Leadership in Mobility-as-a-Service (MaaS)

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Volkswagen Group
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Forecast 2050

- 9 billion
  Population

- 70%
  live in Cities

- 80%
  Ordered goods from other countries

Cities need Smart Mobility solutions!
As core to Digital Transformation, companies need to complement their Digital Innovation efforts with approaches for Digital Disruption.

Digital Innovation in core Business

Digital Disruption New Business

Digital Transformation
The dimensions of disruption of the automotive industry
Self-Driving Vehicles | What if...

...users immediately get picked up by a self-driving vehicle at the push of a button,...

...at a price that is lower than a personal car, but with an equally great experience,...

...and offer mobility for all people, also the blind, elderly and children, and let everyone spend more time on things they truly care about?
Human Thinking
Human Thinking

The self-driving system as the heart of the automobile

- 360° laser, radar, cameras and ultrasonic/short range sensors
- Central computing unit
- Redundancy
Human Thinking

Safety – Self-Driving Vehicles
- don't drink and drive
- don't text and drive
- don't take drugs and drive
- don't get agitated and disappointed about others
- don't get distracted
- don't fall asleep while driving
- don't need a second reaction time
- don't run red lights
- don’t have limited view
- don't speed…
Accessibility for EVERYONE
Will increase Social Mobility!
Human Thinking
Human Thinking
Human Thinking
Human Thinking
Human Thinking

Clean, Park & Charge Towers
Self-Driving System as the next core invention
Our Competitive Advantage:
Cover All Fields of Application

- Passenger Cars
- Trucks & Utility Vehicles
- Busses
- New Mobility-as-a-Service (MaaS) Vehicles
- New Vehicle Concepts for Owned Autonomy
Self-Driving Vehicles Use-Cases

- Autonomous Driving
  - Ownership
  - Mobility-as-a-Service for People
    - Pod
    - Shuttle
  - Mobility-as-a-Service for Goods
    - Urban
    - Highway
Business Disruption of the Automotive Industry: Mobility-as-a-Service (MaaS)
Mobility-as-a-Service (MaaS)

Value Layers & Profit Pools

Layer 5: Content & Services Provider
Layer 4: Mobility Provider
Layer 3: Fleet Operator
Layer 2: Automotive OEM
Layer 1: Self-Driving System Provider
Mobility-as-a-Service (MaaS) Vehicles are developed under new requirements.
Sedric Urban Pod
Sedric Long Distance Lounge
Sedric Racer
Sedric Urban Shuttle
Sedric Delivery Van / Mobile Mailbox Stations
Sedric Long-haul Truck
Vision: Mobility for ALL, at the push of a button
Impact of Mobility-as-a-Service on Cities
Model City Characteristics

— Densely populated urban area
— 5.5 million inhabitants
— 1 million privately owned vehicles
— 28,000 taxis
— 8,000 km of roadways
— 600 major intersections
— Well developed public transportation systems (rail and bus)
— High congestion level of 33%
— 8,000 car accidents per year
— High land values of $7,000/m²
<table>
<thead>
<tr>
<th>Key characteristics</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 City policy</td>
<td>No policy incentives or disincentives for SDV use</td>
<td>City incentivizes the purchase of private SDVs</td>
<td>City disincentivizes private vehicle ownership</td>
<td>City disincentivizes private car ownership, encourages ride-sharing</td>
</tr>
<tr>
<td>2 Sharing economy model</td>
<td>Private vehicle sharing increases, but less than 5% of private vehicles are shared</td>
<td>Private vehicle sharing increases, over 5% of private vehicles are shared</td>
<td>SDV taxis are shared by all city travelers</td>
<td>SDV taxis and rides taken in SDV taxis are shared by all city travelers</td>
</tr>
<tr>
<td>3 SDV share of new vehicle sales</td>
<td>SDVs capture 25% of new vehicle sales</td>
<td>SDVs capture 75% of new vehicle sales</td>
<td>Over 90% of new vehicle sales are SDV</td>
<td>Over 90% of new vehicle sales are SDV</td>
</tr>
<tr>
<td>4 Electric engine share of new vehicle sales</td>
<td>25% of new vehicle sales are electric</td>
<td>50% of new vehicle sales are electric</td>
<td>100% of new vehicle sales are electric</td>
<td>100% of new vehicle sales are electric</td>
</tr>
<tr>
<td>5 Predominant vehicle ownership model</td>
<td>Private vehicle ownership</td>
<td>Private vehicle ownership</td>
<td>Fleet ownership of SDV taxi</td>
<td>Fleet ownership of shared ride SDV taxi</td>
</tr>
<tr>
<td>6 Impact on public transportation</td>
<td>SDV taxi replaces very limited low capacity bus routes</td>
<td>SDV taxi replaces some low capacity bus routes</td>
<td>SDV taxi replaces one fifth of bus routes</td>
<td>SDV taxi replaces one third of bus routes and some rail travel</td>
</tr>
</tbody>
</table>

Source: World Economic Forum; BCG analysis
Vehicle population is the sum of all private vehicles and taxis.

Source: World Economic Forum; BCG analysis
Vehicle utilization in year 10 ('000 km/year)

Baseline¹: 11
Scenario 1 private SDV: 17
Scenario 2 private SDV: 18
Scenario 3 SDV taxi: 56
Scenario 4 SDV taxi: 52

1. Baseline is annual average private traditional vehicle distance traveled in year 0
Source: World Economic Forum; BCG analysis
### Total emissions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Emissions (B tons)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Scenario 1</td>
<td>3.5</td>
<td>-3%</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>3.0</td>
<td>-17%</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>2.7</td>
<td>-25%</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>1.8</td>
<td>-48%</td>
</tr>
</tbody>
</table>

### Rationale

- Change in vehicle hours driven
- Fuel efficiency of self-driving vehicles
- Increasing share of electric vehicles with low emissions

**Note:** In year 10

Source: World Economic Forum; BCG analysis
Note: In year 10
Source: World Economic Forum; BCG analysis
**Lives can be saved over 10 year time period**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of lives saved</th>
<th>Number of accidents avoided</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>213</td>
<td>11,000</td>
</tr>
<tr>
<td>2</td>
<td>611</td>
<td>30,000</td>
</tr>
<tr>
<td>3</td>
<td>858</td>
<td>42,000</td>
</tr>
<tr>
<td>4</td>
<td>748</td>
<td>37,000</td>
</tr>
</tbody>
</table>

**Rationale**

- 90% of accidents occur due to human error, 95,000 accidents in total over 10 years in baseline
- Decrease in all types of accidents proportional to decrease in occurrence of human error
- Occurrence of human error decreases with increasing SDV penetration
- Three types of accidents considered:
  - Fatal accidents
  - Injury accidents
  - Property damage accidents

Source: World Economic Forum; BCG analysis
Mobility-as-a-Service in Numbers
Self-Driving Vehicles driving will be the game changer!

190,900,000 cars will be connected with the internet in 2021

90% of the crashes can be eliminated through autonomous driving

42% of the auto fleet in Germany will be autonomous in 2035

2/3 of participants of a German survey would rather travel by an autonomous vehicle (for long distances)

$77bn revenue will be generated with autonomous vehicles in 2035, after $41.7bn in 2025

Source: ISI Evercore; Autonomous on Autobahn, 12/2017
Self-Driving Vehicles | Market analysis – Volume forecast cumulative 2015-2030

<table>
<thead>
<tr>
<th>Limitations</th>
<th>General assumptions</th>
<th>SDV utilization</th>
<th>SDV lifespan</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKinsey&amp;Company</td>
<td>Only MaaS in urban areas, Focus NAR &amp; EU</td>
<td>n/a</td>
<td>n/a</td>
<td>Consumer Cost pooled SDV taxi in 2025 $0.17-0.29 per mile</td>
</tr>
<tr>
<td>General assumptions</td>
<td>Level 4 SDV likely available by the mid 2020s</td>
<td>70-80% rides with passengers</td>
<td>Ø-Vehicle km p.a.: 100,000, Life span 2-3 years</td>
<td>n/a</td>
</tr>
<tr>
<td>Definition of endgame scenarios low, medium and high for 2035 based on modal split of 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High disruptive potential of SDV and fast expansion due to network effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only MaaS, Focus US market</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cumulative new SDV sales 2015-2030

- 55-60 Million
- 15-35 Million
- 35-40 Million

Sources: Online Research, RethinkX, McKinsey&Company, Berylls Strategy Advisor, P3 analysis
# Mobility-as-a-Service will grow dramatically until 2040

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>74%</td>
<td>56%</td>
</tr>
<tr>
<td>Mobility-as-a-service</td>
<td>11%</td>
<td>19%</td>
</tr>
<tr>
<td>Rail/Bus</td>
<td>11%</td>
<td>12%</td>
</tr>
<tr>
<td>Air</td>
<td>4%</td>
<td>13%</td>
</tr>
<tr>
<td>Private car</td>
<td>13%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Total projected mobility spend in 2040 (compared to 100% in 2015):**
- 95%

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<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>75%</td>
<td>58%</td>
</tr>
<tr>
<td>Mobility-as-a-service</td>
<td>4%</td>
<td>17%</td>
</tr>
<tr>
<td>Rail/Bus</td>
<td>18%</td>
<td>20%</td>
</tr>
<tr>
<td>Air</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Private car</td>
<td>5%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Total projected mobility spend in 2040 (compared to 100% in 2015):**
- 114%

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<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>61%</td>
<td>51%</td>
</tr>
<tr>
<td>Mobility-as-a-service</td>
<td>8%</td>
<td>16%</td>
</tr>
<tr>
<td>Rail/Bus</td>
<td>29%</td>
<td>13%</td>
</tr>
<tr>
<td>Air</td>
<td>2%</td>
<td>20%</td>
</tr>
<tr>
<td>Private car</td>
<td>22%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Total projected mobility spend in 2040 (compared to 100% in 2015):**
- 358%

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Revenue in the automotive industry will grow from $3,500 to $6,700bn.

RECURRING REVENUES FROM NEW SERVICES
- shared mobility – e.g. car sharing, ride hailing, etc.
- Data connectivity services – e.g. apps, remote services, etc.

$39.9bn did companies invest into the “mobility eco system” globally\(^1\)

71% of the ride hailing investments are concentrated on Uber and Didi\(^1\)

Source:
\(^1\)Berylls; The (r)evolution of urban mobility; 07/2017
\(^2\)Berylls; Electric robotaxis – the “silver bullet” for urban mobility?
\(^3\)ETH Zürich; Cost-based Analysis of Autonomous Mobility Services; 05/2017
\(^4\)McKinsey & Company; An integrated perspective on the future of mobility; 10/2016
MaaS SDVs will solve current and future problems of our cities

$23.000.000.000

does congestion cost the city of Los Angeles every year^4

2,9m m²

of parking space could be used otherwise through MaaS^2

30%

will cities become more dense in average over the next 15 years^4

200.000

private cars could be replaced with autonomous shared vehicles in Munich^2

18.000

autonomous shared vehicles could replace 100% of the daily individual motorized transport in the inner city of Munich^2

Source:
1Berylls; The (r)evolution of urban mobility; 07/2017  2Berylls; Electric robotaxis – the “silver bullet” for urban mobility?  3ETH Zürich; Cost-based Analysis of Autonomous Mobility Services; 05/2017  
MaaS SDVs will reduce the costs for mobility significantly

85% utilization can be achieved with shared autonomous vehicles in Munich²

€0,16 would one customer km cost in a shared autonomous vehicle in Munich²

-85% of the costs for a taxi ride per km can be reduced through the shift towards autonomous technology³

+20 to 50% could travel grow within a seamless mobility system – because it is cheap and easy⁴

Source:
¹Berylls; The (r)evolution of urban mobility; 07/2017 ²Berylls; Electric robotaxis – the “silver bullet” for urban mobility? ³ETH Zürich; Cost-based Analysis of Autonomous Mobility Services; 05/2017 ⁴McKinsey & Company; An integrated perspective on the future of mobility; 10/2016
Shared mobility services will cost as little as public transport and deliver convenience like a private car.
ICE vs. MaaS: Projected Trends in Annual Sales (U.S.)

Source: Rethink X Study 2017
Speed of MaaS Adoption (U.S.)

Source: Rethink X Study 2017
2D/3D Mobility-as-a-Service
GROUND MODULE

Electric platform with unmanned SAE 5 level autonomous driving system.

Carries and transports Passenger Cell on the road safely.
CAPSULA

Passive, not self-propelled, fully connected, double-seater compartment in new material with a kerb weight 200 kg, shared, but highly individual (ambient, shift wear etc.).
AIR MODULE

Electric platform, unmanned SAE 5 autonomous flying EVTOL – Vertical Take-Off and Landing - granting the Passenger Cell to fly in the ‘City Sky’.

Equipped with FAA and EASA compliant 4+4 coupled contra-rotating rotors.
Together towards a sustainable, electric self-driving mobility future...
"Only the people who are crazy enough to think they can change the world are the ones who do."

Steve Jobs
WE are the Generation,
That is reinventing the Automobile und Mobility