Market and Technology Trends in the Global Connected/Automated Vehicles Market

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ADAS/Automation is the Fastest Growing Segment in the European and US Automotive Market

1. **Overall ADAS Market Growth**
   ADAS Market is Expected to Grow in Excess of 25% by 2020, Primarily driven by adoption in C/D vehicle segments and contribution from volume hitters

2. **Regulations are Evolving Fast**
   Crash imminent braking and dynamic brake support added to FCW, LDW and RVC to obtain 5 Star Rating

3. **Cooperative Driving**
   While a mandate is expected in US by 2015/16 on V2V (cost to OEM), Europe is unveiling its first ITS corridor focused on V2I initially

4. **Automation Features are Getting In**
   Besides the obvious OEMS, Tesla is coming out with update 7.0 that will feature L3 at high speeds and L4 at low speeds in private property

5. **Low Cost Collision Avoidance Tech is Fast Scaling Up**
   Rear end collisions, Lane keeping and improved pedestrian/night time detection, including low and high speed scenarios
By 2028, Frost & Sullivan expects 6.2 million vehicles to have automated features.

Automated Driving Market: Unit Shipment Forecast, Europe and North America, 2018–2028

Source: Frost & Sullivan
There are Business and Technology Related Challenges to Solve

<table>
<thead>
<tr>
<th>Margin Impact</th>
<th>As collision avoidance ADAS technologies move into standard fitment space, a high margin optional business will be impacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Cost CMOS Strategy</td>
<td>Pureplay CMOS strategy won't work from a redundancy level as the portfolio of ADAS and automation features improve</td>
</tr>
<tr>
<td>Addressing Human Factors</td>
<td>Handoff is still an extremely tricky situation - drastic differences between L3 and L4. L3 handoffs between driver and vehicle is a big tech challenge</td>
</tr>
<tr>
<td>Need to Evolve HMI</td>
<td>Need to augment drivers with more layers of useful alerts/information – need for improved HUD systems with AR without increasing complexity</td>
</tr>
<tr>
<td>Security</td>
<td>Besides the SPYCar act, the industry still needs more than the present band-aid approach to protect V2X channels and the heart of automation</td>
</tr>
</tbody>
</table>
LIDAR becomes a crucial part of this puzzle in the longer run

- With Camera Only - Better object recognition
- With Radar Only – Real-time speed measurement
- With V2X+Camera – All of the above

- Hypothesis generation
- Offsetting bad weather performance
- Enhanced Sensor Fusion

*Hypothesis generation
- Offseting bad weather performance
- Enhanced Sensor Fusion

<table>
<thead>
<tr>
<th>Low</th>
<th>Partial</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Only</td>
<td>Split</td>
<td>Driver Only</td>
</tr>
</tbody>
</table>

- The agility involved in emergency steer assist typically requires the free-space around the vehicle to perform a severe maneuver, which is possible only when accurate object data is generated by LIDAR.

- While LIDARs can be used for below functions, cheaper traditional multi-functional sensors are sufficient:
  - Pedestrian Detection
  - Forward Collision Warning
  - Lane Departure Warning
  - Reversing Assist
  - Blind Spot Detection

- Semi automated driving and active safety can be achieved with traditional ADAS sensors without possibly using a LIDAR, as vision-detection algorithm has reached a certain level of maturity and reliability.

- Typical driver-out-of-loop scenarios require LIDAR for effective sensor fusion.

F R O S T & S U L L I V A N
A lot of Effort is going on at OEMs to get the Technology Mix Right for L3 Automation and Above

<table>
<thead>
<tr>
<th>OEM</th>
<th>Supplier Tie-up</th>
<th>Type of LIDAR used</th>
<th>Level of Automation</th>
<th>Launch Year</th>
<th>Possible models</th>
<th>Functions that require LiDAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audi</td>
<td>Valeo (IBEO)</td>
<td>Laser Scanner</td>
<td>Level 3</td>
<td>2017</td>
<td>A7, A8, Q8</td>
<td>Traffic Assist, Piloted driving, Piloted Parking</td>
</tr>
<tr>
<td>BMW</td>
<td>-Undisclosed-</td>
<td>Laser Scanner</td>
<td>Level 3</td>
<td>2019</td>
<td>7-Series, 5-Series</td>
<td>Active Assist, Remote Valet Parking</td>
</tr>
<tr>
<td>Cadillac</td>
<td>-Undisclosed-</td>
<td>Laser Scanner</td>
<td>Level 3</td>
<td>2018</td>
<td>CTS, Escalade</td>
<td>SuperCruise</td>
</tr>
<tr>
<td>Ford</td>
<td>Continental</td>
<td>Fixed Beam</td>
<td>Level 2</td>
<td>2017</td>
<td>Fusion, Escape</td>
<td>Active City Stop</td>
</tr>
<tr>
<td>Mercedes Benz</td>
<td>Quanergy (For R&amp;D)</td>
<td>Laser Scanner</td>
<td>Level 3</td>
<td>2019</td>
<td>S-Class, E-Class</td>
<td>Distronic Plus with Steer Assist</td>
</tr>
<tr>
<td>Volvo</td>
<td>Continental</td>
<td>Fixed Beam</td>
<td>Level 2/3</td>
<td>2016</td>
<td>Across Range</td>
<td>City Safety</td>
</tr>
<tr>
<td>Google*</td>
<td>Velodyne (For R&amp;D)</td>
<td>Laser Scanner</td>
<td>Level 5</td>
<td>2021</td>
<td>Self Driving</td>
<td>Autonomous Driving</td>
</tr>
</tbody>
</table>

*DISRUPTOR

Source: Frost & Sullivan.
HERE’s Acquisition by the German Consortium and Plans to Set up a Open Standard will help this Market

**Interesting Trends**

- **Fully Automated Driving**
  - Impact on Insurance & Mobility

- **Vertical Integration**
  - between Tier 1 & 2 Suppliers and Overall Consolidation

- **HD Maps & Cloud**
  - HERE’s Open Platform

- **Mobile Edge Computing**
  - HERE’s Finland V2V Pilot

- **Retrofit Automation**
  - Cruise Automation RP1

- **5G Introduction by 2022**
  - For selective use Cases like L3

**Vertical Integration** between Tier 1 & 2 Suppliers and Overall Consolidation
Insurance - Vehicle- and traffic-related parameters will gain importance, apart from opening up new avenues of risks.

Parameters with continued relevance for Level 4 Automated Vehicles:
- Brand
- Peer Traffic
- Vehicle Size and Usage
- Frequently Used Routes
- Desirability, Vehicle age & Value
- Recall History Of Vehicle Model
- Time & Duration Of Journey
- Average Daily Miles Driven
- Vehicle Density
- Residential & Parking Locality
- Damage due theft, fire and vandalism
- Claim Frequency
- Average number of occupants

New-to-bracket parameters relevant to mainly Level 4 Automated Vehicles:
- Driving Algorithm
- Cyber-security vulnerability
- Control logic robustness
- Access security robustness
- Privacy

Parameters not relevant to Level 4 Automated Vehicles:
- Type of Cover
- Occupation
- Age/Driving Experience
- Driving Record
- Driver Behaviour
- Driver Alert / Warning Systems

Source: Frost & Sullivan
US Consumers Rate Safety & ADAS Tech More Important than Other Technologies

### Overall Vehicle Attributes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>Safety</td>
<td>76</td>
</tr>
<tr>
<td>Reliability</td>
<td>76</td>
</tr>
<tr>
<td>Fuel</td>
<td>62</td>
</tr>
<tr>
<td>Driving dynamics</td>
<td>60</td>
</tr>
<tr>
<td>Comfort and...</td>
<td>60</td>
</tr>
<tr>
<td>Ride quality</td>
<td>58</td>
</tr>
<tr>
<td>Price of vehicle</td>
<td>57</td>
</tr>
<tr>
<td>Engine Performance</td>
<td>52</td>
</tr>
<tr>
<td>Design and style of...</td>
<td>46</td>
</tr>
<tr>
<td>Design and style of...</td>
<td>46</td>
</tr>
<tr>
<td>Telematics safety...</td>
<td>42</td>
</tr>
<tr>
<td>Environmentally</td>
<td>34</td>
</tr>
<tr>
<td>Customization or...</td>
<td>33</td>
</tr>
<tr>
<td>Multimedia/Infotainment</td>
<td>33</td>
</tr>
</tbody>
</table>

Base: All respondents (n=1,584).

### Important Feature Expectations

- **Blind Spot Alerts**: 56
- **Forward collision warning with emergency braking**: 53
- **Around View Camera**: 49
- **Emergency Steer Assist**: 43
- **Driver Alert Systems**: 42
- **On Demand All Wheel Drive Systems**: 41
- **Maintenance and recall alerts**: 40
- **Lane keeping assist**: 40
- **Safety Alerts from a Car Ahead**: 40
- **Active all wheel steering**: 39
Thank You!