Microsoft Azure in Autonomous Driving
Microsoft’s approach to automotive

We complement OEMs and suppliers – not compete

We ensure your data is always under your control

We guarantee that the brand and customer experience belongs to you
AD Dev/Test: End-to-End Workflow

DATA INGEST & CURATE → TEST | TRAIN | SIMULATE → BUILD | VALIDATE
Key Industry Ecosystem Engagements

- Cloud and Analytics partner for ACM, an autonomous and smart mobility test facility
- Leveraged by all OEMs, tier ones and technology start ups
- Engaged with ACM to influence standards

- Open source AD Platform
- 200+ Member Consortium
- Microsoft is the cloud provider for Project Apollo worldwide with the exception of China

- OpenADx
- Interoperable Eclipse Framework
AKKA PROUD TO PARTNER WITH ICONIQ MOTORS AND MICROSOFT TO DEVELOP A FULL LEVEL 5 AUTONOMOUS CAR

PRESS RELEASE - 6, March 2018

AKKA PROUD TO PARTNER WITH ICONIQ MOTORS AND MICROSOFT TO DEVELOP A FULL LEVEL 5 AUTONOMOUS CAR
Data Box Disk helps LG gather autonomous vehicle data for analysis in Azure

LG’s autonomous vehicle program had unique requirements, including portability, security, and fast turnaround time; Data Box Disk was the perfect solution.

“We needed a way to transfer massive amounts of data for our autonomous vehicle projects, based all around the world. The solution needed to be portable, simple to use, cost-effective and, of course, very secure. The Azure Data Box Disk met all of those criteria.”

– Hyoyuel (Andy) Kim, Senior Manager, LG Electronics.

<table>
<thead>
<tr>
<th>Products and services</th>
<th>Organization size</th>
<th>Industry</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azure Data Box Disk</td>
<td>91,000</td>
<td>Automotive electronics</td>
<td>Worldwide</td>
</tr>
</tbody>
</table>
AD Dev/Test: E2E Workflow & Partner Ecosystem

- Test Vehicle
- Ingest/Store
- Render/Convert
- Process, Sample, Reduce
- Tag
- Sensor/Algorithm Testing (Open Loop)
- Replay
- Train
- Simulate
- Integrate
- Build
- Control Logic Validation
- Performance Simulation
- Generate Code
- Test-Drive
- Software in the loop
- F(x)
- Hardware in the loop

DATA INGEST & CURATE → TEST | TRAIN | SIMULATE → BUILD | VALIDATE

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Azure Express Route
Azure Storage, Data Lake Gen2
Azure Data Box
Azure Compute
Azure Batch AI
Cycle Cloud
Databricks & HDInsight
Azure Machine Learning
Cognitive Services
Azure IoT Edge
Container and Kubernetes, Visual Studio Team Services
Azure Key Vault, AAD
AD Dev/Test Data Flow and Devops Tool chain

SOFTWARE TOOLS AND DEVOPS PLATFORM
- Visual Studio
- Team Services
- Machine Learning
- Source Control
- Container Registry
- Azure Container Service

DATA ANALYTICS
- Data Factory
- HDInsight, Azure Databricks
- ML
- CosmosDB
- Stream Analytics
- Advanced Analytics

MACHINE LEARNING AND SIMULATION
- Logic App
- Machine Learning
- Azure GPU VM
- Kubernetes Service
- Simplygon
- HDInsight
- Databricks
- Batch AI

VALIDATION AND VERIFICATION
- Cycle Cloud
- Virtual machine
- Cosmos DB
- PowerBI
- Batch
- Service Bus

In-car data storage
- Async upload
- Fast upload

IoT Edge
- Data reduction, redaction
- Azure blob storage (cool, archive)

ADLS Gen 2 and Azure blob storage Hot Tier
AD Dev/Test: End-to-End Workflow
### Options for Massive Data Ingest

<table>
<thead>
<tr>
<th>Offline Data Transfer</th>
<th>Online Data Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Box</strong></td>
<td><strong>Data Box Heavy</strong></td>
</tr>
<tr>
<td>- Capacity: 100 TB</td>
<td>- Capacity: 1000TB</td>
</tr>
<tr>
<td>- Weight: ~50 lbs</td>
<td>- Weight 500+ lbs</td>
</tr>
<tr>
<td>- Secure, ruggedized appliance</td>
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</tr>
<tr>
<td>- Data Box enables bulk migration to Azure when network isn’t an option.</td>
<td>- Currently in Preview</td>
</tr>
<tr>
<td><strong>Data Box Disk</strong></td>
<td><strong>Data Box Gateway</strong></td>
</tr>
<tr>
<td>- Capacity: 8TB ea.; 40TB/order</td>
<td>- Virtual device provisioned in your hypervisor</td>
</tr>
<tr>
<td>- Secure, ruggedized USB drives orderable in packs of 5 (up to 40TB).</td>
<td>- Supports storage gateway, SMB, NFS, Azure blob, files</td>
</tr>
<tr>
<td>- Currently in Preview</td>
<td>- Currently in preview</td>
</tr>
<tr>
<td>- Perfect for projects that require a smaller form factor, e.g., autonomous vehicles.</td>
<td>- Virtual network transfer appliance (VM), runs on your choice of hardware.</td>
</tr>
<tr>
<td><strong>Data Box Heavy</strong></td>
<td><strong>Data Box Edge</strong></td>
</tr>
<tr>
<td>- Capacity: 1000TB</td>
<td>- Local Cache Capacity: ~12 TB</td>
</tr>
<tr>
<td>- Weight 500+ lbs</td>
<td>- Includes Data Box Gateway and Azure IoT Edge.</td>
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### Data Transfer Processes

- **Order**
- **Send**
- **Fill**
- **Return**
- **Upload**

- **Network Data Transfer**
  - Cloud to Edge
  - Edge to Cloud

- **Edge Compute**
  - Pre-processing
  - ML Inferencing
Massive Data Ingest – ExpressRoute

Ingest up to PB of data daily with Azure Networking Express Route Service

Private, high speed network connections

Connecting your data center and Azure

Predictable performance and Secure

100 + Express Route partners
54

Azure regions

More than AWS & Google combined
# Data Storage – Azure Blob Storage

Store up to Exabytes of data in massively scalable object storage for unstructured data

<table>
<thead>
<tr>
<th>Storage Tier</th>
<th>Frequently Accessed Data</th>
<th>Less Frequently Accessed Data</th>
<th>Rarely Accessed Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot</td>
<td>Lowest transaction cost</td>
<td>Lower capacity cost</td>
<td>Lowest capacity cost</td>
</tr>
<tr>
<td>Cool</td>
<td>Immediate (ms)</td>
<td>Immediate (ms)</td>
<td>Hours</td>
</tr>
<tr>
<td>Archive</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Scalable
- Foundational service for Microsoft
- >40 million transactions per second
- Multi-PB accounts

### Performant
- 50+Gbps account throughput
- Continued enhancements under development

### Secure & Compliant
- Client & Service Encryption
- AAD Integration + ACLs
- Broad & deep compliance portfolio

### Durable
- Multiple redundancy options
- Strong consistency, data integrity
- Policy: Versioning & WORM locks

### Cost Effective
- Integrated storage tiers
- Lifecycle management
- Rich metrics

Consistent API across all storage tiers
Data and application security

Identity & access management
- Azure Active Directory
- Multi-Factor Authentication
- Role Based Access Control
- Azure Active Directory (Identity Protection)

Data protection
- Encryption (Disks, Storage, SQL)
- Azure Key Vault

Network security
- VNET, VPN, NSG
- Application Gateway (WAF), Azure Firewall
- DDoS Protection Standard

Threat protection
- Azure Security Center
- Microsoft Antimalware for Azure
- Azure Log Analytics

Security management
- ExpressRoute

+ Partner Solutions
Data Curation

Partner-based Solutions

- Sensor data fusion tools
- Data extraction
- Labeling and annotation
- Data analysis
- Data anonymization
- Workflow orchestration and managed services

Microsoft Services

Data selection and transformation, PII data redaction, annotation and training data preparation
Analyze your Data in one place

Big Data Use Cases

- Ingest & ETL
- Streaming
- Analytics & Machine Learning
- Data Aggregation
- Presentation

Blob Storage Pillars

- Open & Interoperable
- Manageable & Cost Efficient
- Scalable & Performant
- Secure & Compliant
- Durable & Available

Azure HDInsight

Analytics & Machine Learning

- Event Hubs
- IoT Hub
- Functions
- Stream Analytics
- Machine Learning
- Data Lake Analytics
- Batch

Databricks

Data Warehouse

Power BI

CDN

Search

Log Analytics

App Insights

Monitor

Data Factory

Ingest & ETL

Streaming

Analytics & Machine Learning

Data Aggregation

Presentation

Blob Storage/ADLS Gen 2 Storage
Accelerating Ground Truth generation with Auto-Labeling

Deploy AI models in Azure for auto-labeling images to optimize for speed of labeling and possibly cost.

**Semantic Segmentation**
Each Pixel of the image is assigned a category

**Object Detection & Classification**
Bounding box drawn around each object of interest

**3D Point Cloud Labeling**
Objects of interest as assigned a category in 3D LIDAR point cloud
AD Dev/Test: End-to-End Workflow

1. **Test Vehicle**
   - Ingest/Store
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2. **Sensor/Algorithm Testing (Open Loop)**
   - Process, Sample, Reduce
   - Tag
   - Replay

3. **Train**
   - Simulate

4. **Integrate**
   - Build

5. **Control Logic Validation**
   - Performance Simulation
   - Test-Drive

6. **Generate Code**

7. **Software in the loop**

8. **Hardware in the loop**

---

**DATA INGEST & CURATE**  
**TEST | TRAIN | SIMULATE**  
**BUILD | VALIDATE**
Algorithm Validation (Open loop testing)

- Test repository
- Scene Reconstruction and Replay
- Algorithm scoring
- Results Analysis

Partnership Opportunities

- Open loop testing (e.g. ADTF)
- Simulation tools for sensor and algorithm validation

Microsoft Services

- Blob
- Cosmos DB
- Cycle Cloud
- CPU Compute
- Logic Apps
- Batch
- Key Vault
- Service Bus
- PowerBI

Verification and validation of training algorithms and sensors via open loop testing
Azure Developer Tool Chain

DevOps - Agile Development
- Application code repos (SCC)
- Build, CI
- Deploy, CD
- Issue tracking, agile project management

Compute - Container Orchestration
- Developer Workstations (virtual)
- Azure Kubernetes Service (AKS)
- and/or Azure CycleCloud
- VM & Container Orchestration

Supporting Services
- AI and Machine Learning
- Analytics
- Compute
- Databases
- Development Tools
- Integration
- Management Tools
- More...

Data Platform
- Microsoft Azure
Integration with a vast ecosystem of developer tools
Build and deploy deep learning models

Streamline AI development efforts
Leverage popular deep learning toolkits
Develop your language of choice

Scale compute resources in any environment
Choose VMs for your modeling needs
Process video using GPU-based VMs

Quickly evaluate and identify the right model
Run experiments in parallel
Provision resources automatically

Leverage your favorite deep learning frameworks

- TensorFlow
- MS Cognitive Toolkit
- PyTorch
- Scikit-Learn
- ONNX
- Caffe2
- MXNet
- Chainer
Operationalize and manage models with ease

Train and evaluate models

Azure Databricks

Bring models to life quickly
Build and deploy models in minutes
Iterate quickly on serverless infrastructure
Easily change environments

Proactively manage model performance
Identify and promote your best models
Capture model telemetry
Retrain models with APIs

Deploy models closer to your data
Deploy models anywhere
Scale out to containers
Infuse intelligence into the IoT edge

Model MGMT, experimentation, and run history

Azure ML services

Containers

IoT edge

AKS

ACI
Simulation is the fastest way to “drive” the billions of miles needed to discover the breadth of real-world anomalies required to develop AD solutions.

**Sensor Simulation**

Photo-realistic rendering of modeled sensors (Lidar, radar, RGB cameras) for the training and validation of Perception AI algorithms.

Render once, test many times

**Scenario Simulation**

Scenario definition and simulation for path planning and navigational maneuvers (overtake, parallel parking, etc) using post perception object level simulation.

Run 7200 simulated scenarios covering ~5000 miles per day/per node

**Engineering Simulation**

Mathematical based simulation for Structural CAD design, Fluid dynamics, Thermo dynamics, material properties

Design sensor properties and placement on vehicle options at scale before hardware prototyping is needed. Simulate accidents and AD navigation to a safe stop
AD Dev/Test Future: End-to-End Processing & Workflow

Simulation/Reinforcement Learning Centric Model

“Drive Millions, Train on Billions”
AD Dev/Test: End-to-End Workflow

DATA INGEST & CURATE  →  TEST | TRAIN | SIMULATE  →  BUILD | VALIDATE  →  Software in the loop  →  Hardware in the loop
HIL and SIL Validation

Control Logic Validation

Performance Simulation

Generate Code

Software in the loop

Hardware in the loop

Test-Drive

Microsoft Services

Blob storage
Batch
GPU VM
Active Directory
Container service

Partner-based Solutions

Comprehensive test management framework
HIL solutions
System validation tools
Workflow management services
Managed services

Embedded system validation via hardware-in-loop and software-in-loop