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TRENDS IN TECHNOLOGY
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MARKET DYNAMICS
Regulation
Automaker activity
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Sensors

New sensor technologies extend automated driving functionality and increase electronics content in the vehicle.

<table>
<thead>
<tr>
<th>LIDAR</th>
<th>77 GHz SRR</th>
<th>Trifocal camera</th>
<th>Central ADAS ECU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valeo + Ibeo</td>
<td>Delphi</td>
<td>ZF TRW, Delphi, Valeo</td>
<td>Delphi + Audi</td>
</tr>
<tr>
<td>Quanergy, TriLumina, LeddarTech and solid-state sensors</td>
<td>Bosch</td>
<td>Volvo XC90</td>
<td>Autoliv + Mercedes</td>
</tr>
<tr>
<td>Velodyne investment by Ford and Baidu</td>
<td>Current use case and forecast volumes evolve into 79 GHz SRR segment</td>
<td>Tesla Model S update</td>
<td>Delphi + Mobileye</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BMW + Intel?</td>
</tr>
</tbody>
</table>

New generations of sensors attract investment, will change in-vehicle architectures and computing, and introduce new high-tech suppliers.
Deep learning

Automotive Conference – Tokyo | October 2016

Deep learning enabling artificial intelligence will introduce new approaches to system design and management over time.

<table>
<thead>
<tr>
<th>NVIDIA</th>
<th>Mobileye</th>
<th>Intel</th>
<th>Partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry leader with multiple choices</td>
<td>Industry leader in vision systems</td>
<td>Nervana Systems USD400-mil. acquisition</td>
<td>Delphi + Mobileye BMW + Baidu Denso + Morpho</td>
</tr>
<tr>
<td>DGX-1 designed for deep learning</td>
<td>Semantic abstraction to define problems and train solutions</td>
<td>Nervana Neon framework</td>
<td>NXP CEVA Xilinx Synopsys Cadence</td>
</tr>
<tr>
<td>Widely used hardware but uphill battle to get inside production cars</td>
<td>Fleet learning with Tesla and common in production cars</td>
<td>Xeon Phi processors with Nervana accelerator chip expected in 2017</td>
<td></td>
</tr>
</tbody>
</table>

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## Mapping and localization

Many forms of localization will support automated and autonomous driving.

<table>
<thead>
<tr>
<th>Content layers</th>
<th>HERE</th>
<th>TomTom</th>
<th>Google</th>
<th>Startups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative localization helps to position the vehicle in space</td>
<td>High-definition maps with LIDAR sensors</td>
<td>High-definition maps with LIDAR sensors</td>
<td>Civil Maps</td>
<td></td>
</tr>
<tr>
<td>Crowd-sourced data overlaid on base map</td>
<td>Many content layers</td>
<td>Multiple layers of content</td>
<td>Mapbox</td>
<td></td>
</tr>
<tr>
<td>Mobileye REM and others</td>
<td>HERE - sensor data harvesting from German 3 enabling services to all OEMs</td>
<td>New to auto industry</td>
<td>NVIDIA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Uber</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dynamic Map Planning Co. (Japan)</td>
<td></td>
</tr>
</tbody>
</table>

Map data and content layers must coexist and complement each other. Crowd-sourcing and sharing are critical to successful scale.
Market dynamics
# Regulation

Regulatory activity is already influential, but it becomes one of the most important market forces for ADAS.

<table>
<thead>
<tr>
<th>NCAP</th>
<th>Voluntary agreements</th>
<th>Standards and guidance</th>
<th>Sharing economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>US NCAP adding 7+ new ADAS in 2018</td>
<td>US commitment for standard AEB by 2022</td>
<td>ISO 26262 + ASIL</td>
<td>Open question everywhere today</td>
</tr>
<tr>
<td>Euro NCAP continues to move forward on new AEB features</td>
<td>Will effectively make AEB standard everywhere in a few years, with rare local model exceptions</td>
<td>New automated vehicle guidelines (next slide)</td>
<td>Even China allowed ride-hailing services in legal grey zone</td>
</tr>
<tr>
<td>Little to no activity from other countries</td>
<td>What’s next?</td>
<td>Progress on cybersecurity and driver distraction guidance in US</td>
<td>Regulation likely to be defined by the current market</td>
</tr>
</tbody>
</table>

Guidance will shape the future of automotive technology. Regulatory decisions will impact how the sharing economy evolves.
USDOT Federal Automated Vehicles Policy – Four Topics

• Vehicle Performance Guidelines
  • 15 assessment criteria including certification, data recording & sharing, cybersecurity, consumer education, and vehicle automation functions
  • Meet / Does Not Meet / Not Applicable

• Current Regulatory Tools
  • Letters of interpretation
  • Exemptions from existing standards
  • Rulemaking
  • Recall authority

• Model State Policy
  • Division of federal and state roles
  • FED—Policy | STATE—Licensing, and...
  • Vehicle testing and safety inspections
  • Traffic laws, registration & insurance

• New Tools & Authorities
  • Pre-market approval
  • Post-sale software regulation
  • Enhanced recordkeeping & data collect

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Deployment of automated driving tech is one of the most strategic decisions an OEM faces, with regulation and evolving mobility also major factors.

<table>
<thead>
<tr>
<th>Luxury leaders</th>
<th>Tesla</th>
<th>Mass market</th>
<th>Startups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volvo XC90/S90</td>
<td>Autopilot 2.0 coming</td>
<td>Still mostly packages of ADAS options but moving forward</td>
<td>Atieva</td>
</tr>
<tr>
<td>BMW 7 Series</td>
<td>Standard hardware? Trifocal camera 1 x front radar 4 x corner radar + OTA update</td>
<td>Nissan Piloted Drive roadmap to 2020</td>
<td>Faraday Future</td>
</tr>
<tr>
<td>Tesla Model S</td>
<td>Taking algorithms further in-house</td>
<td></td>
<td>NextEV</td>
</tr>
<tr>
<td>2017 Mercedes E</td>
<td></td>
<td></td>
<td>LeEco</td>
</tr>
<tr>
<td>2017 Audi A8</td>
<td></td>
<td></td>
<td>Karma</td>
</tr>
</tbody>
</table>
Automation evolving

Based on NHTSA levels of automation

- **L0**: No automation
- **L1**: Single function control
- **L2**: Multiple function control
- **L3**: Limited autonomy
- **L4**: Full autonomy - Self-driving car
- **L5**: Driverless autonomy only - Driverless car

**NEW ENTRANTS**

**SOURCES:**
- IHS Automotive
- Autonomous Driving Service

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Based on NHTSA levels of automation
NHTSA Level 4 comprises IHS levels 4+5

SOURCE: IHS Automotive
Autonomous Driving Service
Autonomous Vehicle Forecast—June 2016

Autonomous Vehicle Sales Forecast—World

© 2016 IHS Markit

SOURCE: IHS Autonomous Driving Service
Autonomy scenario: Industry impact visualized

As autonomous vehicles arrive, the market impact is split between:

1. Replacing or updating current forecast volumes
2. Adding incremental volume beyond current forecast

Autonomous vehicles can broadly correlate to mobility service models:

- **L4** – Car sharing
- **L5** – Ride hailing
### Mobility

**New mobility services are evolving quickly and challenging traditional tech development, market deployment, and consumer exposure.**

<table>
<thead>
<tr>
<th>Uber</th>
<th>Ride-hailing</th>
<th>Car sharing</th>
<th>Automakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determined and acting quickly</td>
<td>Didi wins in China</td>
<td>Smaller fleets but consistent users and often profitable</td>
<td></td>
</tr>
<tr>
<td>Acquire and deploy plus shed losses</td>
<td>Daimler merging MyTaxi + Hailo</td>
<td>Rental car companies adding new tier of service</td>
<td></td>
</tr>
<tr>
<td>Uber + Volvo</td>
<td>VW + Gett</td>
<td>OEMs starting their own services</td>
<td></td>
</tr>
<tr>
<td>Uber + Toyota</td>
<td>GM + Lyft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uber + Otto</td>
<td>Delphi in Singapore</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OEMs and suppliers are investing heavily to understand the market, seize opportunities, and capture early market share that can be adapted later.
Car-based urban mobility is reshaping transportation

Past
- Taxi
- Rental
Owner/Driver

Present
- Taxi
- Ride-hailing
- Rental
- Car sharing
Owner/Driver

Future
- Autonomous on-demand mobility network
Owner/Driver
Mergers and acquisitions

Supply chain and ecosystem consolidation plus mobility services are fueling partnerships and M&A activity—and new players are coming.

<table>
<thead>
<tr>
<th>Didi + Uber China</th>
<th>Suppliers</th>
<th>Automakers</th>
<th>Tech companies</th>
</tr>
</thead>
</table>
| **Most significant consolidation in mobility to date** | Uber + Otto  
ZF + TRW + Ibeo  
Delphi + Ottomatika  
Freescale + Cognivue  
Lear + Arada | Ford co-lead investor in Velodyne  
Tesla + Solar City  
GM + Cruise  
Renault-Nissan + Sylpheo  
German mobility | Baidu co-lead investor in Velodyne  
Intel + Itseez  
Intel + Nervana  
Samsung interest in Magneti Marelli? |
| **Good for Didi & Uber** | | | |
| **Negative for drivers and users because of reduced competition and fewer subsidies** | | | |

Changes in the supply chain and in consumer-facing markets will continue to force the industry to rethink and reposition within a changing landscape.
Summary

Vehicle technology evolves quickly, but complexity, deep learning and new data will change system design.

Crowd-sourced map and OEM-owned driving data will further increase the value of connectivity and update-able hardware.

Technology deployment happens more quickly than ever. Planning becomes even more important.

Mobility services will change how automakers approach the market, plan products, and position their brand.

Strategic investments and acquisitions help secure valuable opportunities in a rapidly evolving transportation industry.
THANK YOU!

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## Where we are going: Scenario

### Vehicle parc (millions)

<table>
<thead>
<tr>
<th></th>
<th>Owned</th>
<th>Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1100</td>
<td>16</td>
</tr>
<tr>
<td>2025</td>
<td>1400</td>
<td>30</td>
</tr>
<tr>
<td>2035</td>
<td>1600</td>
<td>50</td>
</tr>
</tbody>
</table>

### Total daily trips (millions)

<table>
<thead>
<tr>
<th></th>
<th>Owned</th>
<th>Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>3300</td>
<td>160</td>
</tr>
<tr>
<td>2025</td>
<td>4200</td>
<td>420</td>
</tr>
<tr>
<td>2035</td>
<td>4800</td>
<td>1100</td>
</tr>
</tbody>
</table>

**Owned parc**

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2025</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average trips/day</td>
<td>3</td>
<td>3±</td>
<td>3±</td>
</tr>
<tr>
<td>Total trips/day</td>
<td>3.3B</td>
<td>4.2B</td>
<td>4.8B</td>
</tr>
</tbody>
</table>

**Shared parc**

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2025</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average trips/day</td>
<td>10</td>
<td>14+</td>
<td>22+</td>
</tr>
<tr>
<td>Total trips/day</td>
<td>160M</td>
<td>420M</td>
<td>1,100M</td>
</tr>
</tbody>
</table>

Driverless car mobility scales extremely well compared with current cars. Smaller fleets operate efficiently and make mobility available to more people.

**SOURCE:** IHS Automotive Autonomous Driving Service
Driverless car impact

- Mass transit
  - Last mile service
  - Bus augmentation
  - Bus replacement
  - New mass transit
  - Others?

- Car ownership
  - Augmentation
  - Replacement
  - Fewer cars per HH

- Driverless cars

- Goods delivery
  - Packages
  - Groceries
  - Courier service
  - Restaurants

- Ride hailing
  - Uber, Didi, Lyft, etc.
  - Taxis, rentals
  - Auto OEMs

* Driverless cars mostly BEV
# Medium and heavy commercial vehicles (MHCVs)

Automated driving technology will also have significant impact on MHCVs.

<table>
<thead>
<tr>
<th>European leaders</th>
<th>Japan</th>
<th>Automated, not autonomous</th>
<th>Outlook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daimler Freightliner &amp; Future Truck 2025</td>
<td>NEDO 2013 platoon demonstration</td>
<td>Will require driver supervision of operation and freight even if platooning</td>
<td>Automated driving as early as 2022</td>
</tr>
<tr>
<td>Volvo, Scania</td>
<td>Isuzu-Hino collaboration result</td>
<td>Driver likely required for first and last mile</td>
<td>Likely most popular in US and Europe</td>
</tr>
<tr>
<td>All have strong light vehicle ADAS portfolios to leverage</td>
<td>Pilot program possible in FY 2018</td>
<td>Efficiency benefits are still realized</td>
<td>Can help address driver shortages by repositioning job as high-tech</td>
</tr>
<tr>
<td>Uber joins the game?</td>
<td>2020 Olympics?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Operational and logistics efficiencies will transform transportation of goods.
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