Technology Overview: Enabling Automated Driving

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Chief Technology Officer
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Today’s discussion

- Safe, green and connected megatrends driving increased computing, signal and power demands
  - Continued proliferation of wiring and ECUs to support incremental content becoming unsustainable
  - ADAS and Infotainment features requiring more automation, software and signal distribution

- Uniquely positioned to support the brain and nervous system of the vehicle
  - Optimized vehicle architectures and more powerful compute platforms enabling software defined vehicle
  - Systems integration capabilities, technology partnerships critical to delivering automotive grade solutions

- Smart mobility moving beyond the vehicle
  - Unlocking turnkey data monetization solutions for OEMs through acquisitions and strategic partnerships
  - Integration into infrastructure / smart cities creating new use cases, opportunities to create value

Convergence of safe, green and connected megatrends creating unique opportunities
Megatrends driving computing power requirements

- Assisted automation
- Conditional automation
- Safety eco-system
- Fully autonomous

Increasing levels of:
- Active Safety
- Electrification
- Efficiency
- Software & connectivity
- Infotainment

Increasing personalization
Smartphone integration
Full cloud connectivity
Internet of things

Convergence of megatrends driving demand for increased computing power
E/EA and E&S vision: Enabling smart vehicle architectures

**Features and Content**

- High Speed Sensing and Networking
- Software Enabled Vehicle Features

**Foundation**

- Mobility computing platforms
- Power and Signal Distribution
- OTA and Vehicle Connectivity
- Sensing

**Platforms**

- Active Safety & Autonomous Systems
- Data and Services
- Infotainment & User Experience

**Systems Integration**

**Brain**

- Smart mobility architecture

**Nervous System**

**Internet of Things**

*Uniquely positioned to support smart mobility solutions*
Vehicle architecture evolution

Exponential increases in data content and speeds
Vehicle computing evolution

**Distributed ECUs**
- Separate ECUs with individual custom microprocessors
- Primarily low and mid speed data busses
- Conventional power distribution network
- Autosar and one OS per ECU
- Scalable by removing or adding processors
- Cybersecurity risks

**Domain Centralization**
- Centralized compute platforms
- High speed busses (ETH, LVDS, HDBaseT)
- Fault tolerant power distribution supporting redundancy
- Adaptive Autosar and multi-OS (Hypervisor)
- Scalable computing platform processing power
- Cybersecurity “built-in” with intrusion detection & OTA

**Software Defined Vehicle**

Computing centralization a “must do” to increase functionality
Computing platform: Multi Domain Controller (MDC)

Active Safety Multi-Domain Controller (MDC)

- Scalable software platform
- Reduced architecture complexity
- Faster communication/interconnection
- Multi-processor configurations

Production

2017 Launch

ADAS Centralized Sensor Fusion/Control

Front Radar Controller
Camera Controller
Airbag Controller
ESC Controller
LiDAR Controller
Rear & Side Radar Controller

MDC reduces complexity and enables future expandability
Demonstrated automated leadership

1st automated drive at CES: One of the two companies that passed autonomous vehicle permit testing in urban/residential area in Nevada
1st Coast to Coast automated drive: 3400 miles in 99% autonomous mode
Acquired Ottomatika: Spin-off of Carnegie Mellon University

V2everything™ automated drive at CES: V2V, V2P, V2I and unique HMI with personal device connectivity
Automated Mobility on Demand Pilot: Selected to conduct a trial of an urban, point-to-point, low-speed, autonomous, mobility-on-demand service in Singapore

Most complex highway + urban drive at CES: V2P, V2I and unique HMI with personal device connectivity
Commercialization: Selected by Transdev as first open road, AMoD service in EU. Selected by BMW as a Development Partner and System Integrator.

A rich history of firsts and milestones in active safety and automated driving
CSLP platform and milestones

Key strategic partnerships enabling the CSLP platform execution
Automated Driving Platform Architecture

**Deterministic Policy**

- Absolute rules that govern vehicle behavior, which are used to set boundaries of operation

- Predictable, repeatable behavior

- Difficult to create rules for every scenario

**Artificial Intelligence (AI)**

- AI teaches the car “how” to drive, through path planning, object classification and prioritization

- Flexible, adaptable behavior

- Can’t be debugged, unpredictable in new scenarios

**APPLICATIONS**

- SPEED LIMIT
- STOP LIGHTS
- RIGHT OF WAY
- ROAD MARKINGS
- ACCELERATION & BRAKING
- TURNING RADIUS

- WHEN TO PASS
- ROUTE OPTIMIZATION
- DETOURS & REROUTING
- OBSTACLE AVOIDANCE
- EXERCISE CAUTION

Strengths and weaknesses to both approaches
CLSP taking a hybrid approach

HYBRID APPROACH
Take the strengths of both approaches to obtain the benefits of AI within a configurable deterministic framework.

START WITH POLICY FIRST
Absolute rules that govern how the vehicle performs, and can be changed or updated as required.

AI COMPLETES THE SOLUTION
Teach the car how to drive, recognize the world around it and enable creative solutions to new scenarios.
Data Analytics & Smart Cities
We are only at the beginning …

The vehicle is becoming a software and data driven platform
Delphi: Smart mobility architecture

<table>
<thead>
<tr>
<th>Smart Vehicles</th>
<th>Smart Connectivity</th>
<th>Smart Cloud</th>
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<tbody>
<tr>
<td>• Connected Server Platform</td>
<td>• Secure Gateway</td>
<td>• Data Market Place &amp; Analytics</td>
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<tr>
<td>• High Speed Data Network</td>
<td>• Edge Processing</td>
<td>• IoT Server</td>
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<tr>
<td>• Software Abstraction</td>
<td>• Firmware / Software Over the Air</td>
<td>• Configuration Manager</td>
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<tr>
<td>• Smart Power Distribution</td>
<td>• Connectivity Manager</td>
<td>• Virtual Twins</td>
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Data services and smart mobility moving beyond the vehicle to create value
Connectivity smart vehicle architecture

Smart mobility architecture enabling the software defined vehicle
## Delphi end to end data management solution

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<tr>
<th>Acquisition</th>
<th>Configuration</th>
<th>Monetization</th>
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<tr>
<td><strong>CONTROLTEC</strong></td>
<td><strong>MOVIMENTO™</strong></td>
<td><strong>otonomo</strong></td>
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<tr>
<td><strong>Real time vehicle data monitoring and edge processing</strong></td>
<td><strong>Vehicle telematics, analytics and Over The Air (OTA) updates</strong></td>
<td><strong>Online marketplace managing monetization and data privacy</strong></td>
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### Strategic partnership with otonomo highly complementary to Delphi capabilities

- **Consumer Apps**
- **ADAS & HD Maps**
- **Software & Firmware**
- **Config & Regulatory**
- **Personal Profile**

### Services

#### Fleet Management
- Fleet Mgmt
- Transport Services
- Insurance
- Vehicle Maint

#### Retail
- Emergency Services
- Smart Cities
- Expense Control

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Delphi offering fully connected vehicle platform

CUSTOMER VEHICLE

CONTROLTEC
- CT-EDGE Data Acquisition
- Config Management
- Business Intelligence
- Fleet Management

MOVIMENTO®
- Vehicle information database
- Multi-module OTA Re-flash

OEM / RETAIL / FLEET PLATFORM

Otonomo
- Third party data exchange
  - Fleet Management
  - Transport Services
  - Insurance
  - Vehicle Maintenance
  - Retail
  - Emergency Services
  - Smart Cities
  - Expense Control

DATA USERS

Unlocking turnkey data monetization solution for OEM partners

Flow of Data

Flow of Money
## Illustrative Data Services use cases

<table>
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<th><strong>Roadside Assistance</strong></th>
<th><strong>Retail</strong></th>
<th><strong>Smart Cities</strong></th>
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<td><strong>1</strong> A car breaks down and the driver does not know why</td>
<td><strong>1</strong> As cars move past a certain point, location and gas gauge information is sent to the cloud.</td>
<td><strong>1</strong> As traffic moves through a city, cars send their location data to the cloud.</td>
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<td><strong>2</strong> Vehicle diagnostic data is shared with tow company to determine if it's a lack of fuel or dead battery, or something more serious.</td>
<td><strong>2</strong> Gas station companies purchase access to the location/gas gauge data.</td>
<td><strong>2</strong> Smart cities look at this data to determine when and where traffic is worst.</td>
</tr>
<tr>
<td><strong>3</strong> The average cost of a tow truck trip is $175. If a low or dead battery is detected, a different, less costly vehicle could be sent to help -- saving time and money.</td>
<td><strong>3</strong> A new filling station opens where people's fuel tanks tend to be low and customers are most likely to buy.</td>
<td><strong>3</strong> Traffic signals are better coordinated to reduce gridlock, and times are set to optimize service vehicles, like garbage trucks and street cleaners, cutting CO2 levels.</td>
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Why smart cities?

- traffic & parking
- safety
- environment
- data sharing
- equitable
- quality of life
- coverage
- efficiency

- resources
- growth
- congestion
- regulations
- infrastructure
- expertise

Station zero for mobility
Urban mobility challenges by 2050

- +70% increase in people
- 5x increase in emissions
- 4x increase in cost
- 3x increase in travel time
- +40% increase in freight

*Research by Arthur D. Little*
Benefits of mobility automation to cities

- **28%** Less vehicles
- **44%** Fewer parking spaces
- **30%** Shorter travel time
- **66%** Lower emissions
- **87%** Fewer accidents

*Research by Arthur D. Little*
Smart city examples

**Singapore AMoD**

*Trial of an urban, point-to-point, low-speed, autonomous, mobility-on-demand service in Singapore’s one-north business park*

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**Transdev**

*Pilot for first open road, autonomous on-demand mobility service in the EU.*

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**Continued progress in real world applications**
Summary

- Convergence of megatrends driving exponential computing power demand
- Reducing electrical architecture complexity is a “must do” to enable content growth
- Combination of policy and AI for automated driving to maximize strengths
- Smart cities integration unlocking new opportunities for Delphi to create value
- Future opportunities in data services and smart cities integration

Delphi uniquely positioned to enable smart mobility architectures