
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

Key facts



- ✓ 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 chose 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 ne 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.



1 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



CONNECTED



ELECTRIC



AUTOMATED



SHARED

BoM¹ cost increase²

+2-3%³

+12-16%

+12-22%

+2-3%³



Business model challenges

- **Connectivity** now required by regulation and safety standards
- Fast erosion from perceived **premium to commodity** experience
- **Willingness to pay declining** among customers
- **Low** connected services **renewal rates**

- Investments in **electric car architecture increase costs**
- **Low revenue margins** due to **high development costs**
- **Missing regulation** for technological and geographical expansion of **charging infrastructure**

- **Additional cost elements** being added to ADAS systems
- Economic **challenges** hinder global roll-outs of **AV systems**
- **Fewer acquisition targets** available to extend technological expertise
- **Increase in inter-company co-operation** to distribute additional development costs

- **Ride-hailing** providers still **unprofitable**
- Leading **car-sharing providers** have **withdrawn** from **unprofitable cities**
- Car **manufacturers depreciate** initial **investments**
- **Asset utilization not sufficient** to generate meaningful returns



Infrastructure challenges

- Cost and timing of **high-speed mobile network (5G)** coverage
- Availability of **infrastructure-to-vehicle communications**
- Alternatives to **GPS** (high precision)

- Availability of **high-speed electric charge points**
- Availability of **bidirectional charging solutions**
- Availability of **hydrogen fueling network** for fuel cells

- Availability of **driving zones**
- **Regulation** for **operating alongside traditional traffic** (pedestrian, bike, car, van)
- Limited downtown real estate space for **charging & overhaul**

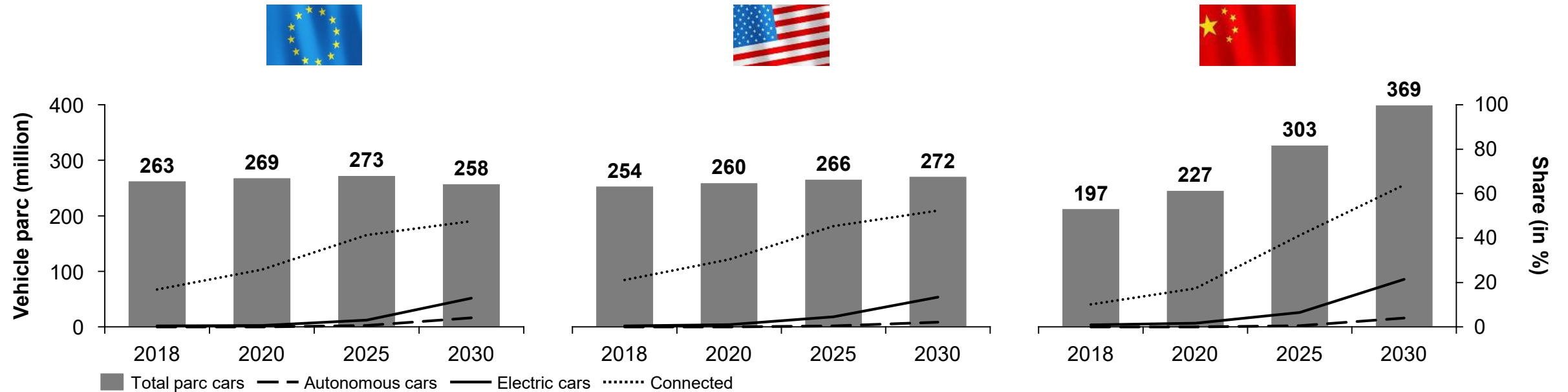
- Cross-provider user **authentication**
- **Integration** with other modes of transport
- Regional and **urban availability**

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

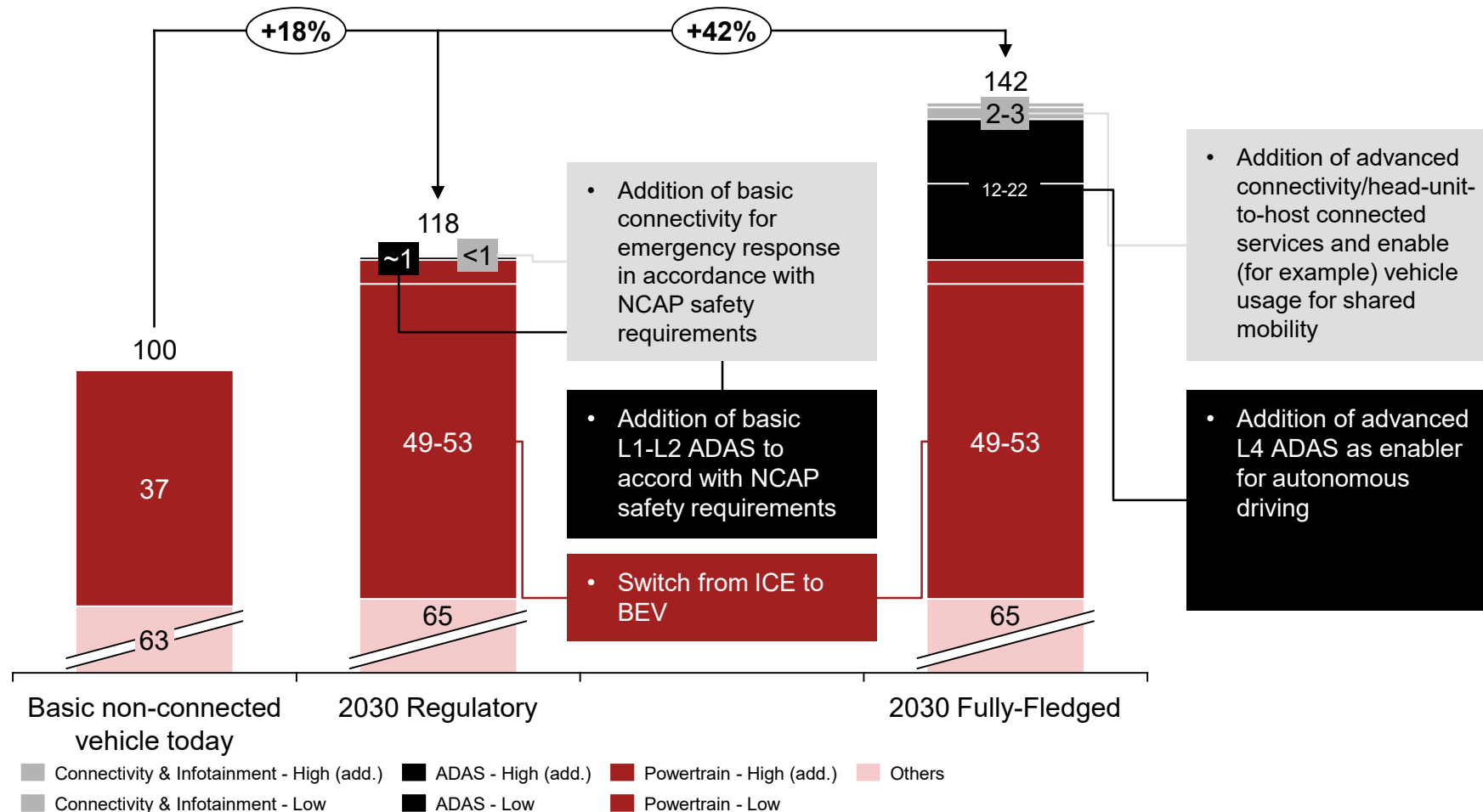
Total vehicle parc (in millions. Autonomous, connected, electric as percentage of total vehicle parc)



- 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



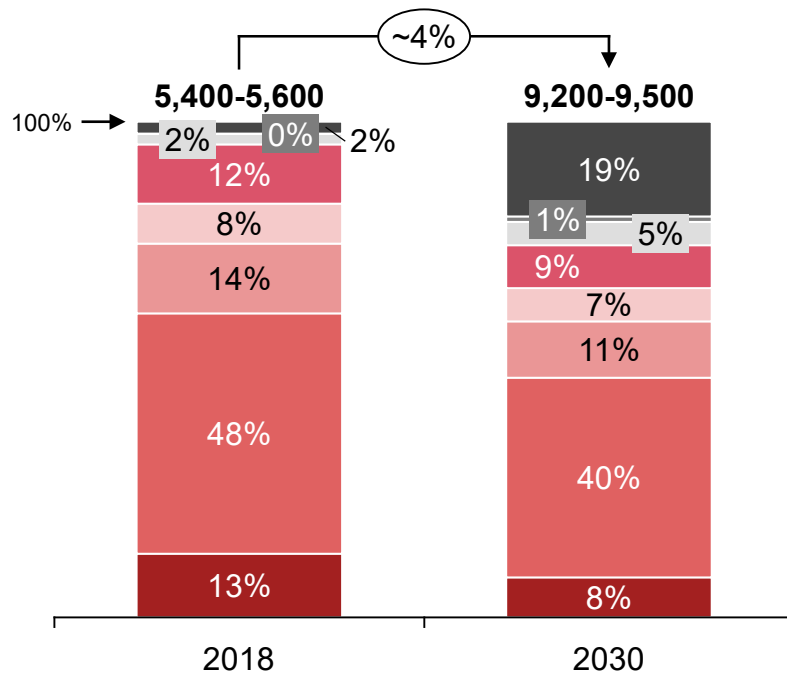
Comments

- 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

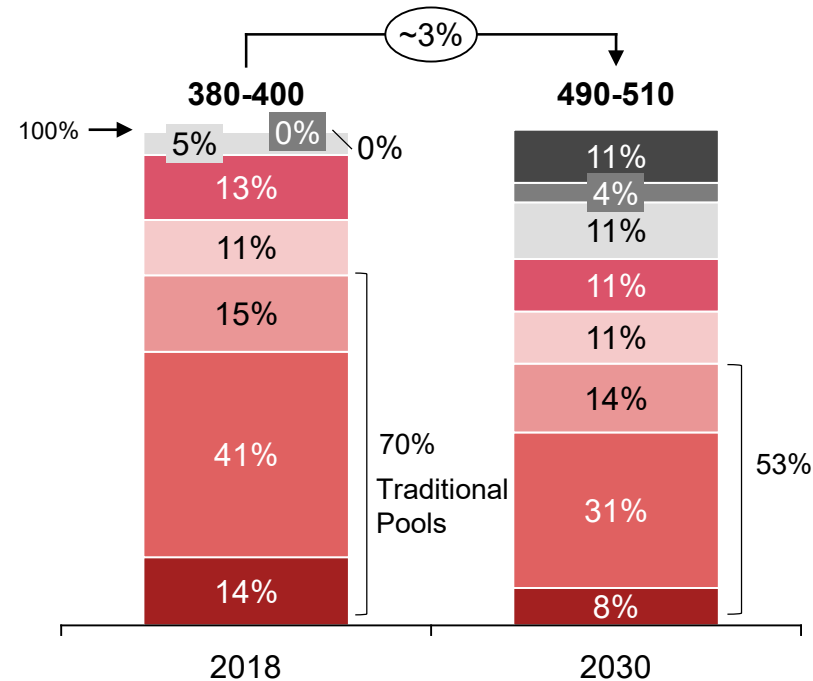
Auto industry revenues keep growing – but profitability shifts away from traditional profit pools

Significant shifts in global automotive value pools

Revenue distribution¹ (in \$bn)



Profit distribution¹ (in \$bn)



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

○ Annual growth in %
 ■ MaaS²⁾ ■ Suppliers - Tech ■ Financing ■ New Vehicle Sales
 ■ Connected Services ■ Insurance ■ Aftermarket ■ Suppliers - Traditional

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" | Note: Consolidated view; supplier value pools not eliminated from vehicle/aftermarket/MaaS revenues to show full industry value pools
 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

Ownership models

- 1** Purchase
- 2** Leasing
- 3** Subscription
- 4** Rental
- 5** Car sharing
- 6** Ride hailing
- 7** Ride sharing¹
- 8** Micro-mobility

Traditional car ownership

Alternative ownership

	1 Purchase	2 Leasing	3 Subscription	4 Rental	5 Car sharing	6 Ride hailing	7 Ride sharing ¹	8 Micro-mobility
Total cost of mobility (TCM) per km today²	0.55 €/km	0.70 €/km	0.60 €/km	0.95 €/km	0.90 €/km	2.50 €/km	1.55 €/km	1.30 €/km
Driver motivation and distance sweet spot	Control-seeking, all distances	Avoiding upfront investment, all distances	Experience-driven, all distances	Flexibility-driven, intercity medium distances	Spontaneous, short urban distances	Comfort-seeking, short urban distances	Price-sensitive, short urban distances	Time-sensitive, super-short urban distances
Profitability today³	5-7%	10-15%	No data available	10-15%	<5%	Not yet profitable	Not yet profitable	Not yet profitable

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



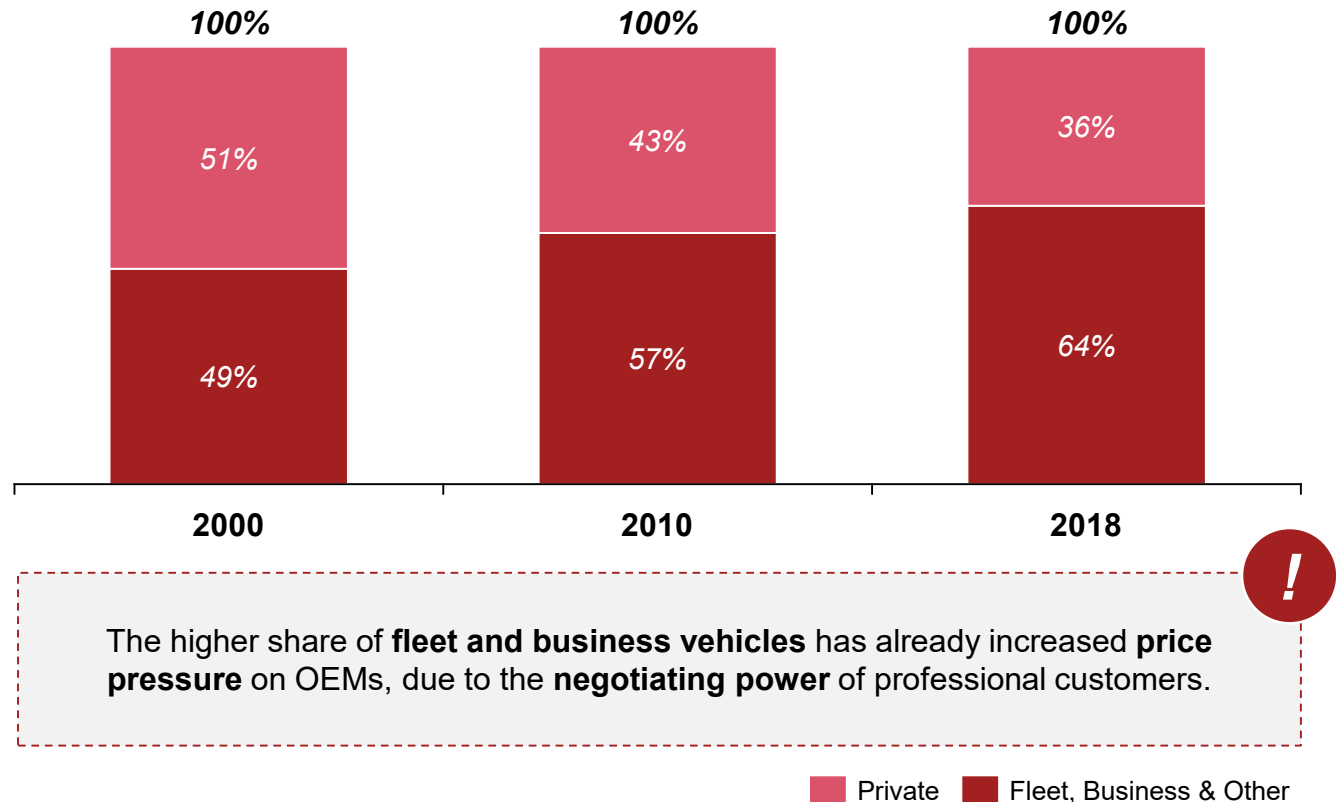
47 percent of European consumers would consider giving up their own car in favor of widely available and adequately priced autonomous robo-taxi services



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



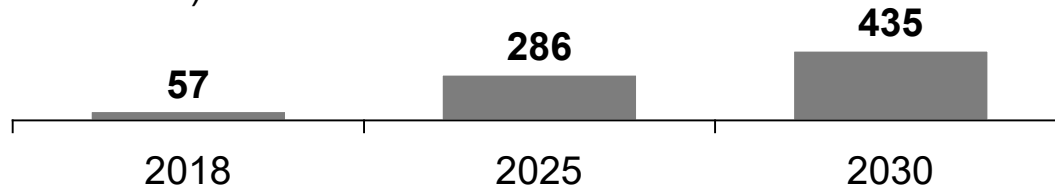
Passenger vehicle registrations by customer group – Germany



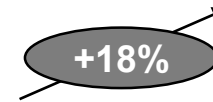
The total value opportunity of alternative ownership will reach \$1.2 trillion in US, EU, CN by 2030

Alternative ownership mobility models market development

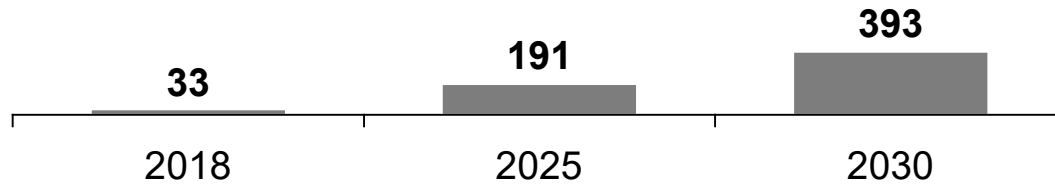
US (in USD billions)



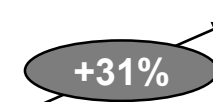
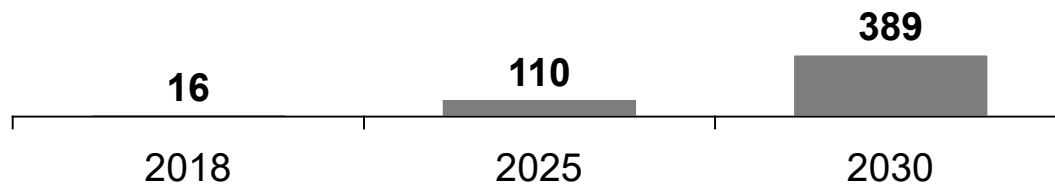
CAGR
2018-30



Europe (in USD billions)



China (in USD billions)



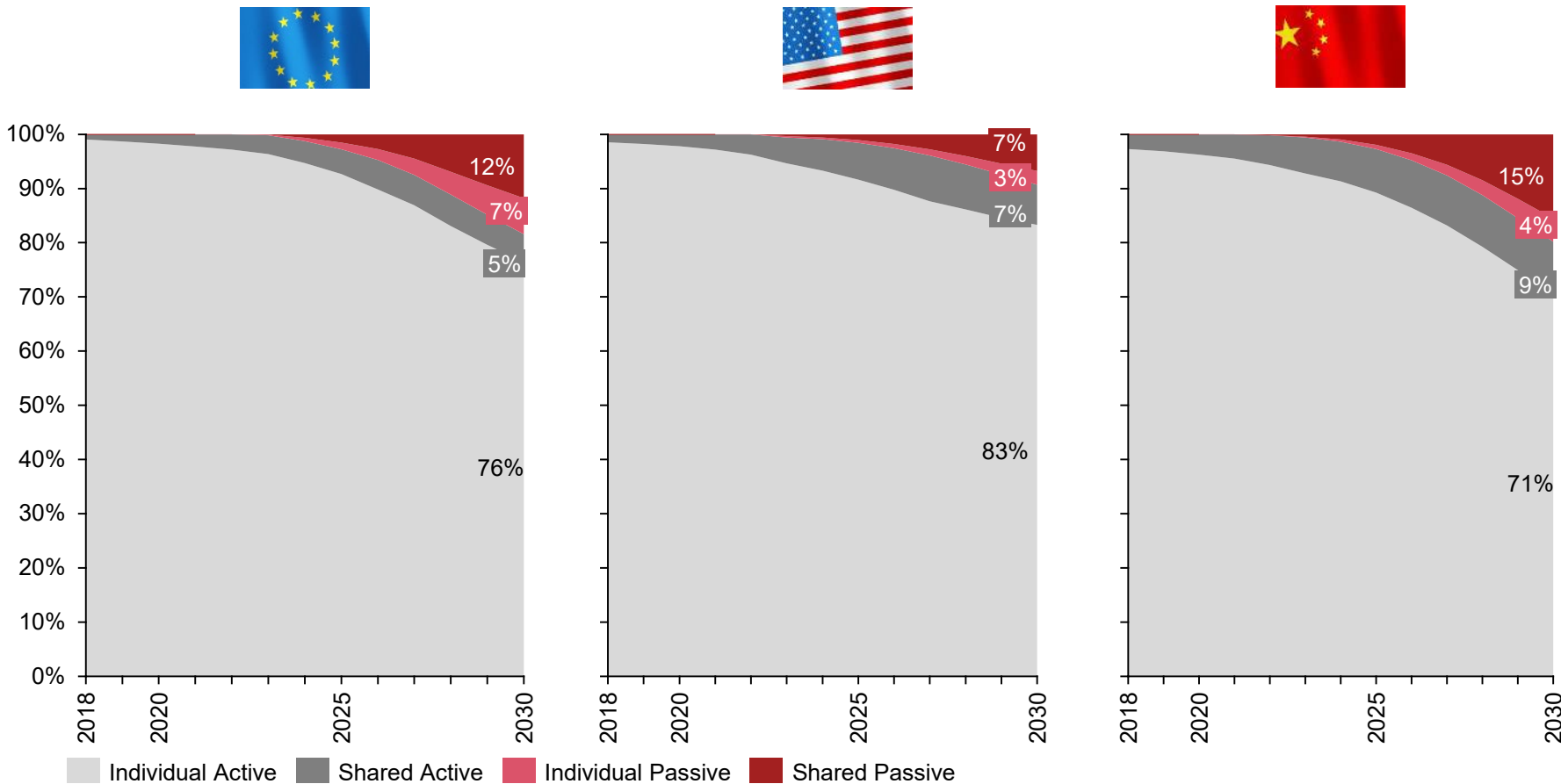
Comments

- 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 types¹



Definitions

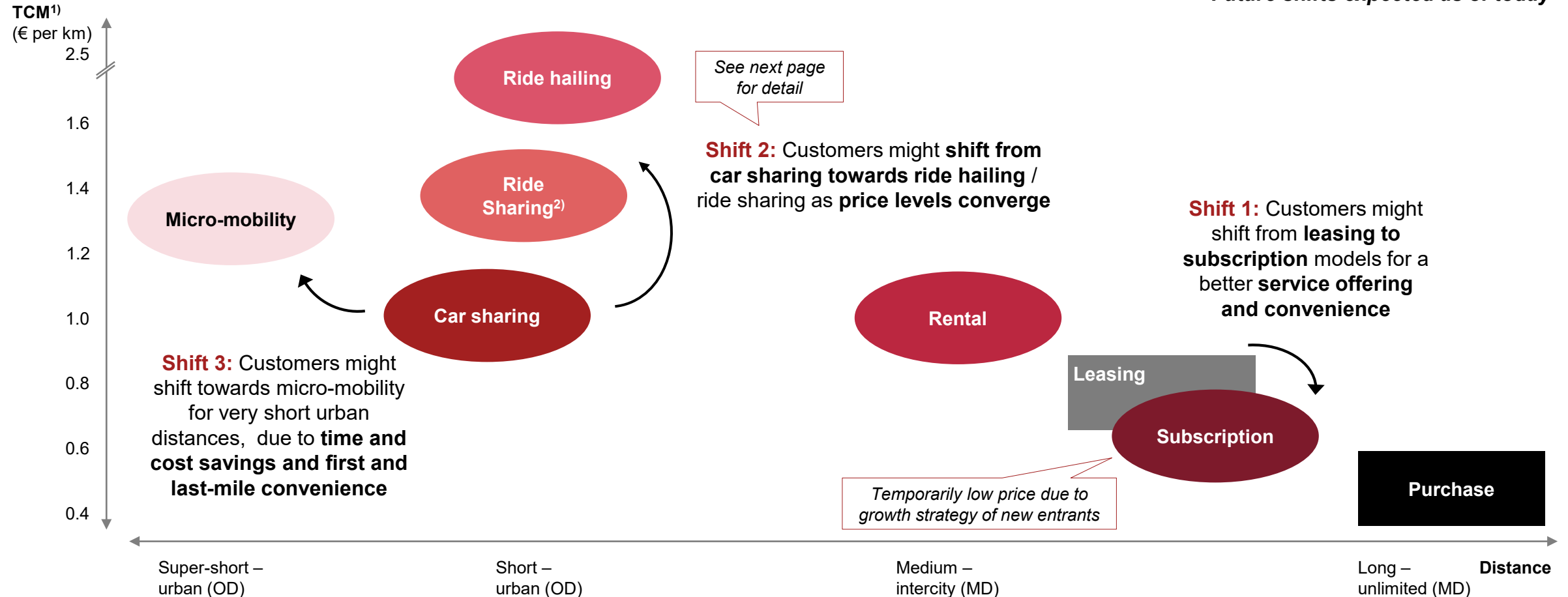
- Individual Active Mobility:**
 Use of individually owned, driver-driven car (private car, family car, personal company car, etc.)
- Shared Active Mobility:**
 Using all forms of shared mobility with an active driver (rental, car sharing, ride hailing, ride pooling, taxi, etc.)
- Individual Passive 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.)

1) Expressed as a % of total annual passenger kilometers driven in the region | Note: Figures may not sum up to 100% due to rounding
 Source: PwC AutoFacts®, Strategy& analysis

However, alternative mobility models continue to cannibalize each other

Customers will seek the best service and greatest convenience

Future shifts expected as of today



■ Traditional ownership
● Alternative ownership
Strategy & | PwC

1) TCM = total costs of mobility for 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 | Note: OD: one-directional, MD: bi-/multi-directional

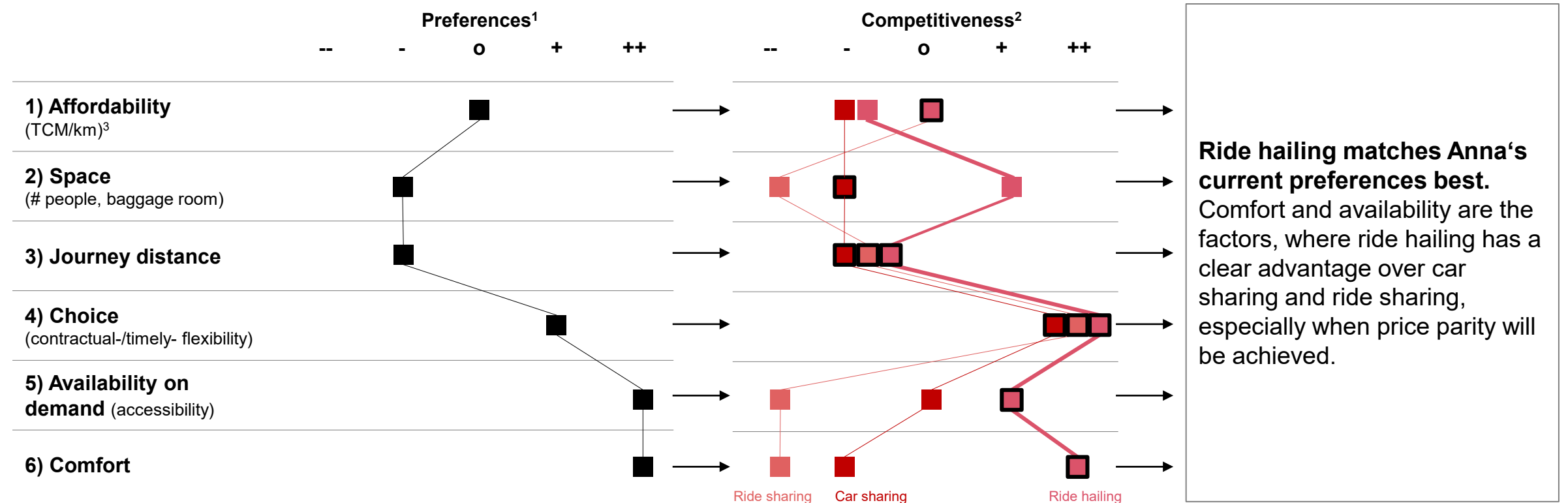
In cities, customers will assess their ride choice on a journey-by-journey basis

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

1 CUSTOMER DECISION CRITERIA

2 MOBILITY OFFERING EVALUATION

3 CUSTOMER CHOICE



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

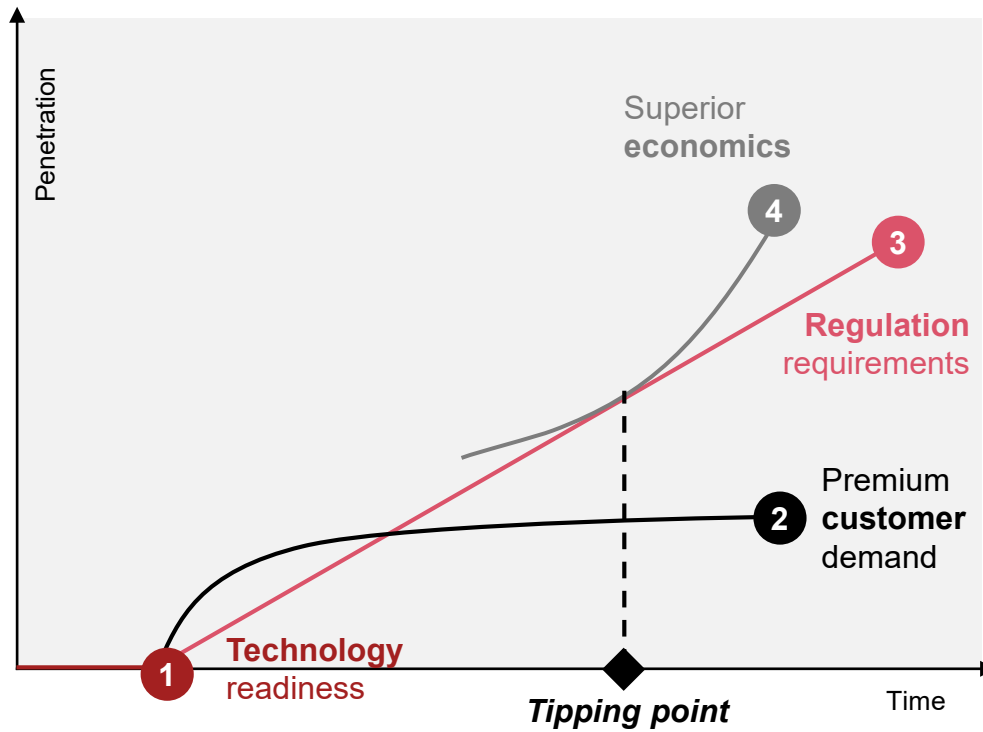


2 Market dynamics & technology

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	<ul style="list-style-type: none">Technical readiness occurs when a technology is applicable to sufficient share of targeted use cases, marking the starting point of adoption
2 Customer demand	<ul style="list-style-type: none">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	<ul style="list-style-type: none">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	<ul style="list-style-type: none">Once a technology results in superior economics due to lower costs or additional revenues, the pace of adoption is exponentialHowever, 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

	1 Technology	2 Consumer	3 Regulation	4 Economics	Expected tipping points		
					earlier	2030	later
 <p>Connected</p>	<ul style="list-style-type: none"> Viable car system capability and EE¹ architecture 3G coverage must be >95% 	<ul style="list-style-type: none"> Share of people paying extra for <ul style="list-style-type: none"> Premium services Experience (e.g. AR windshield) 	<ul style="list-style-type: none"> Timing of requirements such as: <ul style="list-style-type: none"> Mandatory eCall Geo-data privacy 	<ul style="list-style-type: none"> Superior economics <ul style="list-style-type: none"> Cheaper OTA vs. OBDII² updates Low usage-based fees vs. fix rates 			
 <p>Electric</p>	<ul style="list-style-type: none"> Electric powertrain performance Charging network availability [>80% coverage in urban areas] 	<ul style="list-style-type: none"> Consumer preference for <ul style="list-style-type: none"> Acceleration Sustainability Operating cost 	<ul style="list-style-type: none"> Emission target levels [From 95g CO₂/km down to 60g CO₂/km] Cities with ICE bans/restrictions 	<ul style="list-style-type: none"> Superior total cost of ownership (TCO) of BEV vs. ICE [at mid-range for volume segment] 			
 <p>Automated</p>	<ul style="list-style-type: none"> Coverage of a vehicle's operating driving domain [>75% at 50km/h] 4G/5G network coverage 	<ul style="list-style-type: none"> Share of users paying extra for: <ul style="list-style-type: none"> "Having it first" Letting tech do the driving 	<ul style="list-style-type: none"> Enforced L2 safety features e.g. front camera [AV people movers/ robo-taxis approved in restricted areas] 	<ul style="list-style-type: none"> "5th screen" revenues Superior TCO & lower price [in taxi/hailing mode] 			
 <p>Shared</p>	<ul style="list-style-type: none"> Smartphone penetration [>70% of population] International/ intermodal roaming 	<ul style="list-style-type: none"> Share of people willing to give up own car in urban areas [>40%] 	<ul style="list-style-type: none"> Car pool occupancy requirements [in >50 large cities] Insurance/liability requirements 	<ul style="list-style-type: none"> Superior cost vs. own vehicle [>20% cheaper] 			

[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

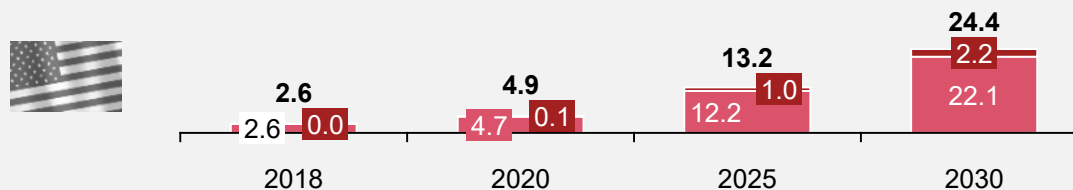
Connected services will be worth \$81bn in US/EU/CN by 2030

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

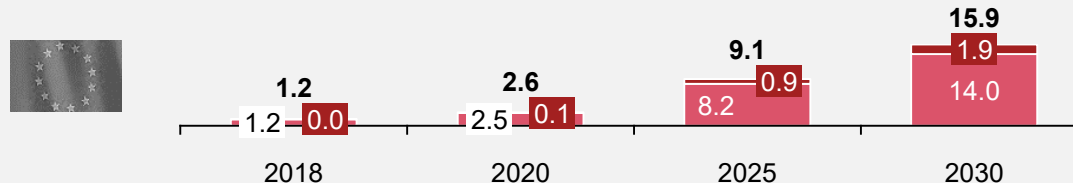
Digital vehicle service archetypes

- 1 Vehicle features as a service
- 2 Vehicle-centric connected services
- 3 5th screen connected services
- 4 Beyond-vehicle services
- 5 Data/insights services

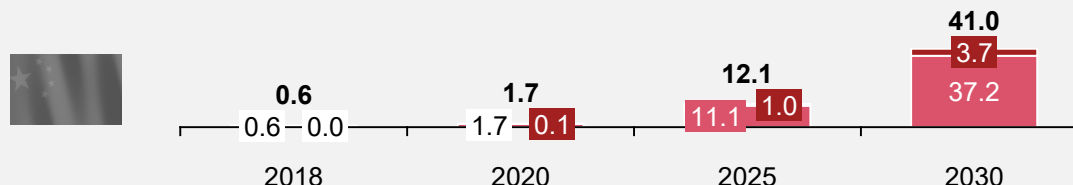
Estimated market size development, US (in USD billions)



Estimated market size development, EU (in USD billions)



Estimated market size development, China (in USD billions)



■ B2C monetization of connected Services (on-top) ■ B2B monetization of 5th screen content

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** often 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**.

Note: based on Strategy& 2030 scenario GMV = Gross Merchant Value
Source: expert interviews, PwC AutoFacts®, Strategy& analysis

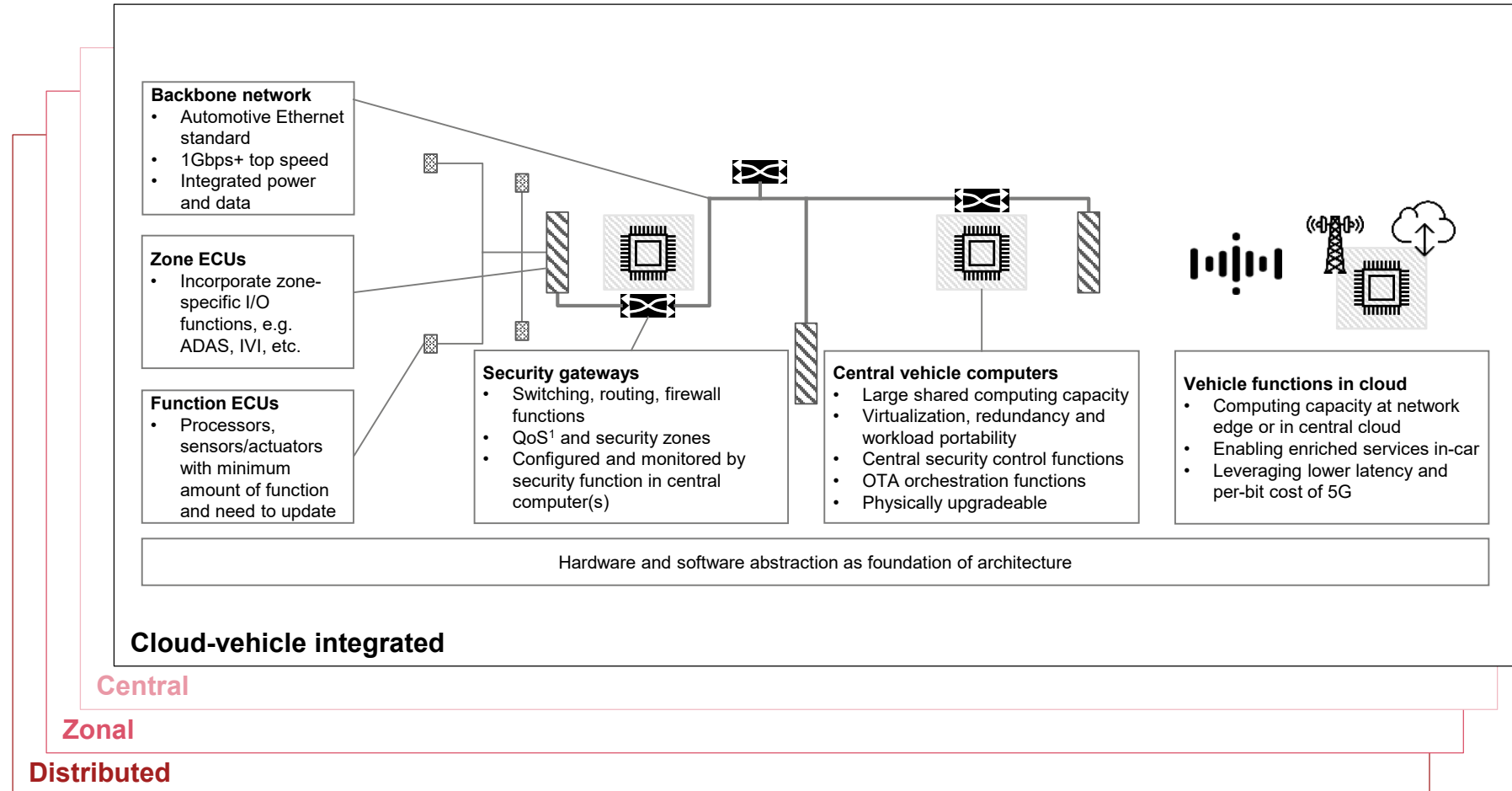
Despite innovation in connected services, the auto industry's share of value is still low

Connected services: an evaluation of recent offerings

Recent service offerings		Key challenges	Value capture potential		
Digital vehicle service archetypes	1 Vehicle features as a Service	 Pay-by-use vehicle features	<ul style="list-style-type: none"> • 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) 	<ul style="list-style-type: none"> • Identification of suitable components to yield healthy cost/benefit relation • Effective definition of price model and price points to avoid cannibalizing vehicle option revenues when the car is first sold 	<ul style="list-style-type: none"> • 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
	2 Vehicle-centric connected services	 In-vehicle voice assistant	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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) 	<ul style="list-style-type: none"> • Limited revenue potential, as similar services are already standard in other domains (on smartphone, at home) • Strong potential for customer experience differentiation and links to other in-vehicle services
	3 5th screen connected services		<ul style="list-style-type: none"> • Commerce platform embedded into vehicle infotainment system • Currently low technological adoption in automotive industry, but accelerating traction especially in the US 		
	4 Beyond-vehicle services	 In-vehicle market-place	<ul style="list-style-type: none"> • Commerce platform embedded into vehicle infotainment system • Currently low technological adoption in automotive industry, but accelerating traction especially in the US 	<ul style="list-style-type: none"> • Partnerships with merchants and advertisers • Standardized technology platform • Scalability dependent on "additional usable time" enabled by automated driving 	<ul style="list-style-type: none"> • On-top revenue possible, but limited to commissions/ad prices • Negotiation power of global partners narrows profit potential
	5 Data/insights services		<ul style="list-style-type: none"> • Commerce platform embedded into vehicle infotainment system • Currently low technological adoption in automotive industry, but accelerating traction especially in the US 		

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

State of tech: connected vehicle architecture



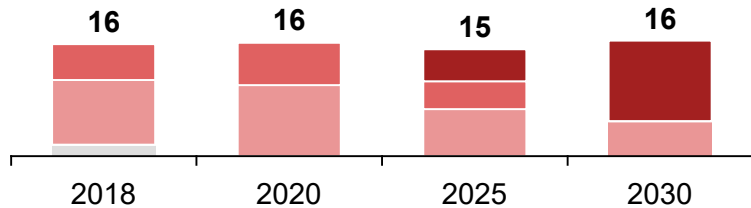
Implications

- **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

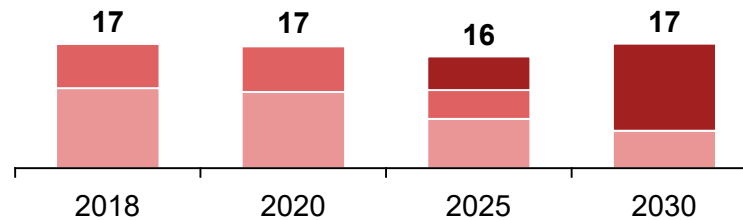
As connected vehicles reach 100% of new cars, technology shifts from 3G / 4G towards 5G readiness

Market outlook: connected vehicles

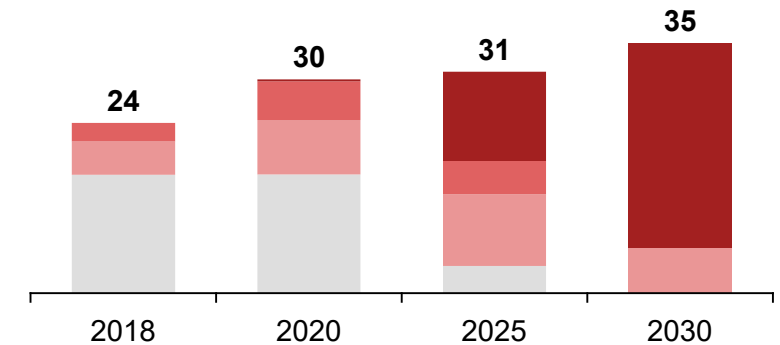
Connected vehicles (in total new vehicle sales) – (EU, US, China; in millions)



- 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 an temporary solution



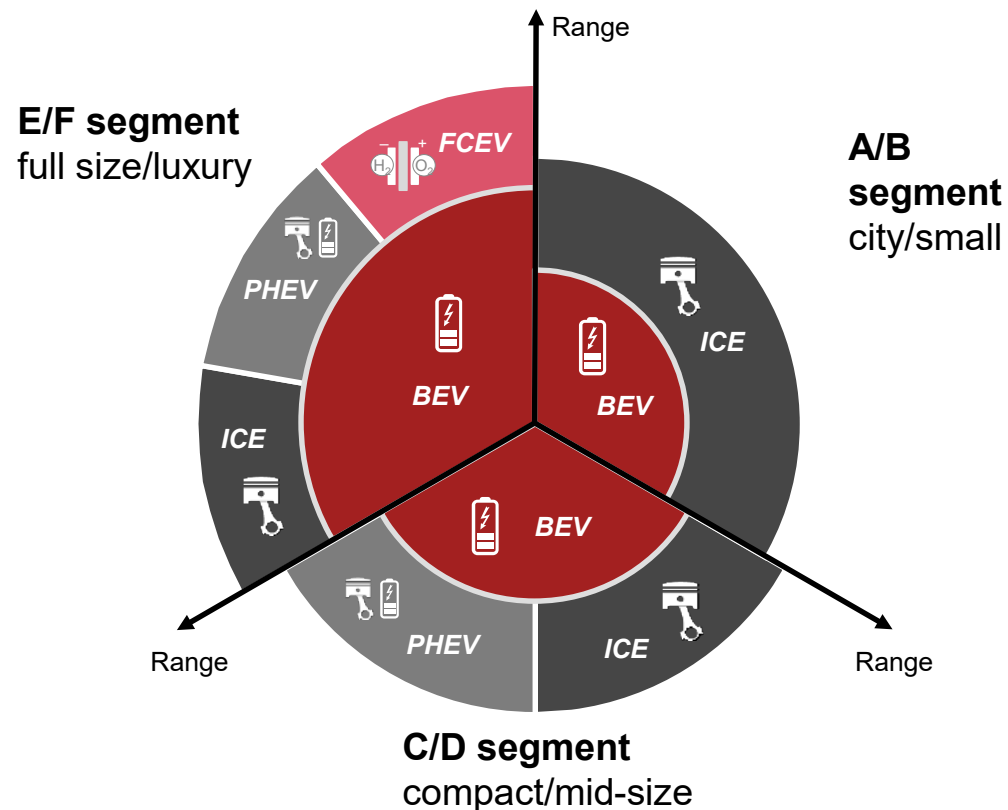
- Connected-Car share 2019 <25%, since only installed in Premium-/JV-vehicles
- Mandatory requirements like V2X or E-Call not yet manifested
- Faster rollout of 5G than in US/EU due to structured rollout in Tier-1 and Tier-2 cities

0G 2G/3G 4G 5G

Electric cars remain limited by range, outside the high-end market

Overview of powertrain technologies

Dominant powertrain technologies and respective reach per segment



Implications

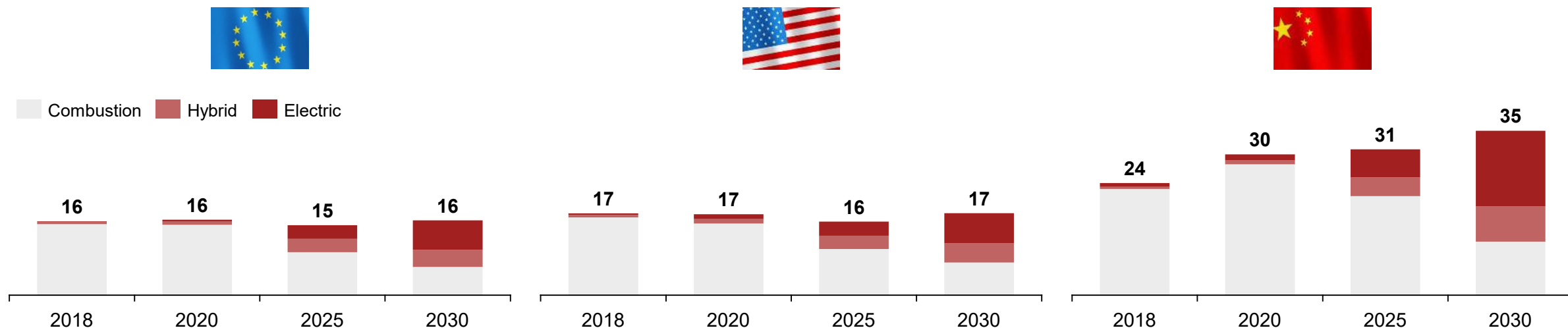
- ICE¹: Increasing costs, unbeaten flexibility/range**
 - Mild electrification based on 12V or 48V technology for efficiency gains
 - Further optimization of friction losses
 - Increasingly complex exhaust gas after treatment
- BEV²: Highly attractive for limited ranges**
 - Lower battery cell cost is 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)



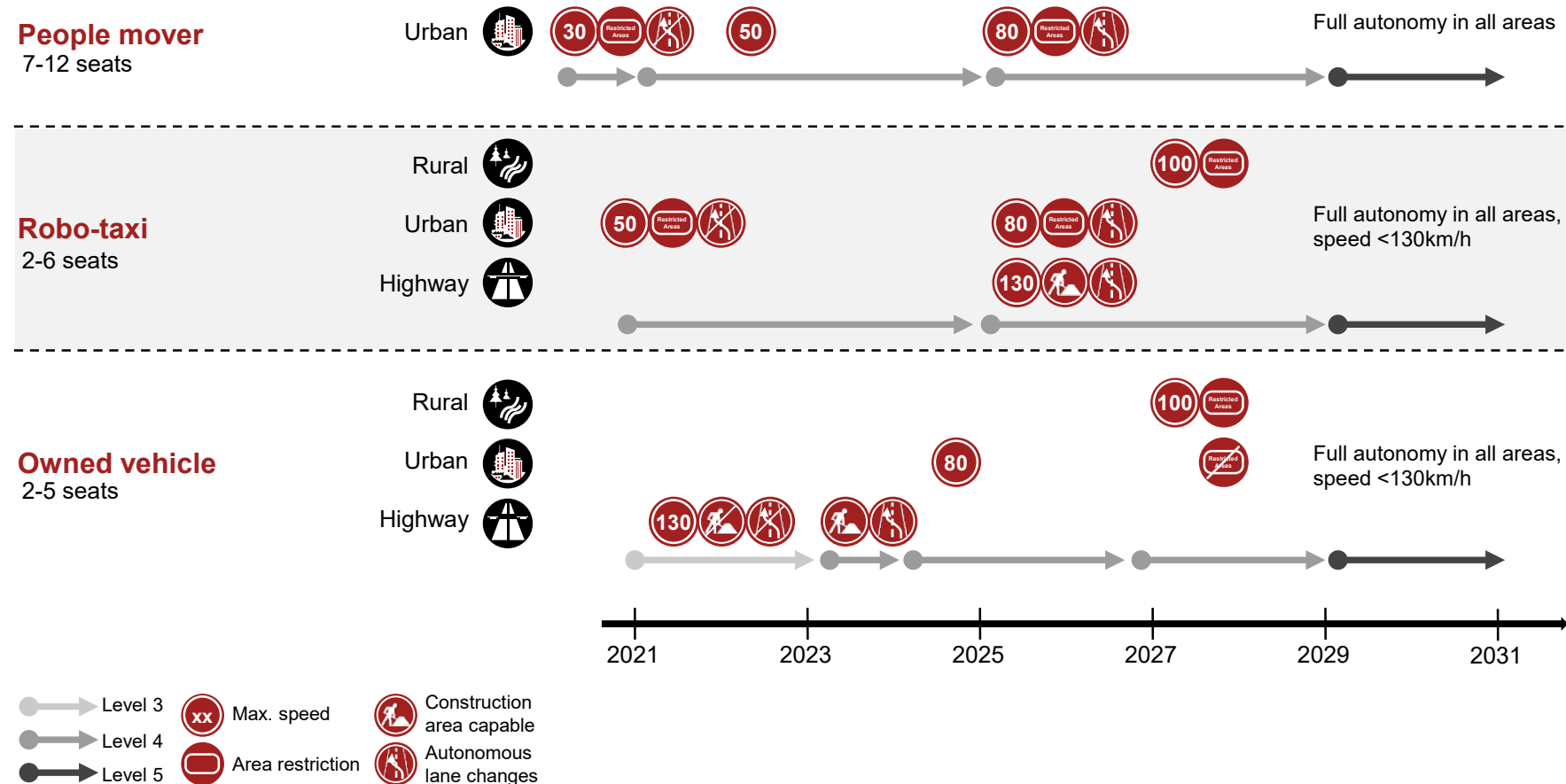
- Around 40 percent of new car registrations electric by 2030
- Sufficient domestic/commercial/public charging infrastructure from 2025 onwards
- Strong legislative push from 2020 onwards
- Cost-of-operating tipping points will vary by segment and pattern of use

- 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



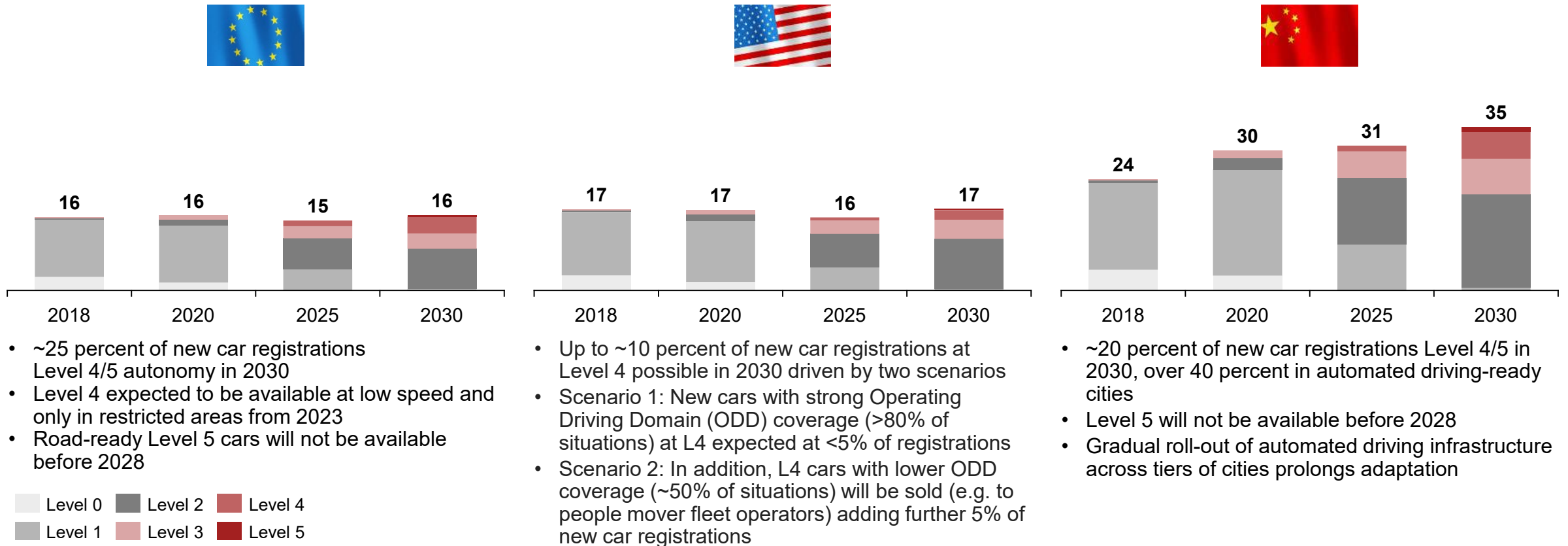
Implications

- Efforts to develop and implement ADAS¹ 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

Automated driving expansion delayed due to higher tech cost and limits on where automated vehicles can operate

Market outlook

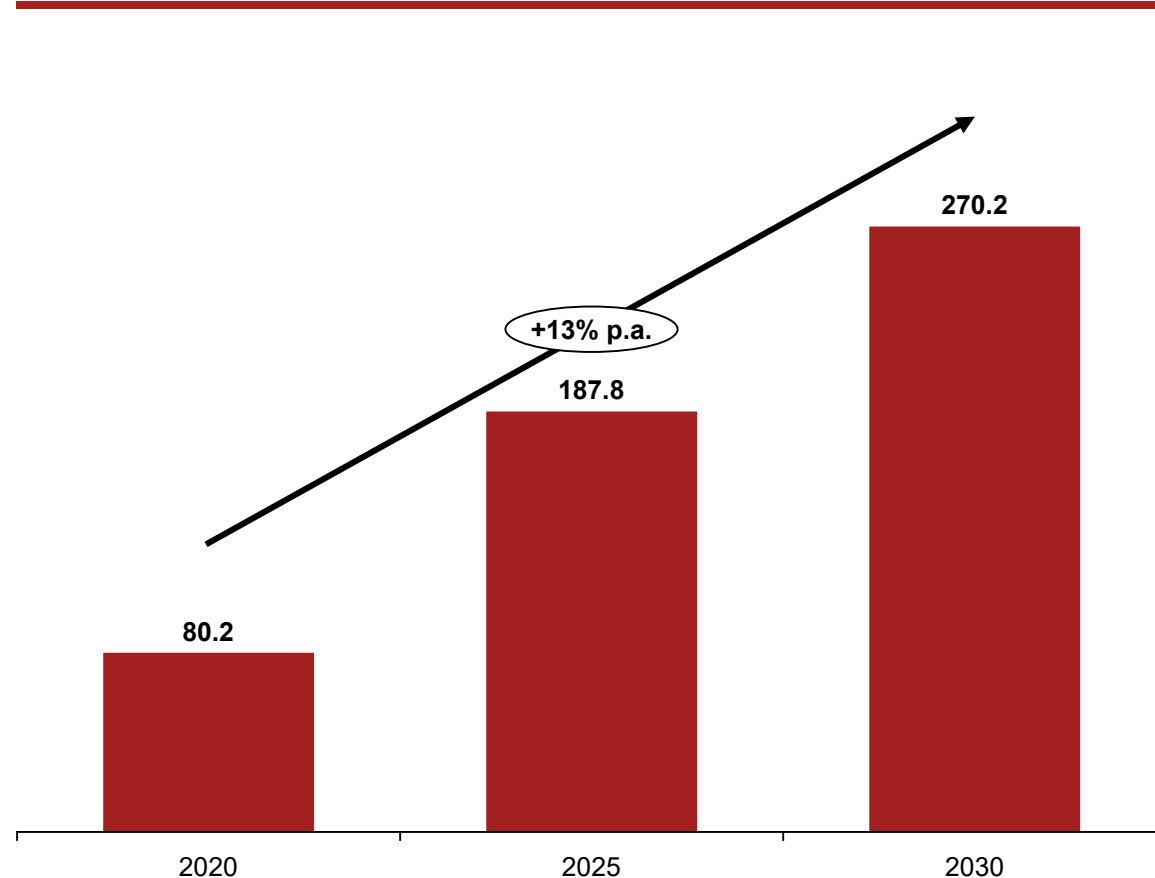
Autonomous vehicles (total new vehicle sales – EU, US, China; in millions)



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)



SAE Level	ADAS Features /Use cases	2020	2025	2030
L1	Adaptive cruise control	M ²	M	M
	Assistive parking (driver-assisted)	M	M	M
	Lane keep assist (system steering)	M	M	M
	Blind spot monitoring rear/side (system steering)	M	M	M
L2	Assistive parking (remote/key parking)	M	M	M
	Lane changing assist	P	M	M
L3	Emergency assistant	P	M	M
	Traffic jam assistant without lane change	P	M	M
	Highway autopilot (single-lane)	P	M	M
	Highway autopilot (incl. lane change)	P	M	M
	Intersection movement assist	P	M	M
L4	Fully autonomous valet parking	P	M	M
	Full highway pilot with lane change	C	M	M
	Urban autopilot	C	P	M
L5	Full autonomy	C	C	P
	People mover	C	C	C

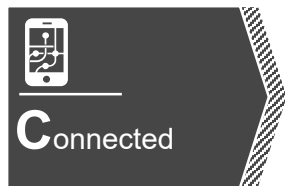
L4/L5 ADAS features will not only be applied to traditional cars, but also form the basis for new types of vehicle for special ODDs (e.g. people mover without steering wheels)

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)

Most relevant regulations (extract)



- **Harmonization of connected car standards** (e.g. 5G as basic connected car technology, 07/2019)
- Promotion of compulsory & optional **connected safety features in vehicles** (e.g. Directive 2010/40/EU)



- **Strong focus** on determining the mandatory **ownership rules for data generated by connected autonomous vehicles** (e.g. SELF Drive & AV START Act 2017)



- Strong push for **enhanced standards** (mandatory and voluntary) on **connected and ADAS technologies** in China (e.g. by national guidelines on "Intelligent & Connected Vehicles", 2018)



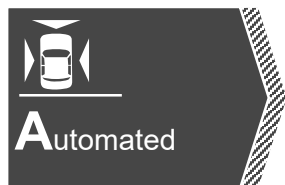
- **Incentives to encourage EV purchase** (e.g. tax reduction in Belgium, Germany)
- **European auto OEMs** subject to strict CO₂ regulations (e.g. penalties for exceeding fleet emission targets)



- **Recent harmful federal regulatory dynamics** (i.e. White House's objective to terminate EV subsidies)
- **State-specific electrification developments** (e.g. compulsory Zero Emission Vehicle program in California)



- **Comprehensive and strict electric vehicle policy for automotive industry** in China (e.g. NEV 2019 mandate)
- **Auto OEMs** in China subject to strict control on new production of ICE vehicles (e.g. by NDRC standards)



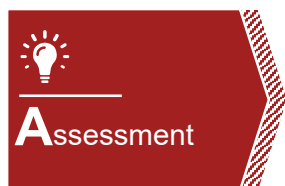
- **Early global agreements** with restrictive regulations for **deploying AD technology** (e.g. VCRT, 1969); recent favorable regulations permitting **testing of AD**
- **Compulsory regulations** enforcing installation of **L0 & L1 ADAS features** by 2022 (by EU GSR); EU NCAP recommending **L2 ADAS safety functions**



- **State-specific regulations permitting test & operation of AVs** on public roads (e.g. CVC 2012)
- **NHTSA's NCAP** with mandatory (e.g. LDW) and recommendation-based **installation of basic L2 ADAS safety features** (e.g. LCA)



- **Favorable AD testing regulations** in China and Japan (e.g. extended public test areas for autonomous vehicles)



Favorable regulatory dynamics in EU states, promoting the adoption of new technologies, with a focus on compulsory safety and environment-specific aspects

Technology adoption (with a focus on autonomous) mainly **enforced by state-specific regulations**, with federal actions protecting the traditional auto industry

Strict incentives and penalties significantly pushing technology adoption across connected, autonomous and electric vehicles in China and also in Japan

Positive regulatory impact on dimension Neutral regulatory impact on dimension Negative regulatory impact on dimension

Note: ADAS = advanced driver assistance systems, AEB = Autonomous Emergency Braking, CVC = California Vehicle Code, GSR = General Safety Requirements, LCA = Lane Centering Assist, LDW = Lane Departure Warning, NCAP = New Car Assessment Program, NDRC = National Development and Reform Commission, NEV = New Energy Vehicles, NHTSA = National Highway Traffic Safety Administration, VCRT = Vienna Convention of Road Traffic | Source: Strategy& analysis



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



ELECTRIC



AUTOMATED



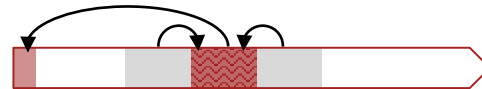
SHARED

OEM



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



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



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



New role:

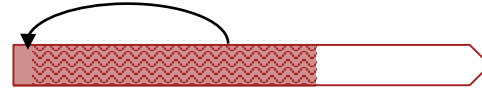
- 1) Shift towards selling to mobility providers to supply vehicles for their car-sharing service (B2C to B2B)
- 2) Maintain customer-facing role as a shared mobility/fleet provider

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)



New role:

- 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

Automotive supply chain including: R&D, production, distribution, marketing & sales, aftersales/customer service (adjustable per case)

 Core business today (still relevant tomorrow)

 Core business today (different strategic approach tomorrow)



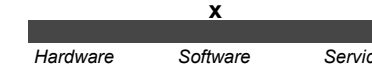

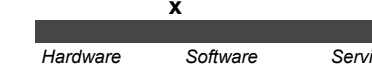
 Potential new business tomorrow

 Core business today (irrelevant tomorrow)

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

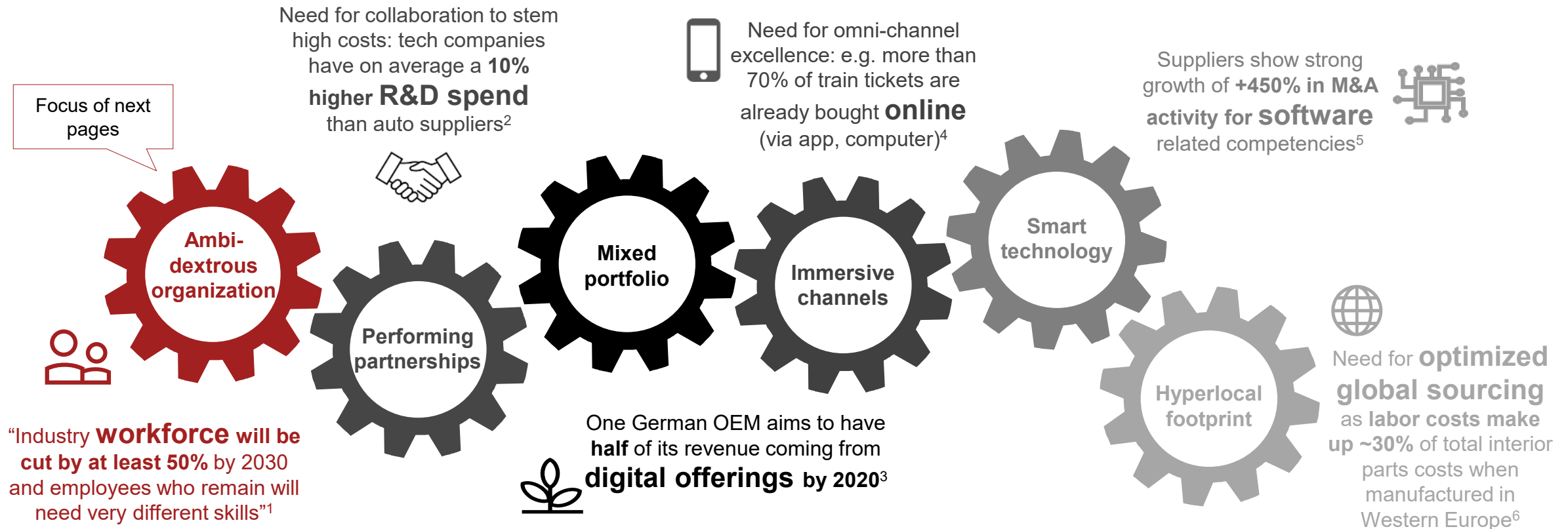
<p>1 SMART INFRASTRUCTURE ENabler</p> <ul style="list-style-type: none"> Digitally-enabled traffic solutions for integrated mobility systems to governments/ institutions (e.g. city councils)  <ul style="list-style-type: none"> Success factors¹: <ul style="list-style-type: none"> Technology excellence Integration capabilities System adaptability Example: Intelligent traffic-management system for a Chinese city that integrates transport information for all travel options 	<p>2 AUTOMATED SHUTTLE MANUFACTURER</p> <ul style="list-style-type: none"> Fully assembled shuttle for public and corporate institutions (e.g. city councils/ shuttle service provider)  <ul style="list-style-type: none"> Success factors¹: <ul style="list-style-type: none"> Production excellence Cost efficiency / lean SC² Fast time-to-market Example of international automotive supplier: autonomous, electric, shared people mover in co-operation with mobility start-up and system provider 	<p>3 PLATFORM PROVIDER</p> <ul style="list-style-type: none"> Platform-as-a-service for business partners (e.g. OEMs, (public) mobility providers, fleet operators)  <ul style="list-style-type: none"> Success factors¹: <ul style="list-style-type: none"> 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 	<p>4 MOBILITY INTELLIGENCE PROVIDER</p> <ul style="list-style-type: none"> Mobility software services and centralized data analytics for fleet operators and mobility service providers  <ul style="list-style-type: none"> Success factors¹: <ul style="list-style-type: none"> Real-time data analytics Service integration Customer centricity Example of German OEM's mobility service company: fleet management software for intelligent mobility solutions 	<p>5 VEHICLE FEATURE ON DEMAND PROVIDER</p> <ul style="list-style-type: none"> Product-as-a-service for end consumers through e.g. mobility providers, allowing for direct monetization  <ul style="list-style-type: none"> Success factors¹: <ul style="list-style-type: none"> 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)
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Low to high focus areas

1) Outlined success factors are most relevant ones but not limited to these 2) Supply chain 3) Platform-as-a-service | Note: x = key success factor | Source: Strategy& analysis, Siemens.com, Alphabet.com, Boschservicesolutions.com, Microsoft.com, Continental.com, Zf.com, Mahle.com

New roles require suppliers to refocus on selected capabilities

Identifying digital auto priorities



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:

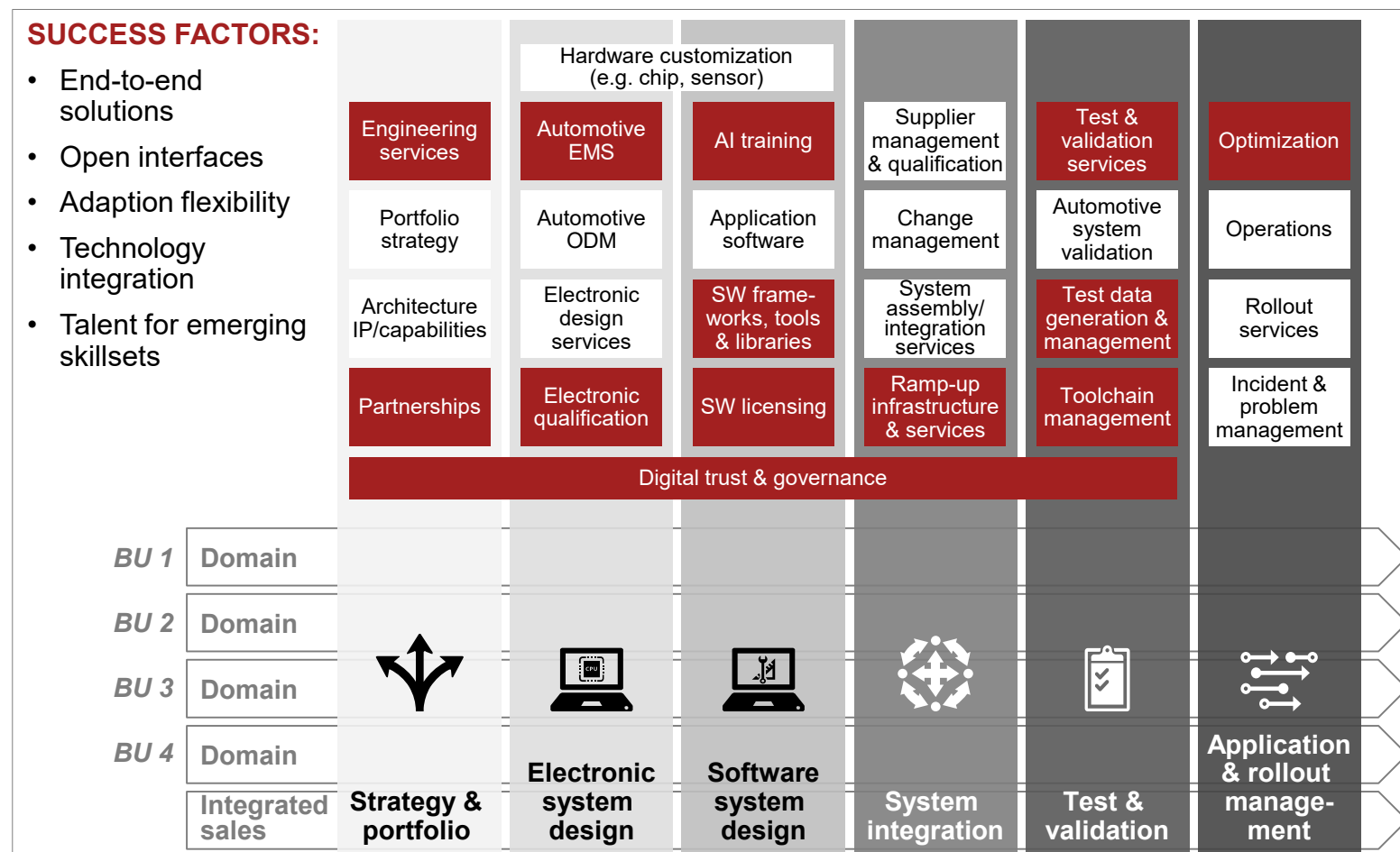
- Current R&D methods, tools & processes **do not match** the increasing complexity of e.g. supporting digital trust and AI
- **New business models may include hardware, software and services** (e.g. being an automated vehicle “platform provider”) and require realignment of processes

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



The auto industry's workforce will also be transformed

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

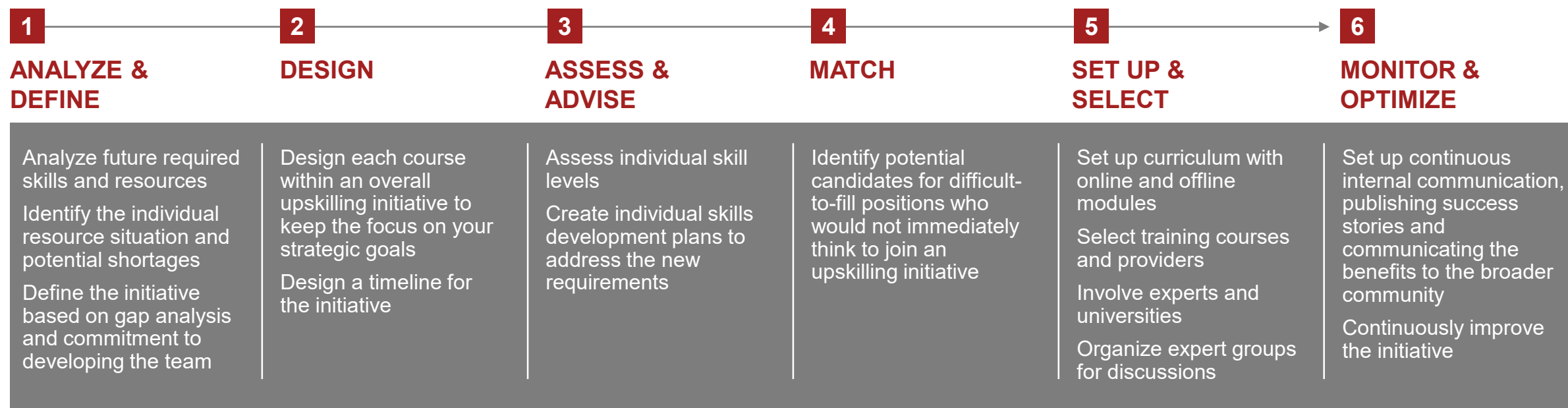
	R&D	Production & logistics	Sales & marketing, and aftersales	Management support functions ¹⁾	Technological support functions ¹⁾
Proportion of workforce affected:	 30%	 30%	 20%	 5%	 50%
New skills required:	<ul style="list-style-type: none"> Innovation management Open sourcing Agile methodologies (Scrum) Business analytics Partnership management 	<ul style="list-style-type: none"> Sustainability Productivity AI Raw materials sourcing Real-time data management Footprint optimization 	<ul style="list-style-type: none"> Lifetime CRM Omni-channel UX/CX User interface/graphic design Stakeholder management Predictive maintenance 	<ul style="list-style-type: none"> Ethics Welfare Work-life balance Blockchain Business development Program management 	<ul style="list-style-type: none"> Cyber (security) Data analytic/-science/-mining Software development Machine learning Cloud computing Software-as-a-service
In-demand roles and typical salaries:	<ul style="list-style-type: none"> Application architect (\$132,000⁴⁾ Software engineer (\$121,000⁴⁾ Product manager (\$119,000⁴⁾ Business intelligence developer (\$104,000⁴⁾ Scrum master (\$103,000³⁾ Product owner (\$101,000³⁾ ERP business analyst (\$99,000⁴⁾ Systems analyst (\$91,000⁴⁾ Research scientist (\$86,776⁵⁾ 	<ul style="list-style-type: none"> Machine learning engineer (\$142,000) Supply chain & logistics manager (\$117,600⁷⁾ AI specialist (\$105,918⁵⁾ Process automation specialist (\$101,650⁷⁾ Industrial mechanical engineer (\$91,650⁷⁾ 	<ul style="list-style-type: none"> Product designer (\$121,500³⁾ Product marketing manager (\$90,000⁶⁾ Customer success manager (\$88,500³⁾ Service and solution designer/ (\$71,000⁶⁾ 	<ul style="list-style-type: none"> Enterprise account executive (third most in-demand job, \$182,000³⁾ Engagement manager (\$130,000³⁾ 	<ul style="list-style-type: none"> Site reliability engineer (second most in-demand job, \$200,000³⁾ Solution architect (\$139,000³⁾ Data scientist (first most in-demand job, \$130,000³⁾ Information technology lead (121,000³⁾ Cloud architect (\$92,500⁴⁾ Quality assurance engineer (\$82,000⁴⁾
Top courses of study and universities:	<ul style="list-style-type: none"> Software engineering Civil engineering Technical engineering Artificial intelligence (AI) 	<ul style="list-style-type: none"> Mechanical engineering System engineering Electrical engineering Industrial engineering 	<ul style="list-style-type: none"> Digital media design Virtual reality Communication 	<ul style="list-style-type: none"> Psychology Business administration International management 	<ul style="list-style-type: none"> Information technology Software/network engineering Knowledge engineering Computer science engineering



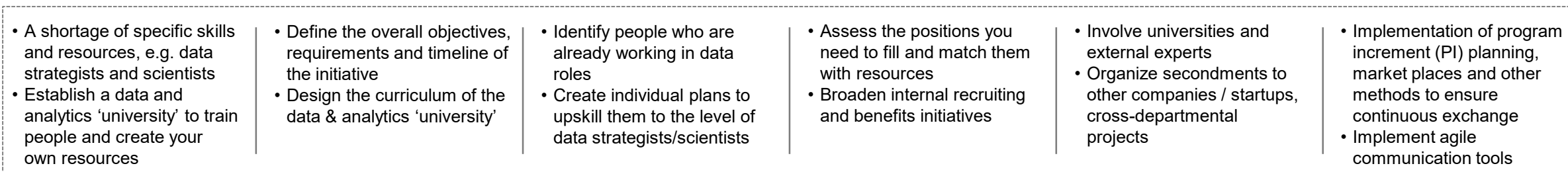
1) Visually modified value chain to incorporate relevant overarching support functions (HR, Finance, Technology) 2) Potential impact on respective function's resources through digitization and CASE
 3) Job roles in bold = within Top 10 most demanded jobs at the moment on the market, salary referring 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

Systematic upskilling needed to bridge digital skills shortage

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



PRACTICAL EXAMPLES:



Get in touch



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Mobility Transformation



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