Introduction to automated driving
General technology and business considerations

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Lecturer at the Stanford Graduate School of Business

Sven Beiker – automotive bio, 20+ years in research, industry, consulting

Mechanical Engineering Education at Technische Universität Braunschweig

13 Years with BMW R&D Groups in Germany, Silicon Valley, Michigan

6 Years with Stanford University, Center for Automotive Research

2.5 Years with McKinsey & Company, Center for Future Mobility

2017 – Silicon Valley Mobility and Stanford Business School
Inside the automated vehicle – sensors, software, and by-wire drive systems

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Processing</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>1 Laser sensor (LiDAR)</td>
<td>7 Speed sensor</td>
<td>12 Drive by wire</td>
</tr>
<tr>
<td>2 Camera(s)</td>
<td>8 User interface</td>
<td>11 Steer by wire</td>
</tr>
<tr>
<td>3 Radar sensor</td>
<td>9 CPU, incl. AI</td>
<td>10 Brake by wire</td>
</tr>
<tr>
<td>4 GPS receiver</td>
<td>5 (HD) map</td>
<td>11 Brake by wire</td>
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<tr>
<td>6 Motion sensor</td>
<td>10 Motion sensor</td>
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The different players in automated driving can be clustered in three main groups

Source: CB Insights
Some people say (a bit teasingly) that a car becomes “a computer on wheels” – taking a closer look shows that it is already two orders of magnitude that

A modern car has well over 100 sensors and up 20 communication networks connecting systems like:

- Location, destination, speed
- Heating / ventilation, restraint systems, infotainment
- Door lock status, window status, seat occupation
- Driver input: brake, throttle, steering, gear selection, lights
- Body motion: yaw rate, lateral / longitudinal / vertical acceleration
- Brakes / steering / suspension / wheels: forces, angles, speeds, pressures, temperatures

Silicon Valley not only attracts the pioneers in autonomous driving, the broader area is also a good example to show the path to deployment.

**2020 Early Phase**
- L4 mobility services for public use in dedicated downtown areas of Mountain View, San Jose;
- Truck platoons on major freight corridor (I5)

**2025 Growth Phase**
- L4 mobility services for public use in downtown Palo Alto, San Francisco, and other cities;
- L4 lanes on major commute highways;
- L4 delivery vans in San Jose business areas

**2030 Mainstream Phase**
- L4 lanes on all major highways
- L4 SFO / SJC airport shuttles in Silicon Valley
- L4 delivery vans in residential and business areas of Silicon Valley, integrated with drones

**2035+ Unlimited autonomous driving**
- L5 vehicles capable of navigating all roads
It seems like AV and AI are holding the key to the future of mobility and investments are flowing to solve the problems human-driven mobility has created – really?

$14bn

has been invested in
183 AV companies
over last 3 years

30%

of AV investment
goes to AI and control software

64

companies have a
permit for AV testing
in California

Source: Woodside Capital Partners, California Department of Motor Vehicles

The Gartner Hype Cycle sees Level 4 automation more than 10 years out

Plateau will be reached in: ○ less than 2 years ● 2 to 5 years ● 5 to 10 years ○ more than 10 years ● obsolete before plateau

The Gartner Hype Cycle for Emerging Technologies distills insights from more than 2,000 technologies profiled into a succinct set of must-know emerging technologies & trends.

The 2019 Hype Cycle features technologies with increasingly enabled mobility and the ability to manipulate objects around them, including 3D sensing cameras and more advanced autonomous driving. As sensors and AI evolve, autonomous robots will gain better awareness of the world around them.
Before AVs go public, several challenges need to be overcome

- **General challenge, solutions anticipated**
  - **REGULATION**
    - Many U.S. states passed laws, guidelines have been issued on the federal level – **not an insurmountable hurdle**
  - **TECHNOLOGY**
    - Sensors, artificial intelligence, HD maps, connectivity are to be further developed – **ready for limited deployment**
  - **CONSUMERS**
    - Concerns regarding safety and security persist, but increasingly positive mood – **a societal learning process**
  - **REPERCUSSIONS**
    - Ultimately more traffic could be generated, cities and land use get affected – **expected to be solved case-by-case**
  - **REALITY**
    - Traffic has evolved over decades w/ human-driven vehicles, AVs might not mix well – **staged deployment will be key**

*Source: self, The Verge*

Getting to 90 percent is fairly easy. Getting to 95 percent starts to get interesting. And then you still need to go way beyond that. Nine point nine nine nine nine... Adding each nine is ten times harder. When you're at 95 percent, you've just scratched the surface.

*Alexandre Haag, CTO Audi AID*

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