduced prices 73 times since AWS launched in 2006

$33 Billion Run Rate 41% YoY (Apr ’19)

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Information Classification: General

AWS for Automotive

AWS enables our customers and partners to deliver intelligent, personalized brand experiences across the value chain

Cloud IT infrastructure

Compute

Storage

Database

Technology Building Blocks

Serverless Computing

Data Lakes

HPC

Alexa

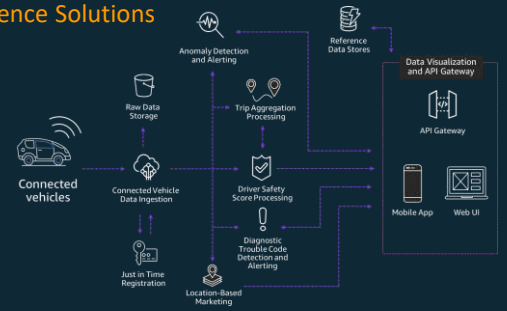
IoT

Machine Learning

Edge Computing

Image Analysis

Reference Solutions



Amazon Ecosystem

amazon music

audible an amazon company

amazon instant video

amazon Prime

amazon fireTV

amazon key

amazon logistics

AWS Partner Network

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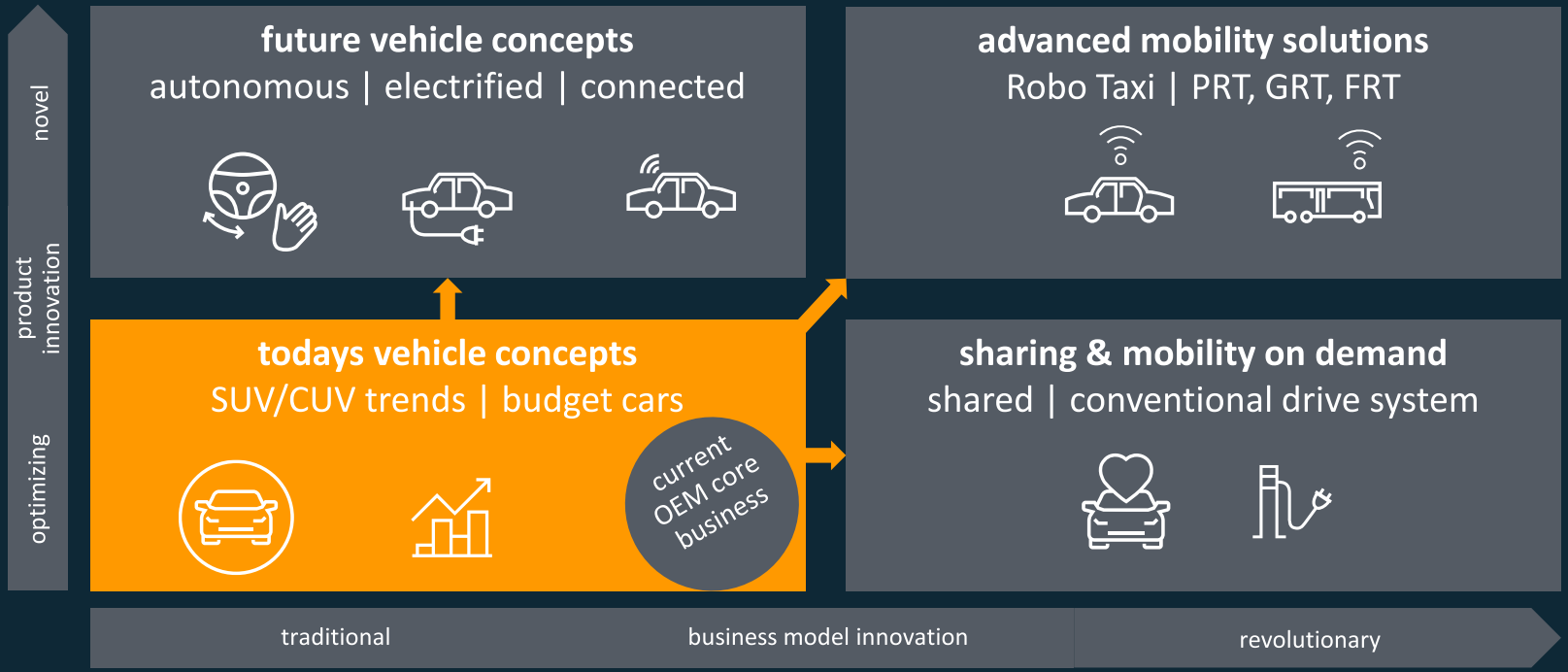
Information Classification: General

The digital transformation is disrupting the traditional OEM business models



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Information Classification: General

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Information Classification: General

AV Industry Observations

- **$500B Market by 2026:** Allied Market Research
- **2019 Investments**
  - Cruise ($2.25B), Uber ATG ($1B), Nuro ($940M)
  - Rivian ($1.2B), Aurora ($530M)
- **Goods Delivery**
  - Self-driving trucks (Daimler, Volvo, Waymo, TuSimple, Embark, Zodiak, Pronto.ai, Ike)
  - Last mile delivery (Nuro, Amazon Scout)
- **Consolidation**
  - M&A: Apple + Drive.ai, Uber ATG + Might AI
  - Partnerships: Daimler + BMW, VW + Ford/Argo, Waymo + Lyft, FCA + Aurora

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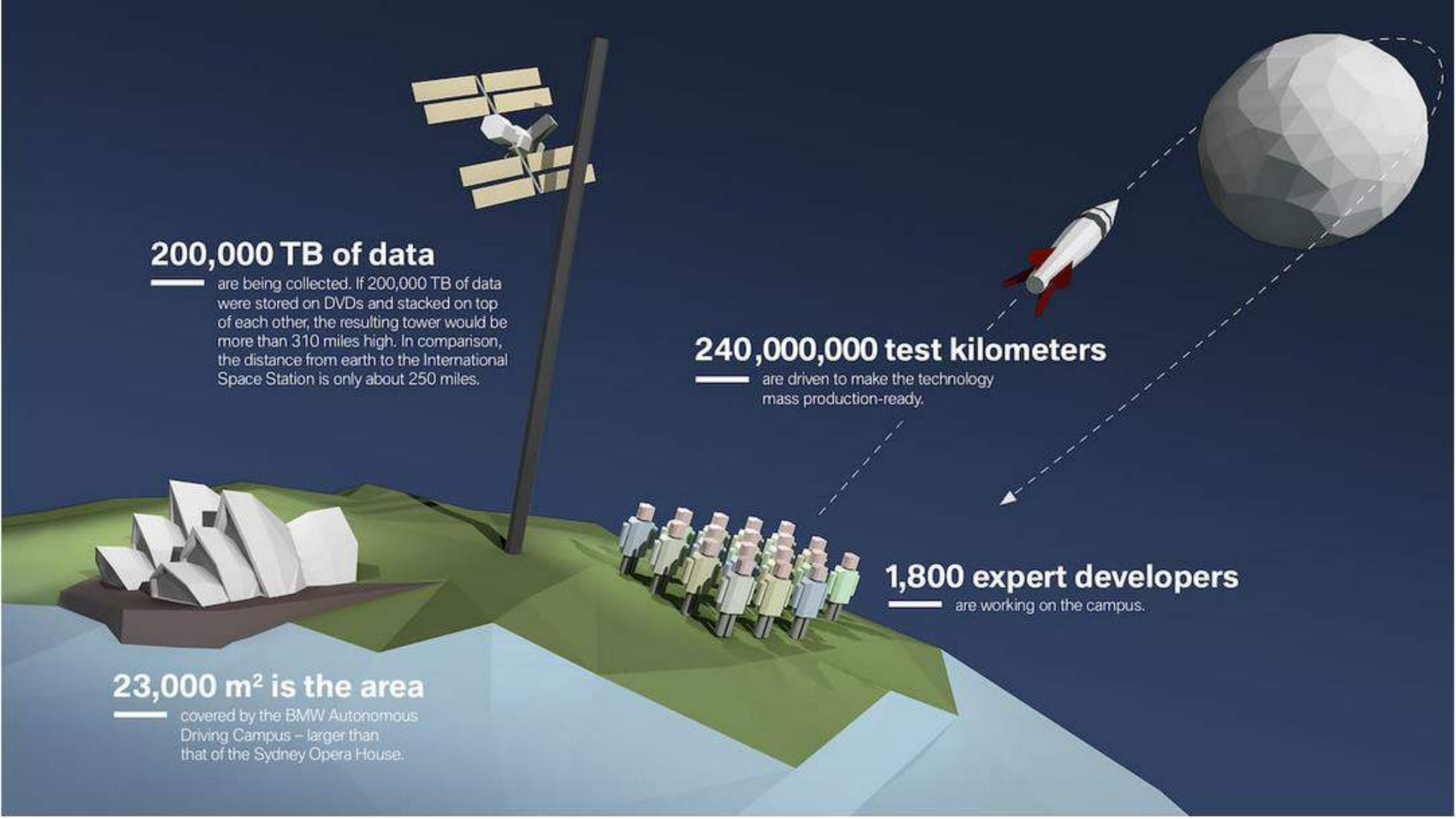
Information Classification: General

RIGHT ON RED LIGHT

POLK ST, SAN FRANCISCO

FULLY AUTONOMOUS (2X SPEED)

ZOOX


200,000 TB of data
are being collected. If 200,000 TB of data were stored on DVDs and stacked on top of each other, the resulting tower would be more than 310 miles high. In comparison, the distance from earth to the International Space Station is only about 250 miles.
240,000,000 test kilometers
are driven to make the technology mass production-ready.
1,800 expert developers
are working on the campus.
23,000 m² is the area
covered by the BMW Autonomous Driving Campus – larger than that of the Sydney Opera House.

SAE Levels of Autonomy

LEVEL	NAME	CONTROL	MONITORING VIGILANCE	FALLBACK HANDOFF	OPERATING CONDITIONS
0	Unassisted	Human			
1	Driver Assist	Human and AD System	Human	Human	Some
2	Partial Automation	AD System	Human	Human (0 warning)	Some
3	Conditional Automation	AD System	AD System	Human (adequate warning, assumed 15 seconds)	Some
4	High Automation	AD System	AD System	AD System	Some
5	Full Automation	AD System	AD System	AD System	All

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Information Classification: General

SAE Levels: Impact on Storage & Compute

LEVEL	NAME	CONTROL	Deep Learning Requirement	DEEP ARCHIVE REQUIREMENT	GPUs REQUIRED
0	Unassisted	Human	None	0	0
1	Driver Assist	Human and AD System	None	Less than 1 PB	0
2	Partial Automation	AD System	None	Less than 1 PB	0
3	Conditional Automation	AD System	Significant	1 to 100 PB	1 to 100s
4	High Automation	AD System	More Significant	30 to 400 PB	100s to 1000s
5	Full Automation	AD System	Bigger than you can Imagine	Measured in Exabytes	1000s to 100,000s

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Information Classification: General

What’s your strategy on development?

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Information Classification: General

Challenges for AD Developers

Data Ingestion & Acquisition	3-25 TB per test vehicle per day; 10-125 Vehicle Test Fleets	200 – 600 PB per year
Data Labeling	Cost, accuracy, and timeline concerns with current data labeling approaches	100s – 1,000s of human data annotators
Model Development & Training	Distributed data scientist teams developing Perception, Localization, Sensor Fusion, Path Planning, Control	10,000 – 100,000 GPU Cores
Simulation and Validation	Massive number of pathing requirements	100,000 + GPU Cores
Model Management & CI/CD	30-50 Data Scientists, Safety Critical Workflows	

Estimates say that 275 million miles of testing would be required for AVs to demonstrate, with 95% confidence, that their failure rate was at most 1.09 fatalities per 100 million miles – the equivalent of the 2013 US human-fatality rate. To achieve 275 million miles, it would take 100 vehicles, 24 hours a day, 365 days year, at an average of 25 mph, to achieve this goal. – Kalra, Paddock, April 2016, RAND Corporation.

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Information Classification: General

AWS Solution Overview

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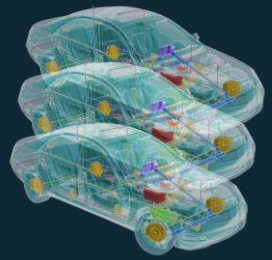
Information Classification: General

Typical Autonomous Vehicle Development Workflow



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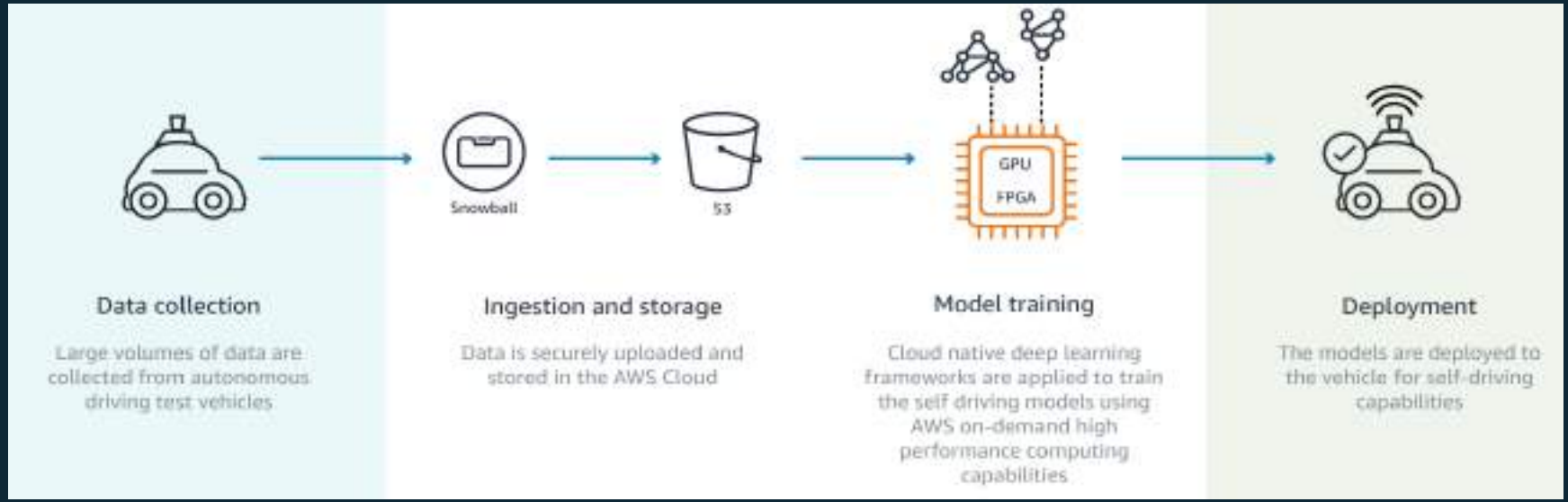
Information Classification: General

One Platform for all Autonomous Driving Needs



- Petabyte Scale, Low Cost, Secure Data Transfer and Storage Options

- High Performance Compute including GPU and FGPA instances, on-demand
- Optimized popular AI Frameworks
- AI Model Management

- Serverless Architecture
- Content Delivery with smart compression
- Secure device integration with cloud
- Edge compute

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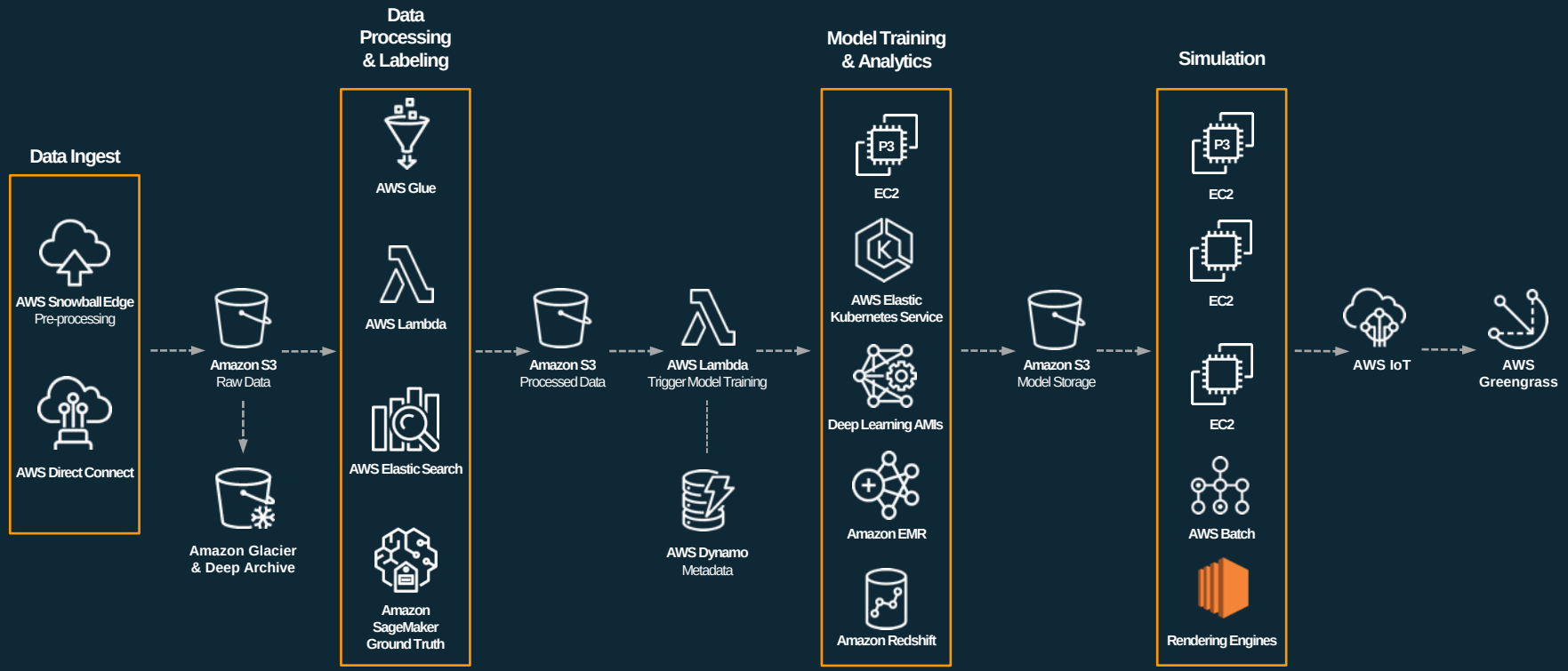
Information Classification: General

AV Development Reference Architecture



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Information Classification: General

Accelerating automated driving development on AWS

Toyota Research Institute accelerates safe automated driving with deep learning at a global scale on AWS

“Using Amazon EC2 P3 instances, we reduced the time to train our models by 75%. This significantly accelerates our research and development velocity as we can quickly incorporate new data and retrain models, explore ideas, increase model accuracy, and introduce new features faster,” says Adrien Gaidon, PhD, Machine Learning Lead, Toyota Research Institute.

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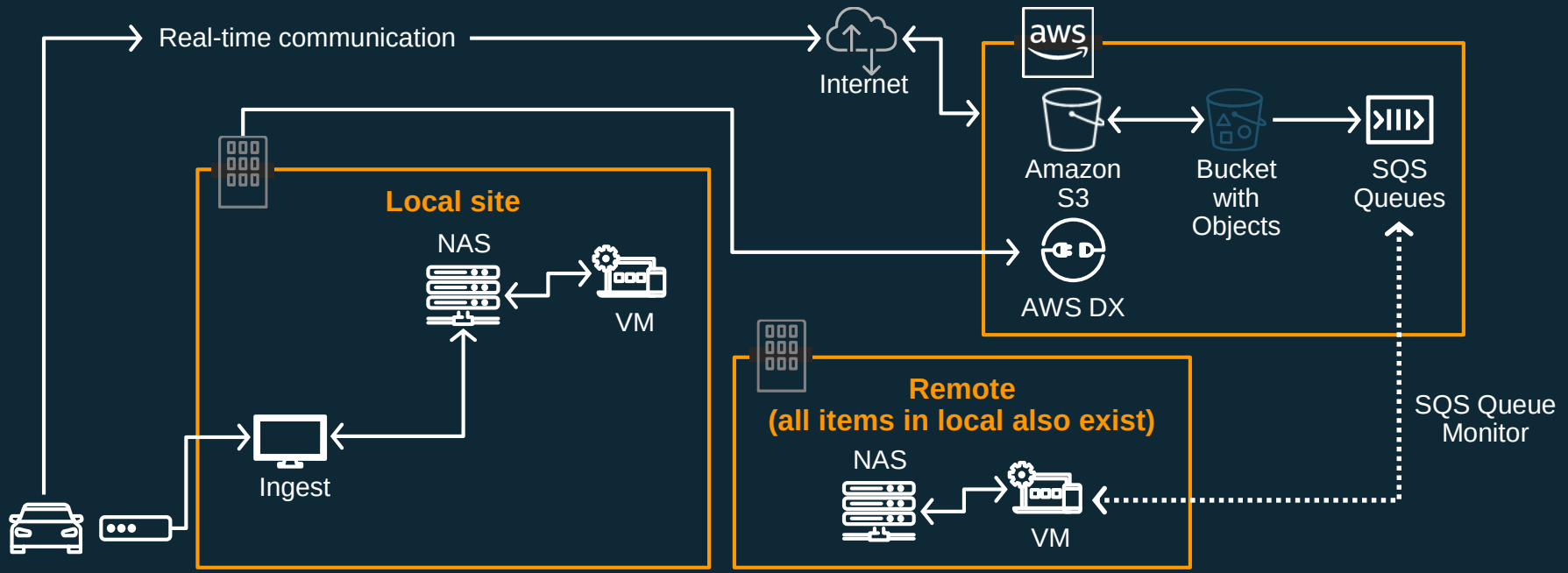
Information Classification: General

Toyota Research Institute – Data Ingestion Pipeline



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Information Classification: General

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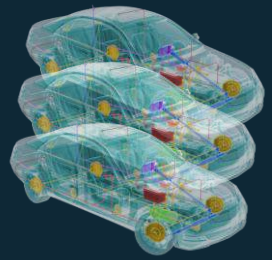

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Information Classification: General

AWS offers the most ways to move data to the cloud

Networks

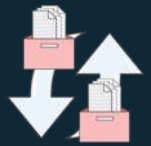
AWS Direct Connect

A private connection between your data center, office, or colocation environment and AWS

Amazon S3 Transfer Acceleration

Up to 300% faster transfers into and out of S3. Ideal when working with long geographic distances

Amazon EFS File Sync



Up to 5x faster file transfers than open source tools. Ideal for migrating data into EFS or moving between cloud file systems

Amazon Kinesis Firehose

Capture, trans-form, & load streaming data into S3 for use with Amazon business intelligence and analytics tools

Roads

AWS Snow family

(Snowball, Snowball Edge, Snowmobile)

Secure, physical transport appliances that move up to Exabytes of data into and out of AWS

Hybrid

APN competency partners

Integrations between 3rd party vendors and AWS services. Ideal for leveraging existing software licenses and skills

AWS Storage Gateways

Hybrid storage that seamlessly connects on-premises applications to AWS storage. Ideal for backup, DR, bursting, tiering or migration

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Information Classification: General

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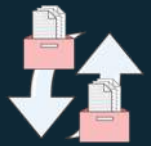

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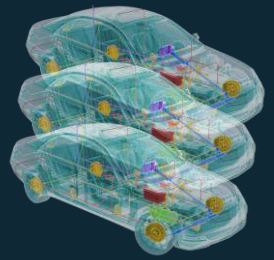

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Information Classification: General

Ingest data from vehicles using Snowball Edge

- Snowball Edge supports the ability to capture data from the vehicles and prepare it for machine learning before it arrives in AWS
- Embedded compute running on Snowball Edge can compress data, organize the vehicle logs, transcode the video, obfuscate faces and license plates (if desired)

Autonomous Car

Collect & Process data

Ship to AWS

Moved to S3

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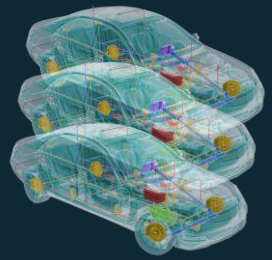
Information Classification: General

Typical Autonomous Vehicle Development Workflow



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Information Classification: General

Data Labeling with amazon mechanical turk beta

On-Demand Workforce, available when you need it, 24x7

Elastic Workforce, pay only for what you use

Lower Cost Structure, turn fixed costs into variable costs

Quality Management, everything you need to ensure quality results

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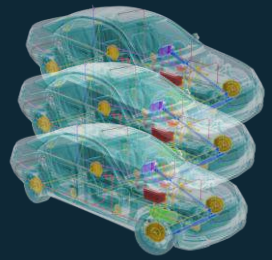
Information Classification: General

Typical Autonomous Vehicle Development Workflow



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Information Classification: General

Amazon ML stack: broadest & deepest set of capabilities

AI Services

VISION	SPEECH	LANGUAGE	CHATBOTS	FORECASTING	RECOMMENDATIONS
REKOGNITION IMAGE REKOGNITION VIDEO TEXTRACT	POLLY TRANSCRIBE	TRANSLATE COMPREHEND & COMPREHEND MEDICAL	LEX	FORECAST	PERSONALIZE

ML Services

Amazon SageMaker

Ground Truth	Notebooks	Algorithms + Marketplace	Reinforcement Learning	Training	Optimization	Deployment	Hosting

ML Frameworks + Infrastructure

FRAMEWORKS	INTERFACES
TensorFlow, mxnet, PYTORCH	GLUON, Keras

INFRASTRUCTURE

EC2 P3 & P3DN | EC2 G4 EC2 C5 | FPGAS | DL CONTAINERS & AMIs | ELASTIC CONTAINER SERVICE | ELASTIC KUBERNETES SERVICE | GREENGRASS | ELASTIC INFERENCE | INFERENTIA

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Information Classification: General

Personalizing the driving experience

Kia Motors uses Amazon Rekognition for advanced image and video analysis of an in-car camera that detects the driver. Then, the car automatically adjusts driver-assistance features like personalized mirror and seat positioning.

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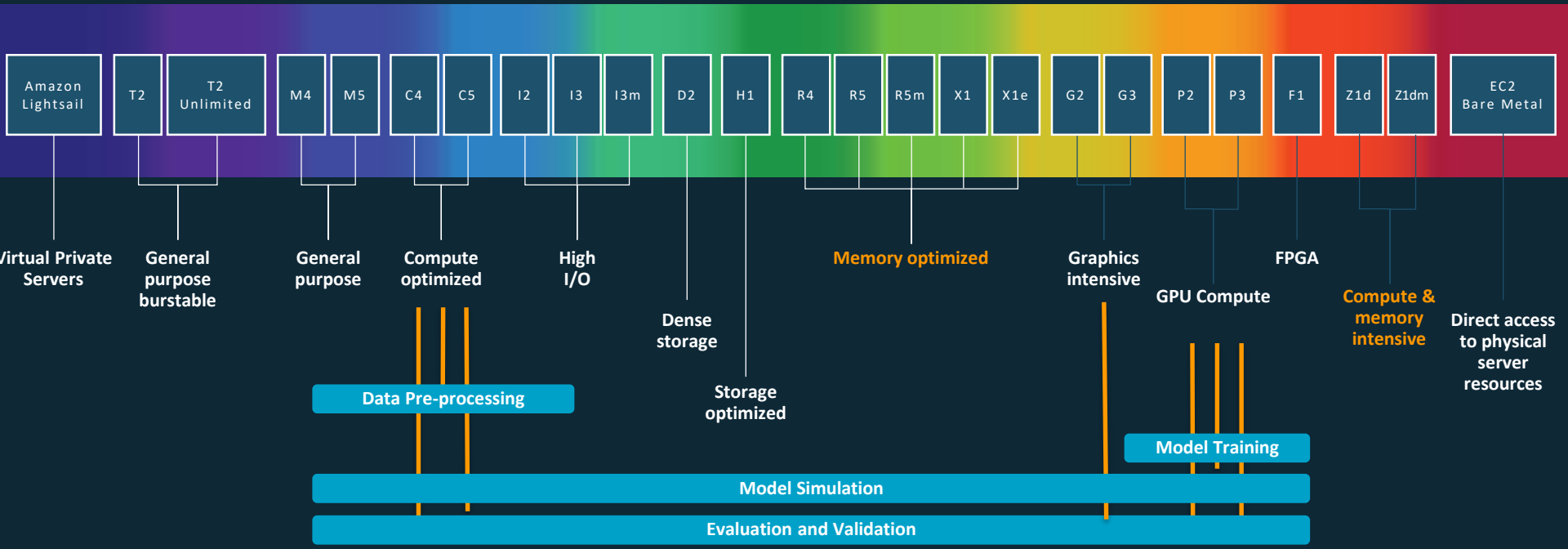
Information Classification: General

Wide range of Compute Instances for HPC AD Workloads



EC2 Elastic GPUs

Graphics acceleration for EC2 instances

EC2 Fleet

- Simplified provisioning
- Massive scale
- Flexible capacity allocation

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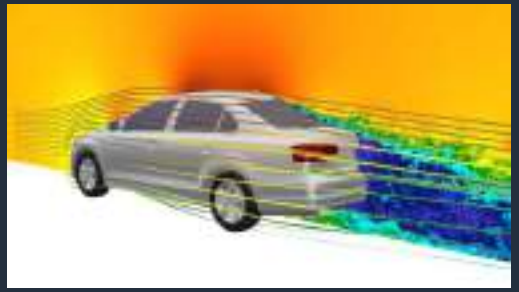
Information Classification: General

Volkswagen Group Research



Volkswagen Group Research Works with Altair on AWS to Accelerate Aerodynamics Concept Design

- Challenge: Many traditional simulations take too long to complete and weaken a car manufacturer's ability to successfully engineer for optimal aerodynamic performance and flow physics while also designing for style.
- Solution: 100 simulation runs each to be turned around within five business days
- Benefit: The team was able to run 200 car shape variants in a time frame that would typically correspond to only a few runs with its current operational tools

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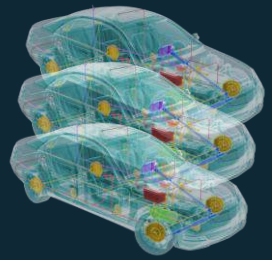
Information Classification: General

Typical Autonomous Vehicle Development Workflow



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Information Classification: General

Data is precious

RAND

Autonom
Enough M
Alternati

FOR RELEASE
Tuesday
April 12, 20

Autonomous vehicle
miles and, under con
enough data to clear
RAND report.

It takes time to find corner cases...

10 year moving average accident rate per million flights*

The Trillion Mile Challenge: Simulation

Data Gathering from Ordinary Drivers	environment, behavior	Cloud Simulator	validation	Test Cars with Professional Drivers
millions of miles	low-res maps	billions of miles	high-res maps	millions of miles

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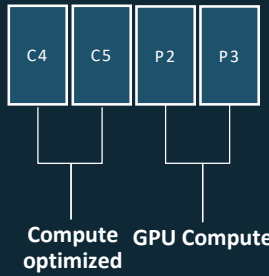
Several Simulation Solutions

AWS EC2 CPU & GPU instances



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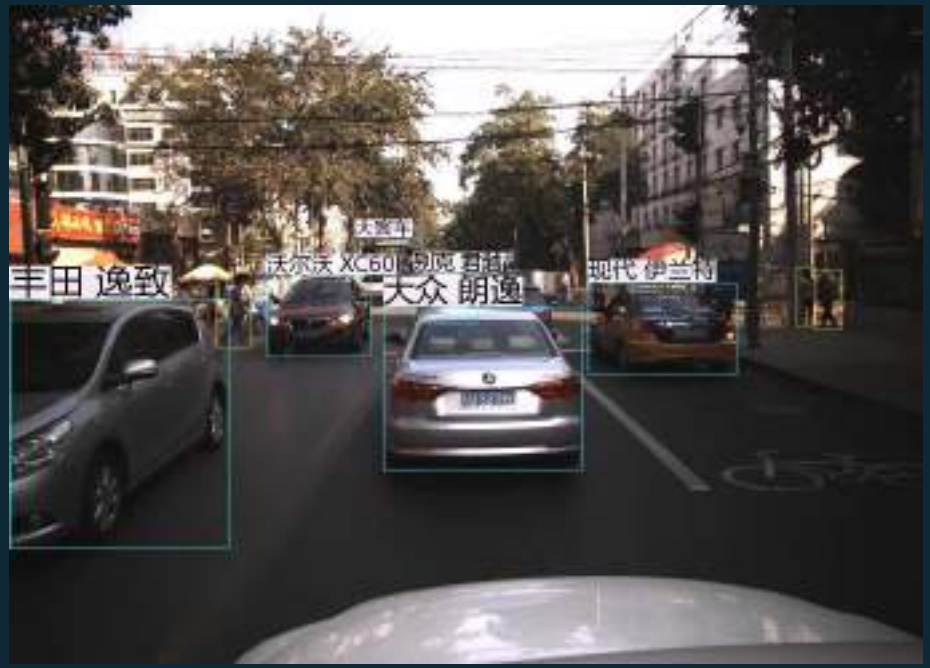
Information Classification: General

End-to-end Autonomous Development on AWS

MXNet User 图森 tuSimple



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Information Classification: General

Using deep learning to map a virtual world

Mapillary uses deep learning to create street-level virtual environments by stitching together crowd-sourced photos.

Applied fine-grain computer vision algorithms to combine 142 million user-submitted images, creating nearly 2 million miles of mapped roads.

Accelerated training and inference of deep neural networks for graphic-intensive workloads using AWS EC2 P2 and G2 instances.

Use Caffe and TensorFlow to gain insight from large volumes of unstructured public data to improve global mobility and transportation.

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Information Classification: General

Assisting drone navigation with deep learning

Iris Automation uses computer vision and deep learning to help unmanned aerial vehicles (UAVs) detect objects and avoid collisions.

Analyzes and draws insights from videos captured by drone's cameras in real time—the system has a detection range of over 500 meters, significantly farther than what other systems can currently do.

Uses NVIDIA GPUs on AWS to train deep learning models and a Jetson TX1 onboard the UAV to analyze video capture in real time.

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Information Classification: General

Thank you!

cavazzin@amazon.com

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