The 2019 Strategy& Digital Auto Report

Time to get real: opportunities in a transforming market
The 2019 Digital Auto Report: addressing market reality

Key facts and main content

- Eighth annual Digital Auto Report, developed by Strategy &
- Global study with a focus on the US, EU and China
- Quantitative market outlook based on detailed research
- Interviews with key industry executives at OEMs and suppliers, leading academics and industry analysts

Chapter 1
New value opportunities

- The search for new business models as technology investment drives up costs
- What are the value opportunities in alternative ownership models?
- How do customers choose between mobility options?

Chapter 2
Market dynamics & technology

- Overview of the current state of connected, autonomous, shared and electric (CASE) technologies
- When will these technologies ramp up?
- How is regulation influencing progress?

Chapter 3
Value chain & capability shifts

- How can suppliers reposition themselves in a transforming market?
- What new organizational structures are required to address hardware, software and services?
- How can auto makers and suppliers close the digital skills gap?
The auto industry’s dilemma: traditional profit pools no longer match the rising level of tech investment required

Summary – the search for profitable new business models

• The total number of cars in use (parc) in Europe is forecasted to peak at 273 million in 2025 and to decline thereafter. The number will continue to increase in China and at a slower pace in the US

• During the same time period, the cost of vehicle content is going up – electric powertrains and automated features could increase the Bill of Material (BoM) by between 20 and 40 percent by 2030

• Alternative ownership models and new revenue opportunities for OEMs are required to ensure customer affordability and economic returns for the industry: mobility spending is expected to be worth $1.2 trillion in Europe, the US and China by 2030, growing by more than 20 percent a year

• There will be a significant shift in value pools as OEMs and suppliers search for new business models. We estimate that profit share from traditional car sales, parts and aftersales will shrink from 70 to ~55 percent of total automotive market, while non traditional player profit shares could raise from 5 to ~25 percent by 2030

• As a result, intense efforts are needed by suppliers and OEMs to drive down technology costs in the coming decade – a reduction of 65 to 75 percent of costs for advanced driver assistance systems (ADAS), for example
Connected, automated, shared, electric: what’s driving the pace of digital change?

Summary – technical readiness, consumers, regulation and economics dictate transformation speed

- **Connected**: sales of 5G enabled vehicles are expected to reach **16 million in the EU, US and China by 2030**. However, we believe connected services mainly make a positive contribution to user experience with little potential for OEMs and suppliers to make money directly from connectivity.

- **Automated**: we still expect people movers with Level 4 autonomy to be operating in restricted areas at less than 50km/h by 2021, however we expect a delay until **2029** in highly automated Level 4/5 vehicles making it on to the road.

- **Shared**: our research shows that **47 percent** of European consumers would consider giving up their own car in favor of widely available and adequately priced autonomous robo-taxi services.

- **Electric**: by 2030, **46 percent of new car registrations in China will be for electric vehicles**. In Europe the figure will be 40 percent and in the US 35 percent. Internal combustion engines (ICE) still have the advantage when it comes to range, with only premium-priced fuel-cell electric vehicles able to compete.

These changes have fundamental implications for OEMs and their suppliers. OEMs need strategies to reduce their R&D costs through partnerships, and to focus on developing new ideas while outsourcing non-core back-office, R&D and technology solutions.

We also believe five new sustainable roles for suppliers will emerge: as smart infrastructure enablers; automated shuttle-vehicle manufacturers; platform providers; mobility intelligence providers; and vehicle feature and demand providers.

Finally, new flexible and hybrid organizations need to be created, and due to the scarcity of people with the right skills, the auto industry must upskill its existing workforce to perform digital and data-management roles.

Note: Please refer to respective section for detailed assumptions and sources behind stated propositions.
New value opportunities: alternative ownership models
New technologies add significantly to vehicle costs while infrastructure could become bottleneck for user adoption

Electric and automated features are the biggest cost drivers

<table>
<thead>
<tr>
<th>Business model challenges</th>
<th>CONNECTED</th>
<th>ELECTRIC</th>
<th>AUTOMATED</th>
<th>SHARED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BoM</strong> cost increase²</td>
<td>+2-3%³</td>
<td>+12-16%</td>
<td>+12-22%</td>
<td>+2-3%³</td>
</tr>
<tr>
<td>• Connectivity now required by regulation and safety standards</td>
<td>• Investments in electric car architecture increase costs</td>
<td>• Additional cost elements being added to ADAS systems</td>
<td>• Ride-hailing providers still unprofitable</td>
<td></td>
</tr>
<tr>
<td>• Fast erosion from perceived premium to commodity experience</td>
<td>• Low revenue margins due to high development costs</td>
<td>• Economic challenges hinder global roll-outs of AV systems</td>
<td>• Leading car-sharing providers have withdrawn from unprofitable cites</td>
<td></td>
</tr>
<tr>
<td>• Willingness to pay declining among customers</td>
<td>• Missing regulation for technological and geographical expansion of charging infrastructure</td>
<td>• Fewer acquisition targets available to extend technological expertise</td>
<td>• Car manufacturers depreciate initial investments</td>
<td></td>
</tr>
<tr>
<td>• Low connected services renewal rates</td>
<td></td>
<td>• Increase in inter-company co-operation to distribute additional development costs</td>
<td>• Asset utilization not sufficient to generate meaningful returns</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infrastructure challenges</th>
<th>CONNECTED</th>
<th>ELECTRIC</th>
<th>AUTOMATED</th>
<th>SHARED</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cost and timing of high-speed mobile network (5G) coverage</td>
<td>• Availability of high-speed electric charge points</td>
<td>• Availability of driving zones</td>
<td>• Cross-provider user authentication</td>
<td></td>
</tr>
<tr>
<td>• Availability of infrastructure-to-vehicle communications</td>
<td>• Availability of bidirectional charging solutions</td>
<td>• Regulation for operating alongside traditional traffic (pedestrian, bike, car, van)</td>
<td>• Integration with other modes of transport</td>
<td></td>
</tr>
<tr>
<td>• Alternatives to GPS (high precision)</td>
<td>• Availability of hydrogen fueling network for fuel cells</td>
<td>• Limited downtown real estate space for charging &amp; overhaul</td>
<td>• Regional and urban availability</td>
<td></td>
</tr>
</tbody>
</table>

1) BoM = Bill of material  2) BoM increase until 2030 compared to today's base vehicle (13,500€) excluding connectivity solutions 3) connected and shared analyzed together as highly correlated, hence 2-3% BoM increase estimated considering both connected and shared shift together | Source: Strategy& analysis
Number of cars in use will likely peak in the EU by 2025 –
continued growth in China and the US

Shared mobility will impact the total number of vehicles in use

Total vehicle parc (in millions. Autonomous, connected, electric as percentage of total vehicle parc)

- Declining car parc in EU due to increase of shared mobility & integrated mobility platforms
- Delayed roll-out of shared mobility pushes car parc in US and China in line with growth of total mobility demand
- In China, parc projection may exceed sustainable levels
Regulation as well as innovation could raise vehicle bill of material cost by 20-40%.

Regulatory requirements push installation of enhanced connectivity, automation, and electrification.

Comments:
- Powertrain changes due to environmental requirements have the largest cost impact from a regulatory viewpoint.
- Enabling vehicles to earn additional revenues from connected or automated features adds further margin pressure to the vehicle BoM, to be recovered via vehicle price or services contribution.
- Intense effort necessary by suppliers and OEMs to drive down technology costs by 2030 – e.g. reduction of 65-75% for ADAS – to reach profitability.

Note: Bill of material indexed to 100% in 2018 | Source: Strategy& analysis
Auto industry revenues keep growing – but profitability shifts away from traditional profit pools

Significant shifts in global automotive value pools

### Revenue distribution¹ (in $bn)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>MaaS ²</th>
<th>Connected Services</th>
<th>Suppliers - Tech</th>
<th>Financing</th>
<th>New Vehicle Sales</th>
<th>Aftermarket</th>
<th>Suppliers - Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>5,400-5,600</td>
<td>12%</td>
<td>8%</td>
<td>14%</td>
<td>48%</td>
<td>13%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>9,200-9,500</td>
<td>19%</td>
<td>9%</td>
<td>7%</td>
<td>40%</td>
<td>11%</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

### Profit distribution¹ (in $bn)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>MaaS ²</th>
<th>Connected Services</th>
<th>Suppliers - Tech</th>
<th>Financing</th>
<th>New Vehicle Sales</th>
<th>Aftermarket</th>
<th>Suppliers - Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>380-400</td>
<td>5%</td>
<td>13%</td>
<td>11%</td>
<td>41%</td>
<td>11%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>490-510</td>
<td>11%</td>
<td>70%</td>
<td>14%</td>
<td>31%</td>
<td>11%</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

### Key levers

- **Mobility as a Service (MaaS)** increases **vehicle utilization** and vehicle wear and tear, leading to higher parts sales but a declining share of vehicle sales
- **MaaS fleet owners** emerge as an important new group of buyers, with higher bargaining power, leading to lower margins in aftermarket, financing and insurance
- **Autonomous features** increase vehicles’ technical complexity, and the share of value provided by new tech suppliers. However, there are fewer collisions, cutting insurance and aftersales demand
- **Electric powertrains** are less complex than ICE equivalents and need less maintenance, which reduces traditional supplier revenue streams

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¹) Based on Strategy& 2030 Scenario. Totals may not equal sums shown due to rounding. ²) Vehicle-based mobility as a service, including “shared autonomous” and “shared driver-driven”  

Source: PwC AutoFacts®, IHS, HBR, Technavio, Thomson Reuters, Oxford Economics, OEM Reports, Strategy& Analysis
Alternative ownership models offer new revenue opportunities

**Traditional vs. alternative car ownership models**

<table>
<thead>
<tr>
<th>Ownership models</th>
<th>Purchase</th>
<th>Leasing</th>
<th>Subscription</th>
<th>Rental</th>
<th>Car sharing</th>
<th>Ride hailing</th>
<th>Ride sharing</th>
<th>Micro-mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total cost of mobility (TCM) per km today</strong>²</td>
<td>0.55 €/km</td>
<td>0.70 €/km</td>
<td>0.60 €/km</td>
<td>0.95 €/km</td>
<td>0.90 €/km</td>
<td>2.50 €/km</td>
<td>1.55 €/km</td>
<td>1.30 €/km</td>
</tr>
<tr>
<td><strong>Driver motivation and distance sweet spot</strong></td>
<td>Control-seeking, all distances</td>
<td>Avoiding upfront investment, all distances</td>
<td>Experience-driven, all distances</td>
<td>Flexibility-driven, intercity medium distances</td>
<td>Spontaneous, short urban distances</td>
<td>Comfort-seeking, short urban distances</td>
<td>Price-sensitive, short urban distances</td>
<td>Time-sensitive, super-short urban distances</td>
</tr>
<tr>
<td><strong>Profitability today</strong>³</td>
<td>5-7%</td>
<td>10-15%</td>
<td>No data available</td>
<td>10-15%</td>
<td>&lt;5%</td>
<td>Not yet profitable</td>
<td>Not yet profitable</td>
<td>Not yet profitable</td>
</tr>
</tbody>
</table>

1) Pooled shuttles shared with multiple people  
2) TCM = total cost of mobility for end user in Germany incl.: asset (mid-sized car), insurance, maintenance and gas; assumptions: mode 2: average of leasing offers 15,000km yearly, 24 months, mode 3: average of current subscription offers, mode 4: average of rental offers 15,000km yearly, 24 months, mode 5: typical city trip, mode 6: typical city trip by taxi, mode 7: typical city trip, mode 8: average of current micro-mobility offerings (e-scooter)  
3) best view generated based on respective annual reports, newspapers and expert input
Car ownership will continue to shift away from private owners

Further increase of alternative ownership is expected

Customer demand for mobility services is increasing:

74 percent of consumers opt for the most convenient way of getting from A to B, including using more than one mode of transport

28 percent of European vehicle owners could imagine earning money from sharing their car via a peer-to-peer platform

47 percent of European consumers would consider giving up their own car in favor of widely available and adequately priced autonomous robo-taxi services

>50 percent of consumers would be willing to pay up to $250 for a monthly subscription for unlimited rides within town

Passenger vehicle registrations by customer group – Germany

The higher share of fleet and business vehicles has already increased price pressure on OEMs, due to the negotiating power of professional customers.

Sources: (left) PwC Strategy& consumer research, 2018, n=3000 (EU, USA, CHN); (right) Automobilwoche, CAR Uni Duisburg-Essen
The total value opportunity of alternative ownership will reach $1.2 trillion in US, EU, CN by 2030

Alternative ownership mobility models market development

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</thead>
<tbody>
<tr>
<td></td>
<td>57</td>
<td>286</td>
<td>435</td>
<td>+18%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Europe (in USD billions)</th>
<th>2018</th>
<th>2025</th>
<th>2030</th>
<th>CAGR 2018-30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33</td>
<td>191</td>
<td>393</td>
<td>+23%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>China (in USD billions)</th>
<th>2018</th>
<th>2025</th>
<th>2030</th>
<th>CAGR 2018-30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16</td>
<td>110</td>
<td>389</td>
<td>+31%</td>
</tr>
</tbody>
</table>

Comments

- The global shift to alternative / shared ownership is heavily dependent on the achievable price points / cost per kilometer in each market
- After initial price battles to gain market share, mobility providers will have to reach profitability to survive, despite their intensive cost base
- Long-term decrease in the cost of shared mobility operations depending on the individual operator’s capabilities
- Split of market into few global players and substantial long-tail of local players with specialized offers expected

Note: vehicle-based Mobility as a Service, incl. "shared autonomous" and "shared driver-driven"; based on Strategy& 2030 scenario
Source: PwC AutoFacts®, Strategy& analysis
New mobility models are expected to account for 17 - 28% of vehicle-based mobility globally by 2030

Distribution of mobility types

Definitions

- **Individual Active Mobility**: Use of individually owned, driver-driven car (private car, family car, personal company car, etc.)
- **Shared Active Mobility**: Using all forms of shared mobility with an active driver (rental, car sharing, ride hailing, ride pooling, taxi, etc.)
- **Individual Passive Mobility**: Provided by cars with capability to drive automated, without driver intervention (private car, family car etc.)
- **Shared Passive Mobility**: Provided by all forms of shared mobility with a fully automated vehicle (ride hailing, robotaxi, people mover etc.)

Note: Figures may not sum up to 100% due to rounding
However, alternative mobility models continue to cannibalize each other. Customers will seek the best service and greatest convenience.

Future shifts expected as of today

Shift 1: Customers might shift from leasing to subscription models for a better service offering and convenience.

Shift 2: Customers might shift from car sharing towards ride hailing / ride sharing as price levels converge.

Shift 3: Customers might shift towards micro-mobility for very short urban distances, due to time and cost savings and first and last-mile convenience.

TCM: total costs of mobility for the end user in Germany incl. asset (mid-sized car), insurance, maintenance, and gas. Assumptions: for mode 2: average of leasing offers, 15,000km yearly, 24 months, for mode 3: average of current subscription offers, for mode 4: average of rental offers 15,000km yearly, 24 months, for mode 5: typical city trip, for mode 6: typical city trip by taxi, for mode 7: typical city trip, for mode 8: average of current micro-mobility offerings (e-scooter). 2) Pooled shuttles shared with multiple people.
In cities, customers will assess their ride choice on a journey-by-journey basis

Example: Anna is late for a meeting in the city center, it’s raining. What mobility service suits her best?

<table>
<thead>
<tr>
<th>CUSTOMER DECISION CRITERIA</th>
<th>Preferences¹</th>
<th>MOBILITY OFFERING EVALUATION</th>
<th>CUSTOMER CHOICE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>--</td>
<td>-</td>
<td>o</td>
</tr>
<tr>
<td>1) Affordability (TCM/km³)</td>
<td></td>
<td></td>
<td>Ride sharing</td>
</tr>
<tr>
<td>2) Space (# people, baggage room)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Journey distance</td>
<td></td>
<td></td>
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<tr>
<td>4) Choice (contractual-/timely- flexibility)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Availability on demand (accessibility)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Comfort</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1) Perceived importance and preference based on individual perceptions and ever-changing situational use cases 2) Selective evaluation of three mobility modes on their applicability and hence competitiveness level within each criteria 3) TCM = Total cost of mobility

Strategy& | PwC
2 Market dynamics & technology
What are the key drivers for new forms of mobility?

Change happens rapidly once favorable economics are achieved

**Illustrative ramp-up curves**

**Penetration drivers**

1. **Technology**
   - Technical readiness occurs when a technology is applicable to sufficient share of targeted use cases, marking the starting point of adoption.

2. **Customer demand**
   - New, superior technology is quickly adopted by premium users as high costs are not prohibitive to them. However, penetration stagnates at 5-15% due to limited customer segment size.

3. **Regulation**
   - Regulation plays a role by defining certain technology components as mandatory (e.g., the eCall system, which automatically places an emergency call after a crash, is mandatory in the EU since 2018).
   - However, penetration only increases in line with new car registrations and often remains below the total global market (due to regional scope).

4. **Economics**
   - Once a technology results in superior economics due to lower costs or additional revenues, the pace of adoption is exponential.
   - However, typically a certain level of volume is needed first, before cost parity to alternatives is reached.
### Transformation will happen at varying speeds globally

**Key considerations to anticipate tipping point of exponential technology adoption**

<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
<th>Consumer</th>
<th>Regulation</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Viable car system capability and EE¹ architecture</td>
<td>• Share of people paying extra for</td>
<td>• Timing of requirements such as:</td>
<td>• Superior economics</td>
</tr>
<tr>
<td></td>
<td>• 3G coverage must be &gt;95%</td>
<td>- Premium services</td>
<td>- Mandatory eCall</td>
<td>- Cheaper OTA vs. OBDII² updates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Experience (e.g. AR windshield)</td>
<td>- Geo-data privacy</td>
<td>- Low usage-based fees vs. fix rates</td>
</tr>
<tr>
<td>2</td>
<td>Electric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Electric powertrain performance</td>
<td>• Consumer preference for</td>
<td>• Emission target levels</td>
<td>• Superior total cost of ownership (TCO) of BEV vs. ICE</td>
</tr>
<tr>
<td></td>
<td>• Charging network availability</td>
<td>- Acceleration</td>
<td>[From 95g CO₂/km down to 60g CO₂/km]</td>
<td>[at mid-range for volume segment]</td>
</tr>
<tr>
<td></td>
<td>(&gt;80% coverage in urban areas)</td>
<td>- Sustainability</td>
<td>- Cities with ICE bans/restrictions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Operating cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Automated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Coverage of a vehicle’s operating driving domain (&gt;75% at 50km/h)</td>
<td>• Share of users paying extra for:</td>
<td>• Enforced L2 safety features e.g. front camera</td>
<td>• “5th screen” revenues</td>
</tr>
<tr>
<td></td>
<td>• 4G/5G network coverage</td>
<td>- “Having it first”</td>
<td>[AV people movers/ robo-taxis approved in restricted areas]</td>
<td>Superior TCO &amp; lower price</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Letting tech do the driving</td>
<td></td>
<td>[in taxi/hailing mode]</td>
</tr>
<tr>
<td>4</td>
<td>Shared</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Smartphone penetration (&gt;70% of population)</td>
<td>• Share of people willing to give up own car in urban areas (&gt;40%)</td>
<td>• Car pool occupancy requirements [in &gt;50 large cities]</td>
<td>• Superior cost vs. own vehicle (&gt;20% cheaper)</td>
</tr>
<tr>
<td></td>
<td>• International/ intermodal roaming</td>
<td></td>
<td>• Insurance/liability requirements</td>
<td></td>
</tr>
</tbody>
</table>

[Assumed moment of truth / penetration before reaching tipping point of transformation]

1) EE = electric/ electronics 2) OTA = Over the Air; OBDII = On board diagnosis interface

Source: expert interviews, PwC AutoFacts®, Strategy& analysis

[Strategy& | PwC]

**Expected tipping points**

<table>
<thead>
<tr>
<th></th>
<th>earlier</th>
<th>2030</th>
<th>later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Connected services will be worth $81bn in US/EU/CN by 2030

**Connected services market potential (vehicle-centric and 5th screen)**

<table>
<thead>
<tr>
<th>Digital vehicle service archetypes</th>
<th>Estimated market size development, US (in USD billions)</th>
<th>Estimated market size development, EU (in USD billions)</th>
<th>Estimated market size development, China (in USD billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vehicle features as a service</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>2. Vehicle-centric connected services</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>3. 5th screen connected services</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>4. Beyond-vehicle services</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>5. Data/insights services</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Comments**

**Revenues** from vehicle-centric connected services (e.g. predictive navigation) are driven by higher connected car penetration and corresponding demand. However, willingness-to-pay per service quickly declines as customers get used to it (commoditization).

Provision of “5th screen” content (e.g. content shown within the car) offers high GMV, but limited margin potential due to low commissions. **In-vehicle advertising** with some potential, but likely to collide with OEMs brand values.

OEM’s ability to maximize profits from connected features depends on their pricing strategy and efficiency of data usage.

While car makers have limited direct monetization potential with connected services, they significantly contribute to overall customer experience.
Despite innovation in connected services, the auto industry’s share of value is still low

**Connected services: an evaluation of recent offerings**

<table>
<thead>
<tr>
<th>Digital vehicle service archetypes</th>
<th>Recent service offerings</th>
<th>Key challenges</th>
<th>Value capture potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vehicle features as a Service</td>
<td>• Pay-by-use vehicle features</td>
<td>• Identification of suitable components to be digitally booked by vehicle occupants (prerequisite: availability of inactivated components in every vehicle)</td>
<td>• Limited additional revenue potential. Mainly one-off revenues as vehicle options are shifted to a later time</td>
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<tr>
<td>2. Vehicle-centric connected services</td>
<td>• Voice-enabled virtual personal assistants integrated into vehicle infotainment center</td>
<td>• Maintaining control over customer data, while sourcing language processing system from tech players</td>
<td>• Limited revenue potential, as similar services are already standard in other domains (on smartphone, at home)</td>
</tr>
<tr>
<td>3. 5th screen connected services</td>
<td>• Recent strong customer adoption observed, focus on two key use cases: providing navigation information and initiating phone calls</td>
<td>• Integration of voice assistant with customers’ assistants from other domains (e.g. smartphone, smart home)</td>
<td>• Strong potential for customer experience differentiation and links to other in-vehicle services</td>
</tr>
<tr>
<td>4. Beyond-vehicle services</td>
<td>• Commerce platform embedded into vehicle infotainment system</td>
<td>• Partnerships with merchants and advertisers</td>
<td>• On-top revenue possible, but limited to commissions/ad prices</td>
</tr>
<tr>
<td>5. Data/insights services</td>
<td>• Currently low technological adoption in automotive industry, but accelerating traction especially in the US</td>
<td>• Standardized technology platform</td>
<td>• Negotiation power of global partners narrows profit potential</td>
</tr>
</tbody>
</table>

**Recent service offerings**

- **Vehicle-specific add-on services/functions** to be digitally booked by vehicle occupants (prerequisite: availability of inactivated components in every vehicle)
- Currently only **limited implementation observed** (e.g. navigation upgrade)
- **In-vehicle voice assistant**
  - Voice-enabled virtual personal assistants integrated into vehicle infotainment center
  - Recent strong customer adoption observed, focus on two key use cases: providing navigation information and initiating phone calls
- **In-vehicle marketplace**
  - Commerce platform embedded into vehicle infotainment system
  - Currently low technological adoption in automotive industry, but accelerating traction especially in the US

**Value capture potential**

- **Limited additional revenue potential.** Mainly one-off revenues as vehicle options are shifted to a later time
- **Limited profitability** due to required installation of more kinds of hardware

**Key challenges**

- Maintaining control over customer data, while sourcing language processing system from tech players
- Integration of voice assistant with customers’ assistants from other domains (e.g. smartphone, smart home)
- Partnerships with merchants and advertisers
- Standardized technology platform
- Scalability dependent on “additional usable time” enabled by automated driving

**Strategic and **

Source: Strategy& analysis
5G will drive not only new connected services, but also foster shift towards cloud-based vehicle architecture

State of tech: connected vehicle architecture

- Different vehicle electronics architectures will coexist, but with a clear trend toward in-vehicle centralization
- Car truly becomes “smartphone on wheels”:
  - Software design re-use and software-based innovation
  - Lower complexity and volumes of physical components (e.g. ECUs)
  - Optimization of power consumption across vehicle, cloud, and potentially other vehicles
  - Higher longevity due to ability to physically upgrade

1) QoS = Quality of service

Source: Strategy& analysis
As connected vehicles reach 100% of new cars, technology shifts from 3G / 4G towards 5G readiness

Market outlook: connected vehicles

**Connected vehicles** (in total new vehicle sales) – (EU, US, China; in millions)

- Since April 2018 e-Call is compulsory (minimum 2G) in the EU
- Spread of 5G begins in premium and volume segment at the same time
- 4G will only be a temporary solution

- Around 70% of new cars are 5G connected in 2030
- Spread of 5G begins in premium and volume segment at the same time
- 4G will only be a temporary solution

- Connected-Car share 2019 <25%, since only installed in Premium-/JV-vehicles
- Mandatory requirements like V2X or E-Call not yet manifested
- Faster rollout of 5G than in US/EU due to structured rollout in Tier-1 and Tier-2 cities

---

Source: PwC AutoFacts®
Electric cars remain limited by range, outside the high-end market

Overview of powertrain technologies

Dominant powertrain technologies and respective reach per segment

Implications

ICE¹: Increasing costs, unbeaten flexibility/range
- Mild electrification based on 12V or 48V technology for efficiency gains
- Further optimization of friction losses
- Increasingly complex exhaust gas after treatment

BEV²: Highly attractive for limited ranges
- Lower battery cell cost is the most important lever for economic attractiveness
- Increasing energy densities, but ICE range not feasible yet
- Further functional integration of power electronics

FCEV³: The premium solution
- Plug-in architecture with fuel cell range-extended BEV expected
- Best of ICE (high range and fast refill) combined with BEV advantages (zero local emissions), but cost premium persists

PHEV⁴: Complex technology, high cost
- Increasing minimum electric range for eligibility as a low-emissions vehicle, requiring larger batteries
- Increasing electric power, driving characteristics becoming more “EV-like”

1) ICE – internal combustion engine 2) BEV – battery electric vehicle 3) FCEV – fuel-cell electric vehicle 4) PHEV – plug-in hybrid electric vehicle

Source: Strategy& analysis
Electric vehicle sales boosted by legislation in China and EU

Market outlook to 2030

Electric vehicles (total new vehicle sales – EU, US, China; in millions)

- Around 40 percent of new car registrations electric by 2030
- Sufficient domestic/commercial/public charging infrastructure from 2025 onwards
- Strong legislative push from 2020 onwards
- Cost-of-operating tipping points will vary by segment and pattern of use

- Around 35 percent of new car registrations electric by 2035
- Penetration of electric lower than other regions due to relatively low cost of existing ICE alternatives
- Municipal and state-level privileges support local market dynamics
- Domestic charging infrastructure wide-spread only after 2030

- Around 46 percent of new car registrations electric by 2030
- Sufficient public charging infrastructure from 2022 in priority cities and main travel routes
- Consumer demand for electric vehicles growing from sub-car segments to all segments
Level 4 autonomy available by 2021 in people movers traveling at less than 50km/h

Automated driving: timeline of road-readiness

People mover
7-12 seats

Robo-taxi
2-6 seats

Owned vehicle
2-5 seats

Implications

- Efforts to develop and implement ADAS\(^1\) software in vehicles have resulted in higher cost than originally anticipated
- Launch dates for high-level automated driving features have been postponed time and again
- Sensors for ADAS systems are still far from being at target cost level, due to the small quantities being made
- The legal side is also still unclear: the technical framework regulations of the UN/ECE (Economic Commission for Europe) are not yet fully in place: and the approval of Level 3 vehicles for assisted driving on motorways is still not defined

\(^1\) ADAS = Advanced Driver Assistance Systems | Source: Strategy& analysis
Automated driving expansion delayed due to higher tech cost and limits on where automated vehicles can operate

**Market outlook**

**Autonomous vehicles** (total new vehicle sales – EU, US, China; in millions)

- ~25 percent of new car registrations Level 4/5 autonomy in 2030
- Level 4 expected to be available at low speed and only in restricted areas from 2023
- Road-ready Level 5 cars will not be available before 2028

- Up to ~10 percent of new car registrations at Level 4 possible in 2030 driven by two scenarios
  - Scenario 1: New cars with strong Operating Driving Domain (ODD) coverage (>80% of situations) at L4 expected at <5% of registrations
  - Scenario 2: In addition, L4 cars with lower ODD coverage (~50% of situations) will be sold (e.g. to people mover fleet operators) adding further 5% of new car registrations

- ~20 percent of new car registrations Level 4/5 in 2030, over 40 percent in automated driving-ready cities
- Level 5 will not be available before 2028
- Gradual roll-out of automated driving infrastructure across tiers of cities prolongs adaptation
Automated driving technology market for cars to be worth $270bn by 2030

ADAS market development (vehicle-based)

Market potential ADAS technology EU/US/CN¹ (in USD)

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>ADAS Features /Use cases</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Adaptive cruise control</td>
<td>M²</td>
<td>M</td>
<td>M</td>
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<tr>
<td></td>
<td>Assistive parking (driver-assisted)</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<td></td>
<td>Lane keep assist (system steering)</td>
<td>M</td>
<td>M</td>
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<td>Blind spot monitoring rear/side (system steering)</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<tr>
<td>L2</td>
<td>Assistive parking (remote/key parking)</td>
<td>P</td>
<td>M</td>
<td>M</td>
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<td>Lane changing assist</td>
<td>P</td>
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<td>M</td>
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<td>L3</td>
<td>Emergency assistant</td>
<td>P</td>
<td>M</td>
<td>M</td>
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<td>Traffic jam assistant without lane change</td>
<td>P</td>
<td>M</td>
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<td>Highway autopilot (single-lane)</td>
<td>P</td>
<td>M</td>
<td>M</td>
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<td>Highway autopilot (incl. lane change)</td>
<td>P</td>
<td>M</td>
<td>M</td>
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<td>Intersection movement assist</td>
<td>P</td>
<td>M</td>
<td>M</td>
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<tr>
<td>L4</td>
<td>Fully autonomous valet parking</td>
<td>C</td>
<td>M</td>
<td>M</td>
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<td></td>
<td>Full highway pilot with lane change</td>
<td>C</td>
<td>P</td>
<td>M</td>
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<td></td>
<td>Urban autopilot</td>
<td>C</td>
<td>P</td>
<td>M</td>
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<tr>
<td>L5</td>
<td>Full autonomy</td>
<td>C</td>
<td>C</td>
<td>P</td>
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<tr>
<td></td>
<td>People mover</td>
<td>C</td>
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</tbody>
</table>

L4/L5 ADAS features will not only be applied to traditional cars, but also form the basis for new types of vehicle for special ODDs (e.g. people mover without steering wheels)

1) Focus on passenger vehicles, based on end customer prices, 2) M: Mass Market, C: Concept, P: Premium;

Source: Strategy& analysis
Regulation will play a key role for adoption and is increasingly supportive for connected, electric and autonomous vehicles

**Technology regulation assessment: EU vs. US vs. Asia (China and Japan)**

<table>
<thead>
<tr>
<th>Connected</th>
<th>Electric</th>
<th>Automated</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Harmonization of connected car standards (e.g. 5G as basic connected car technology, 07/2019)</td>
<td>• Incentives to encourage EV purchase (e.g. tax reduction in Belgium, Germany)</td>
<td>• Early global agreements with restrictive regulations for deploying AD technology (e.g. VCRT, 1969); recent favorable regulations permitting testing of AD</td>
<td>Favorable regulatory dynamics in EU states, promoting the adoption of new technologies, with a focus on compulsory safety and environment-specific aspects</td>
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<tr>
<td>• Promotion of compulsory &amp; optional connected safety features in vehicles (e.g. Directive 2010/40/EU)</td>
<td>• European auto OEMs subject to strict CO2 regulations (e.g. penalties for exceeding fleet emission targets)</td>
<td>• Compulsory regulations enforcing installation of L0 &amp; L1 ADAS features by 2022 (by EU GSR); EU NCAP recommending L2 ADAS safety features</td>
<td>Technology adoption (with a focus on autonomous) mainly enforced by state-specific regulations, with federal actions protecting the traditional auto industry</td>
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<td>Strict incentives and penalties significantly pushing technology adoption across connected, autonomous and electric vehicles in China and also in Japan</td>
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</table>
3 Value chain & capability shifts
New business models blur the boundaries of OEMs & suppliers

How the value chain can be adapted as some present-day core processes become irrelevant

CONNECTED

Refocus:
1) Concentrate on product ideation and design, and outsource non-core back-end/R&D/technology solutions
2) Move into direct-to-consumer services instead of offering them through a dealer network

ELECTRIC

Shift:
1) Reduce ICE production capacity due to electric powertrain shift (motor/battery cell production outsourced as little opportunity for differentiation, and high price pressure)¹
2) Enter partnerships for sourcing battery raw materials

AUTOMATED

New role:
1) Focus on partnerships and close collaboration with tech companies and suppliers to reduce investment costs in, for example, R&D
2) Maintain close interaction with customers by being a mobility provider

SHARED

New role:
1) Shift towards selling to mobility providers to supply vehicles for their car-sharing service (B2C to B2B)
2) Maintain customer-facing role as a shared mobility/fleet provider

OEM

New role:
1) Concentrate on product ideation and design, and outsource non-core back-end/R&D/technology solutions
2) Move into direct-to-consumer services instead of offering them through a dealer network

Supplier

New role:
1) Fill the opportunity gap left by OEMs by providing independent back-end/technology solutions leveraging scale benefits (e.g. digital infrastructure)
2) Provide customer solutions B2B2C (e.g. vehicle features on demand)

Shift:
1) Independently and/or in partnership with OEMs, enter market for R&D/manufacturing of battery cells, packs and electric motors²
2) Enter partnerships for raw material sourcing to secure supply (e.g. lithium)

New role:
1) Enter into deeper co-operation with OEM’s R&D processes, with stronger end-product responsibility
2) Take on a customer-facing role by building fully assembled automated shuttles and/or enabling services (e.g. digital services for fleet operators)

New role:
1) Work directly with customers in co-operation with a mobility/fleet provider to offer enabling services (e.g. digital services for mobility provider)
2) Enter fleet operating services by managing all service tasks for mobility providers

¹ Alternatively: extension into e-motor and battery cell production possible
² Note: high necessity to refocus for traditional IC-focused suppliers

Source: Strategy& analysis | 1) Alternatively: extension into e-motor and battery cell production possible 2) Note: high necessity to refocus for traditional IC-focused suppliers
Suppliers need to explore new software & service opportunities

Five new ways to play for auto-industry suppliers

1. SMART INFRASTRUCTURE ENABLER
   - Digitally-enabled traffic solutions for integrated mobility systems to governments/ institutions (e.g. city councils)
     - Success factors:
       - Technology excellence
       - Integration capabilities
       - System adaptability
   - Example: Intelligent traffic-management system for a Chinese city that integrates transport information for all travel options

2. AUTOMATED SHUTTLE MANUFACTURER
   - Fully assembled shuttle for public and corporate institutions (e.g. city councils/ shuttle service provider)
     - Success factors:
       - Production excellence
       - Cost efficiency / lean SC
       - Fast time-to-market
   - Example of international automotive supplier: autonomous, electric, shared people mover in cooperation with mobility start-up and system provider

3. PLATFORM PROVIDER
   - Platform-as-a-service for business partners (e.g. OEMs, (public) mobility providers, fleet operators)
     - Success factors:
       - Agile development
       - Flexible & open domain
       - Customer centricity
   - Example of global industrial supplier: PaaS³ for the Internet of Things with end-to-end solutions incl. hardware, software and services

4. MOBILITY INTELLIGENCE PROVIDER
   - Mobility software services and centralized data analytics for fleet operators and mobility service providers
     - Success factors:
       - Real-time data analytics
       - Service integration
       - Customer centricity
   - Example of German OEM’s mobility service company: fleet management software for intelligent mobility solutions

5. VEHICLE FEATURE ON DEMAND PROVIDER
   - Product-as-a-service for end consumers through e.g. mobility providers, allowing for direct monetization
     - Success factors:
       - Partnership management
       - Customer centricity
       - User experience
   - Example of manufacturing company/ supplier: fully automated “valet parking” (parking and car return upon user’s request via app)

1) Outlined success factors are most relevant ones but not limited to these
2) Supply chain
3) Platform-as-a-service

Strategy & | PwC
New roles require suppliers to refocus on selected capabilities

Identifying digital auto priorities

Need for collaboration to stem high costs: tech companies have on average a 10% higher R&D spend than auto suppliers²

One German OEM aims to have half of its revenue coming from digital offerings by 2020³

Suppliers show strong growth of +450% in M&A activity for software related competencies⁵

Need for omni-channel excellence: e.g. more than 70% of train tickets are already bought online (via app, computer)⁴

Need for optimized global sourcing as labor costs make up ~30% of total interior parts costs when manufactured in Western Europe⁶

Ambidextrous organization

Performing partnerships

Mixed portfolio

Immersive channels

Smart technology

Hyperlocal footprint

"Industry workforce will be cut by at least 50% by 2030 and employees who remain will need very different skills"¹

1) PwC Strategy& report “Transforming vehicle production: How shared mobility and automation will revolutionize the auto industry by 2030” 2) Strategy& analysis based on annual reports of several technology companies and suppliers; average R&D spent as percentage of revenue in 2018: 16% tech. vs. 6% supplier 3) Strategy& analysis based on OEM press releases 4) Tagesspiegel press release on Deutsche Bahn tickets 5) Strategy& analysis 6) PwC Strategy& report “Capabilities-driven restructuring – A manufacturing footprint strategy for a commodity automotive supplier industry”
Future organizations need a flexible and hybrid structure
Shifting functional tech expertise and horizontal domain responsibility

SITUATION:
• Current R&D methods, tools & processes do not match the increasing complexity of e.g. supporting digital trust and AI
• New business models may include hardware, software and services (e.g. being an automated vehicle “platform provider”) and require realignment of processes

SOLUTION:
• Hybrid organizational structure with horizontal and vertical business units for a flexible overarching coordination
• Mix of new and existing capabilities ensures integration and continuous improvement of skills, technology and portfolio

SUCCESS FACTORS:
• End-to-end solutions
• Open interfaces
• Adaption flexibility
• Technology integration
• Talent for emerging skillsets

Source: Strategy& analysis

New capabilities required
Based on existing capabilities
EMS: electronics manufacturing services
OMD: original design manufacturer

Ambidextrous organization
The auto industry’s workforce will also be transformed

Producing connected, automated, shared and electric vehicles requires new roles and skills

<table>
<thead>
<tr>
<th>Proportion of workforce affected:</th>
<th>R&amp;D</th>
<th>Production &amp; logistics</th>
<th>Sales &amp; marketing, and aftersales</th>
<th>Management support functions</th>
<th>Technological support functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of workforce affected:</td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
<td>50%</td>
</tr>
<tr>
<td>Proportion of workforce affected:</td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
<td>50%</td>
</tr>
</tbody>
</table>

New skills required:

- Innovation management
- Open sourcing
- Agile methodologies (Scrum)
- Business analytics
- Partnership management
- Sustainability
- Productivity
- AI
- Raw materials sourcing
- Real-time data management
- Footprint optimization
- Machine learning
- Product design
- Product marketing
- Customer success management
- Service and solution design
- Industrial mechanical engineering

In-demand roles and typical salaries:

- Application architect ($132,000[^4])
- Software engineer ($121,000[^4])
- Product manager ($119,000[^4])
- Business intelligence developer ($104,000[^4])
- Scrum master ($103,000[^3])
- Product owner ($101,000[^3])
- ERP business analyst ($99,000[^4])
- Systems analyst ($91,000[^4])
- Research scientist ($86,776[^5])
- Machine learning engineer ($142,000[^3])
- Supply chain & logistics manager ($117,600[^3])
- AI specialist ($105,918[^5])
- Process automation specialist ($101,650[^7])
- Industrial mechanical engineer ($91,650[^7])
- Product designer ($121,500[^3])
- Product marketing manager ($90,000[^3])
- Customer success manager ($88,500[^3])
- Service and solution designer ($71,000[^3])
- Enterprise account executive (third most in-demand job, $182,000[^3])
- Engagement manager ($130,000[^3])
- Site reliability engineer (second most in-demand job, $200,000[^3])
- Solution architect ($139,000[^3])
- Data scientist (first most in-demand job, $130,000[^3])
- Information technology lead (121,000[^7])
- Cloud architect ($92,500[^4])
- Quality assurance engineer ($82,000[^4])

Top courses of study and universities:

- Software engineering
- Civil engineering
- Mechanical engineering
- Electrical engineering
- Artificial intelligence (AI)
- System engineering
- Communication
- Business administration
- International management
- Digital media design
- Virtual reality
- Information technology
- Software/network engineering
- Knowledge engineering
- Computer science engineering

[^1]: Visually modified value chain to incorporate relevant overarching support functions (HR, Finance, Technology)
[^2]: Potential impact on respective function’s resources through digitization and CASE
[^3]: Job roles in bold = within Top 10 most demanded jobs at the moment on the market, salary referring to median base salary, LinkedIn publication “2019’s most promising jobs in the US”
[^4]: Robert Half Technology Salary Guide 2018
[^5]: Avance Consulting AI Big Data Talent Assessment US West Coast April 2019
[^6]: TCG/Robert Half Creative & Marketing Salary Guide 2019
[^7]: Randstad 2019 Salary Guide

Strategy & PwC
Systematic upskilling needed to bridge digital skills shortage

Six steps to providing your people with the right training for the digital future

1. ANALYZE & DEFINE
   - Analyze future required skills and resources
   - Identify the individual resource situation and potential shortages
   - Define the initiative based on gap analysis and commitment to developing the team

2. DESIGN
   - Design each course within an overall upskilling initiative to keep the focus on your strategic goals
   - Design a timeline for the initiative

3. ASSESS & ADVISE
   - Assess individual skill levels
   - Create individual skills development plans to address the new requirements

4. MATCH
   - Identify potential candidates for difficult-to-fill positions who would not immediately think to join an upskilling initiative

5. SET UP & SELECT
   - Set up curriculum with online and offline modules
   - Select training courses and providers
   - Involve experts and universities
   - Organize expert groups for discussions

6. MONITOR & OPTIMIZE
   - Set up continuous internal communication, publishing success stories and communicating the benefits to the broader community
   - Continuously improve the initiative

PRACTICAL EXAMPLES:

- A shortage of specific skills and resources, e.g. data strategists and scientists
- Establish a data and analytics ‘university’ to train people and create your own resources
- Define the overall objectives, requirements and timeline of the initiative
- Design the curriculum of the data & analytics ‘university’
- Identify people who are already working in data roles
- Create individual plans to upskill them to the level of data strategists/scientists
- Assess the positions you need to fill and match them with resources
- Broden internal recruiting and benefits initiatives
- Involve universities and external experts
- Organize secondments to other companies / startups, cross-departmental projects
- Implementation of program increment (PI) planning, market places and other methods to ensure continuous exchange
- Implement agile communication tools