Technology Overview:
Enabling Automated Driving

Glen De Vos
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

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

INTERNET OF THINGS

BRAIN

SYSTEMS INTEGRATION

NERVOUS SYSTEM

Uniquely positioned to support smart mobility solutions
Vehicle architecture evolution

Exponential increases in data content and speeds

- **1990**: CAN (< 1 Mbps), MOST25 (25 Mbps)
- **2000**: LIN (20 Mbps), FlexRay (10 Mbps), MOST50 (50 mbps)
- **2010**: MOST150 (150 mbps), FlexRay (10 Mbps), MOST50 (50 mbps), MOST150 (150 mbps)
- **2020**: Multi-Gigabit Ethernet (10 Gbps), Base T1 (1 Gbps), HDBaseT (6 Gbps)
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)

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

Active Safety Multi-Domain Controller (MDC)

ADAS Centralized Sensor Fusion/Control

Production 2017 Launch

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

**2015**

**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

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**2016**

**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.

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**2017**

**2019+**

*Automated Mobility-on-Demand*

**2019**

**V2V & V2X**

**2016**

**RACam:** Radar and camera fusion

**2017**

**Driver Monitoring & Workload Manager**

**2018**

**First pedestrian detection system with full automatic braking from Delphi**

**2010**

**Launch first multi-mode electronically scanning radar**

**1999**

**First radar-based smart cruise control from Delphi**

**1993**

**First collision warning system from Delphi**

**1999**

**Industry-first cruise control from Delphi**

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

#### Applications

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

### 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

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

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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>
</tr>
</thead>
<tbody>
<tr>
<td>• Connected Server Platform</td>
<td>• Secure Gateway</td>
<td>• Data Market Place &amp; Analytics</td>
</tr>
<tr>
<td>• High Speed Data Network</td>
<td>• Edge Processing</td>
<td>• IoT Server</td>
</tr>
<tr>
<td>• Software Abstraction</td>
<td>• Firmware / Software Over the Air</td>
<td>• Configuration Manager</td>
</tr>
<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

External Signals
- Bluetooth
- CAR2CAR
- GPS
- 4G/5G LTE

SECURE GATEWAY
- CPU
- DSP
- 4G/5G
- Body
- Security
- Audio
- Broadcast
- 10/Port Ethernet
- CAN Gateway

INTEGRATED COCKPIT SERVER
- CPU
- AI
- GPU
- Storage
- GR
- RVC
- DMS
- Displays
- Removable Media Hub

MOBILITY SERVER
- CPU
- AI
- GPU
- Storage
- Radar
- Vision
- LIDAR

DELPHI
Delphi end to end data management solution

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Configuration</th>
<th>Monetization</th>
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<tbody>
<tr>
<td><strong>CONTROLTEC</strong></td>
<td><strong>MOVIMENTO™</strong></td>
<td><strong>otonomo</strong></td>
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**Real time vehicle data monitoring and edge processing**

**Vehicle telematics, analytics and Over The Air (OTA) updates**

**Online marketplace managing monetization and data privacy**

- **Passenger Vehicles**
- **Commercial Vehicles**
- **Fleets**

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

- **Fleet Mgmt**
- **Transport Services**
- **Insurance**
- **Vehicle Maint**
- **Retail**
- **Emergency Services**
- **Smart Cities**
- **Expense Control**

Strategic partnership with otonomo highly complementary to Delphi capabilities
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

DATA USERS
• Fleet Management
• Transport Services
• Insurance
• Vehicle Maintenance
• Retail
• Emergency Services
• Smart Cities
• Expense Control

Flow of Data  Flow of Money

Unlocking turnkey data monetization solution for OEM partners
### Illustrative Data Services use cases

<table>
<thead>
<tr>
<th>Roadside Assistance</th>
<th>Retail</th>
<th>Smart Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A car breaks down and the driver does not know why</td>
<td>1. As cars move past a certain point, location and gas gauge information is sent to the cloud.</td>
<td>1. As traffic moves through a city, cars send their location data to the cloud.</td>
</tr>
<tr>
<td>2. 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>2. Gas station companies purchase access to the location/gas gauge data.</td>
<td>2. Smart cities look at this data to determine when and where traffic is worst.</td>
</tr>
<tr>
<td>3. 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>3. A new filling station opens where people’s fuel tanks tend to be low and customers are most likely to buy.</td>
<td>3. Traffic signals are better coordinated to reduce grid lock, and times are set to optimize service vehicles, like garbage trucks and street cleaners, cutting CO₂ levels.</td>
</tr>
</tbody>
</table>
Why smart cities?

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

- safe
- accessible
- available
- reliable
- affordable
- first/last-mile
- universal ride payment

REQUIREMENTS

CONRAINTS

Station zero for mobility
Urban mobility challenges by 2050

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

Transdev

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

Moving autonomously with Transdev-Delphi

A trip can be planned via phone app or computer by looking at the driverless pod routes and times.

At a designated stop a customer can buy and validate a ticket, then board the autonomous pod.

The autonomous pod moves to next designated stop. All pods are monitored for safety at a control center.

Customer arrives at destination safety and can now plan a return trip.

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