Technology Overview:
Centralized Computing Platforms

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Overview

• Vehicle automation increasing computing and electrical architecture demands
  ▪ Vehicles increasingly “smart”; massive amount of computing power going into the vehicle
  ▪ Systems integration capabilities critical to optimize performance, mass and cost
  ▪ Delphi well positioned with foundation in computing, signal and power distribution

• Accelerating demand for “smartphone like” experience, connectivity and consolidation
  ▪ Seamless integration into the vehicle environment remains a differentiator
  ▪ New more powerful compute platforms enabling the next level of integration
  ▪ Delphi V2X tech enabling connectivity between autos and infrastructure; creating new challenges and opportunities

• Powertrain electrification required to enable efficiency and control
  ▪ “Drive by wire” and sensor power demands increasing electrical demands
  ▪ Emissions and fuel efficiency regulations driving demand for cost effective green solutions
  ▪ Delphi comprehensive Powertrain components portfolio enabling intelligent electrification

Convergence of safe, green and connected
Megatrends driving computing power requirements

- **Increasing personalization**
- **Assisted automation**
- **Conditional automation**
- **Safety eco-system**
- **Fully autonomous**
- **Increasing levels of Active Safety**
- **Increasing levels of Electrification**
- **Increasing levels of Efficiency**
- **Increasing levels of software & connectivity**
- **Increasing levels of Infotainment**
- **Internet of things**

**Convergence of megatrends driving demand for increased computing power**
Exponential computing power

### Computing power

<table>
<thead>
<tr>
<th>Year</th>
<th>Electro-mechanical safety</th>
<th>Advanced Driver Assist</th>
<th>Partially automated</th>
<th>Self-Driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>100</td>
<td>1000</td>
<td>1000</td>
<td>10,000</td>
</tr>
<tr>
<td>2010</td>
<td>1000</td>
<td>10,000</td>
<td>10,000</td>
<td>100,000</td>
</tr>
<tr>
<td>2020</td>
<td>10,000</td>
<td>100,000</td>
<td>100,000</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Source: Intel

### Architecture capabilities

#### Diagnostic parameters
- Rapid increase in number of systems monitored helps provide early warnings of issues.

#### Data transfer speeds
- High speed Ethernet replaces antiquated 1980s technology.

- **Future**
  - 2020: 1.5 GBPS (~22X)
  - 2015: 300 MBPS (~3X)
  - 2000: 1000 MBPS (~7X)
  - 2000 (~7X)
  - 1000 (~3X)
  - 300

6+ GBPS (~90X)

Rapid acceleration in automotive computing power
# Centralized computing demand drivers

<table>
<thead>
<tr>
<th>Managing complexity</th>
<th>Lower mass</th>
<th>Reduced cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplifying architecture; managing data speeds, complexity</td>
<td>“Basic” sensors and optimized architecture</td>
<td>Meet future computing demands with fewer controllers</td>
</tr>
</tbody>
</table>

- Centralized decision making provides multiple data-points in decision making
- Strategically locating computers helps minimize cable length, unlock content growth

- Centralizes computing power onto chip
- Sensors become more basic (smaller & lighter) and easier to integrate

- Reduces incremental controllers needed
- Focuses workload on handful of supercomputers

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**~30% savings from lower mass and cost**

- ~30% savings from lower mass
- Lower mass
- Reduced cost
- Centralized computing demand drivers

- **Without centralization, future vehicles would require 100+ Medium & High End controllers required today, higher cost, larger mass**
- **Future vehicles: ~70 with Centralized Computing; mostly basic computers with a few super computers**
Delivering technology innovation

<table>
<thead>
<tr>
<th>Automated capabilities</th>
<th>Infotainment</th>
<th>Intelligent electrification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensor data fusion enabling:</strong></td>
<td><strong>Cockpit integration:</strong></td>
<td><strong>Sophisticated software driving:</strong></td>
</tr>
<tr>
<td>• Blind spot warning</td>
<td>• V2X Intelligent Driving</td>
<td>• Engine control</td>
</tr>
<tr>
<td>• Adaptive cruise control</td>
<td>• Eye glance</td>
<td>• Valve Train and engine sensors</td>
</tr>
<tr>
<td>• Lane departure warning / prevention</td>
<td>• Gesture control</td>
<td>• Fuel injection systems</td>
</tr>
<tr>
<td>• Forward collision warning</td>
<td>• Voice recognition</td>
<td>• DC/DC converter</td>
</tr>
<tr>
<td>• Automatic emergency braking</td>
<td>• On Board Diagnostics</td>
<td>• Connected Infotainment</td>
</tr>
<tr>
<td>• Collision mitigation</td>
<td>• Customized / 3D displays</td>
<td>• Active Safety</td>
</tr>
</tbody>
</table>

Innovation creates value through best-in-class technologies
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

MDC reduces complexity and enables future expandability
CSLP platform and partnerships

Delphi
- Radar & Lidar Systems & Fusion
- Route Planning and Behavioral Policy
- Vehicle control and Interface

Mobileye
- Vision Systems & Fusion
- Reference Learning / AI
- Localization using REM

Intel
- Automated Driving SoC
- Connectivity
- Data Centers / Management

Intel / Delphi / Partners
- OS and support Software
- Middleware and Tools
- Functional Safety

Key strategic partnerships enabling the CSLP platform execution
Increasing content per vehicle – Automated Driving

- Additional architecture: $+100 CPV
- Vision sensors: $+220 CPV
- Actuation & other sensing: $+285 CPV
- Radar sensors: $+330 CPV
- Lidar sensors: $+2000 CPV
- Embedded controls, algorithms: $+2,300 CPV

~$5,000 CPV when moving to a Level 4/5 vehicle in 2020

Note: assumes 2020 volumes; and four lidar sensors, five radar sensors and six vision sensors
### Integrated Cockpit Controller (ICC)

**Production 2018 Launch**

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

### Centralized sensor fusion & user experience control

- Cluster Controller
- Gesture Controller
- Head Unit Controller
- V2X Connectivity Controller
- Radio Controller

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**Future system software optimization and upgradeability**
Goal: Become the industry standard for infotainment platforms
Delphi’s approach to Cockpit Architecture

**Today**

**Ferrari Cockpit Controller**
- In production
- Up to 2 displays
- QNX®

**2017 Entry Cockpit Controller**
GENIVI®
Multi-modal HMI includes gesture control for entry to mid-level vehicles
Up to 2 displays

**2018 Android Cockpit Controller**
Android N with the latest Android automotive functionality
Delivers popular Android apps into the vehicle with improved speed to market and lower development costs
up to 10% cost savings + 25% mass reduction

**2018 Integrated Cockpit Controller (ICO)**
Green Hills INTEGRITY, GENIVI® Linux, Android N with the latest Android automotive functionality
Delivers popular Android apps into the vehicle with improved speed to market and lower development costs
Hypervisor domain separation supports ASIL-B functional safety certification
up to 12% cost savings + 33% mass reduction

**2020+ Next-Generation Integrated Cockpit Server (ICS)**
Real-time Server Framework
Hypervisor domain separation supports ASIL-B functional safety certification
40X improved graphics performance
10X improved computational speed
up to 7 displays
Powertrain Domain Controller (PDC)

- Powertrain domain control for HEV, PHEV, and EV vehicles
- Consistent, centralized platform to manage complexity
- Integrated interface between Powertrain and Vehicle in EV’s
- Delivers torque required with optimal engine and electrification design

Centralizing powertrain control and optimization
Creating intelligent electrification with Delphi’s 48V solution

Enabling intelligent electrification
- Engine Management Systems
- Electrical Architecture
- Valve Train & engine sensors
- Converters & Inverters
- Connected Infotainment
- Active Safety

Software and hardware optimized electrification architecture

Enabling power intensive features
- Active Safety
- Infotainment
- Performance

Cost effective efficiency
- Emissions
- Fuel Economy

CONSUMER PREFERANCE
- Active Safety
- Infotainment
- Performance

MEETING REGULATIONS
- Emissions
- Fuel Economy
Electrification increases Delphi content per vehicle (CPV)

**Delphi technologies**

**Powertrain Management**
- Supervisory controller
- Supervisory software
- Inverter
- Battery pack controller
- Combined inverter/converter
- 48V Driver module
- DC/DC converter
- On-board charger

**Electrical/Electronic Architecture**
- 48V fusing & distribution
- High power & voltage connectors
- Charging inlets and cables
- High voltage shielded cable
- Internal battery connections
- 12V battery monitor

**Electrification CPV\(^1\) 2020+ opportunities**

<table>
<thead>
<tr>
<th></th>
<th>ICE</th>
<th>48V</th>
<th>HEV</th>
<th>PHEV</th>
<th>BEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>~$300</td>
<td>~$600</td>
<td>~$1,600</td>
<td>~$2,400</td>
<td>~$2,400</td>
</tr>
<tr>
<td>Multiples</td>
<td>1.0x</td>
<td>1.5x</td>
<td>4.0x</td>
<td>5.0x</td>
<td>5.0x</td>
</tr>
</tbody>
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Comprehensive portfolio enables vehicle electrification

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\(^1\) Content per vehicle multiples represent Total Addressable Market (TAM) for electrified vehicles

Note: Content per vehicle multiples calculated off ~$300 content on a base gasoline GDi, 2-step variable valvetrain internal combustion engine in 2023 and beyond
### Power of data analytics

<table>
<thead>
<tr>
<th><strong>CONTROL TEC</strong></th>
<th><strong>DELPHI</strong></th>
<th><strong>MOVIMENTO®</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Leverages real-time data and the cloud to identify and solve issues</td>
<td>• Scalable vehicle software enhances Services business revenues via expanding usage with global OEMs</td>
<td>• Provider of telematics, analytics and OTA update technologies</td>
</tr>
<tr>
<td>• Broadens our “Big Data” capabilities</td>
<td>• Continued organic and inorganic investment in software and service</td>
<td>• Opportunity to drive market adoption</td>
</tr>
</tbody>
</table>

#### Enabling capabilities

<table>
<thead>
<tr>
<th><strong>Over-the-air updates</strong></th>
<th><strong>Cybersecurity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Manage update/upgrade campaigns for OEMs</td>
<td>• Detect and defeat unauthorized intrusions into the vehicle</td>
</tr>
<tr>
<td>• Deliver and validate software updates/upgrades on vehicles</td>
<td>• Combine hardware and software capabilities to develop secure platform</td>
</tr>
</tbody>
</table>

#### Commercial opportunities

<table>
<thead>
<tr>
<th><strong>Fleet management</strong></th>
<th><strong>Data brokerage</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Support fleet compliance with regulations for CVs</td>
<td>• Leverage vehicle data to deliver value to third parties (insurance, etc.)</td>
</tr>
<tr>
<td>• Enable total-cost-of-ownership savings by improving driver behavior, routes/planning</td>
<td></td>
</tr>
</tbody>
</table>

**Great opportunities with more to come**
Computing capabilities enabling intelligent mobility solutions
Computing power enabling Safe, Green and Connected

Convergence of megatrends driving exponential computing power demand

Reducing electrical architecture complexity is a “must do” to enable content growth

Delphi Multi Domain Controller unlocking ADAS capabilities

Delphi Integrated Cockpit Controller integrating Infotainment features

Delphi Power Domain Controller enabling intelligent electrification

Delphi competitive advantages critical for future mobility
DELPHI
Innovation for the Real World