The Road to Autonomous Driving:
Transforming Automotive Engineering in a Connected World...

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Delphi Electronics & Safety (E&S)
On the road to automated vehicles...

Sensors pave the way!
IoT: Reality or Hype?
26B connected devices
250M connected vehicles
by 2020...

Source: Gartner
The Connected Car Evolves...

The embedded era
1995–2002
Examples: GM Onstar

The infotainment era
2007–2012
Examples: Ford SYNC, Kia UVO, GM MyLink

The R&D era
1966–1995
Examples: GM’s DAIR system

The V2X era
2012–ongoing
Examples: Tesla app, Nissan Nismo, Progressive Snapshot

The new mobility era
2020–ongoing
Examples: Tesla Autopilot, self-driving initiatives by Google, Audi, Daimler

Source: Deloitte University Press
Cars talking with surrounding infrastructure...

Vehicle-to-Everything (V2E)

I'm stalled and can't move.

My left light turns green in 30 seconds.

Thanks! I'll change my route and turn at this light coming up.
Vehicle-to-Everything (V2E)

- Delphi MY17 V2V production system (in NA)
  - Stationary/ Slow Vehicle Ahead (SVA)
  - Emergency electronic Braking Lights (EEBL)
  - Road Condition Hazard Ahead (RCHA)
  - Cross Traffic Assistant (CTA) – Enabled in MY18

- Delphi MY18 V2X production system (in EU+NA)
  - Stationary/ Slow Vehicle Ahead (SVA)
  - Emergency Electronic Braking Lights (EEBL)
  - Hazard Location Warning (HLW)
  - Intersection Collision Warning (ICW)
  - Signal Violating Warning (SVW)
  - Emergency Vehicle Warning (EVW)
  - Traffic Jam Assist (TJA)
  - Road Work Warning (RWW)
  - Green Light Optimization Speed Advisory (GLOSA)
Advanced Driver Assistance Systems (ADAS) & Automated Driving
1st Coast-to-Coast Automated Drive

Automated Drive Highlights:
>3,400 miles traveled
>99% of drive fully Automated
Duration: 9 days across 15 states

~20 Sensors:
- RADAR
- Vision
- LIDAR

Automated Software Source: Ottomatika
1st Coast-to-Coast Automated Drive: Challenges

- Construction
- Traffic circles
- Bridges
- Tunnels
- Lane hogs
CES (Las Vegas) 2016: Automated Car Demo

Delphi’s New Self-Driving Car Teaches Give Up the Wheel

Wired Magazine Article from Jan 4, 2016

CES (Las Vegas) 2016: Automated Car Demo

First on CNBC: Cars talking to each other
Monday, 4 Jan 2016 | 7:00 PM ET
CNBC's Phil LeBeau goes behind the wheel of several autonomous vehicles at the Consumer Electronics Show in Las Vegas.

CNBC Video Article from Jan 4, 2016
http://video.cnbc.com/gallery/?video=3000473657

Automated Driving Route, CES Jan 4-9, 2016
# NHTSA Automated Driving Levels (0-4)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
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<tbody>
<tr>
<td>Driver only</td>
<td>Driver only</td>
<td>Assisted</td>
<td>Partial</td>
<td>Conditional</td>
<td>Full</td>
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<td>Active high beam</td>
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<td>Collision imminent braking</td>
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<td>Cruise control</td>
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<td>Traffic jam assist</td>
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<td>Adaptive cruise</td>
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<td>&amp; lane keeping</td>
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<td>Self-parking</td>
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<td>(with driver)</td>
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<td>Collision avoidance</td>
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<td>Automated highway</td>
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<td>Automated urban</td>
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<td>Valet self-parking</td>
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<td>Highway point-to-point</td>
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<td>Urban point-to-point</td>
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<table>
<thead>
<tr>
<th>Technology</th>
<th>Today</th>
<th>2020</th>
<th>2025+</th>
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<tbody>
<tr>
<td>Forward Radar</td>
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<td>Forward Vision</td>
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<tr>
<td>Multi-domain controller</td>
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<td>Lidar &amp; 360° Radar</td>
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<td>High accuracy GPS</td>
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<td>Driver State Sensor (DSS)</td>
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<td>V2X</td>
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*Driver only* refers to the level where the driver does all driving tasks, while *Assisted* refers to levels where the driver needs to monitor the system for接管 driving tasks. *Partial* indicates the system can take over for a short period if the driver is not watching. *Conditional* means the system can take over if a pre-defined condition is met. *Full* implies the system can take over in all conditions.

*Feature* includes elements like active high beam, traffic jam assist, and collision avoidance.

*Technology* includes components like forward radar, forward vision, lidar and 360° radar, driver state sensor (DSS), V2X, and IMU.
Vision/Radar/Lidar Operation and Fusion

**Camera**
- **How it works:** A camera takes images of the road that are interpreted by a computer.
- **Strengths:** Distinguish and classifies objects, such as traffic lights, tail lights, road lines and signs. It can also classify some objects, such as the deer being a large animal.
- **Weakness:** Like us, what it can’t see, it can’t see — in the dark, into direct sunlight and when objects are hidden.

**LiDAR**
- **How it works:** Light pulses are sent out, reflected off objects and received for interpretation.
- **Strengths:** Can define specific objects, such as a deer and its distance. Can tell where lines are on the road. Works in the dark.
- **Weakness:** In bad weather, the light reflects off fog, rain or snow, making objects hard to define.

**Radar**
- **How it works:** Radio waves are sent out, bounced off objects and received for interpretation.
- **Strengths:** Knows there are large objects that could be a deer. Does a good job calculating the deer’s speed and its distance. Can work in all weather, day or night. Can even fill in some hidden objects.
- **Weakness:** Can’t see color or differentiate objects, such as a deer from a big rock.

**Multi-domain controller**
- **With cameras, Radar and LiDAR, you’re getting three forms of input. Putting them all together is the multi-domain controller’s job. It takes the best of all three. Add mapping and navigation information and you can confirm decisions in multiple ways.**
Multi-domain Controller

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

Production launch in 2017

Enables future system optimization/upgradability
Typical Software Applications: Lines of Code

12 million lines of code
Android Operating System

24 million lines of code
F-35 fighter jet

44 million lines of code
Microsoft Office 2013

61 million lines of code
Facebook

Premium vehicle

50+ computers
To deliver a world-class user experience, active safety and high performance drivability

Premium vehicles today operate with over 100 million+ lines of code

*Software lines of code information courtesy of informationisbeautiful.net*
The future for Automated Driving is...

Safe  Green  Connected
Active Safety is the Foundation for Automated Driving

Winning through innovation
The Past & Present: Automotive Safety...

Automotive fatalities: USA

- Seat Belt Mandates
- Air Bag Sensors/Mandates
- ESC and Roll Over Sensors
- Distracted Driving

Drivers in their 20s make up 27 percent of the distracted drivers in fatal crashes. (NHTSA)

Source: http://www.iihs.org/iihs/topics/t/general-statistics/fatalityfacts/overview-of-fatality-facts

National Highway Traffic Safety Administration (NHTSA)
U.S. DOT and IIHS announce historic commitment of 20 automakers to make automatic emergency braking standard on new vehicles

McLEAN, Va. — The U.S. Department of Transportation's National Highway Traffic Safety Administration and the Insurance Institute for Highway Safety announced today a historic commitment by 20 automakers representing more than 99 percent of the U.S. auto market to make automatic emergency braking a standard feature on virtually all new cars no later than NHTSA's 2022 reporting year, which begins Sept. 1, 2022.
ADAS Radar and Vision Sensors

**ESR 2.5**
- Long Range RADAR (LRR)
- Med Range RADAR (MRR)
- 200 m
- 80 MHz BW
- 90°

**RACam 1.0**
- Euro NCAP 5-Star Safety Rating
- (ESR 2.5 + Camera)

**360° Sensing System**
- Front/Rear/Side Detection System

**Feature | RACam 1.0**
| High Beam Control (AHBC & GFHB) | ✓
| Lane Departure Warning (LDW) | ✓
| Lane Keeping Assist (LKA) | ✓
| Traffic Sign Recognition (TSR) | ✓
| Distance Warning (DW) | ✓
| Forward Collision Warning (FCW) | ✓
| AEB City | ✓
| AEB Urban | ✓
| AEB Pedestrian | ✓
| AEB for Animals | ✓
| AEB for General Objects | ✓
| AEB for Crossing Vehicles | Optional
| AEB for Left Turns Across Path | ✓
| Night Vision (NV) | Optional
| Adaptive Cruise Control (ACC) | ✓
| Traffic Jam Assist | ✓
| Active Body Control | ✓
| Passive Safety | ✓
RACam (Radar/Camera) Sensor Fusion

Key product features
- Adaptive cruise control, lane departure warning / lane keep assist, forward collision warning, low speed collision mitigation
- Autonomous Emergency Braking (AEB) for vehicles, pedestrians, animals, general objects

Benefits
- Most cost effective and robust auto-braking system
- Vehicle benefits: integration savings, weight savings, front styling, performance, reduced service costs, streamlined factory alignment process

Delphi advantages
- Only supplier with single integrated sensor module that combines radar sensing, vision sensing, and sensor fusion
- Leverages Delphi’s first to market and industry leading Radar / vision fusion experience
- Uses data fusion algorithms to combine inputs from the radar and camera to reduce the potential for accidents, injury and costly property damage
Delphi RACam Sensor Fusion

• Integrated radar and camera
• Major building block to automated driving
Automated Driving Mobility-On-Demand

Delphi Mobility Cloud

Automated Driving Sensor Suite

Multi-domain Controller

Automated Driving Software Algorithms