Fahrzeugkonzepte und Technologien der nächsten Generation
Vehicle concepts and technologies of the next generation

5. Automotive Photonics, 14. Februar 2019, Ditzingen

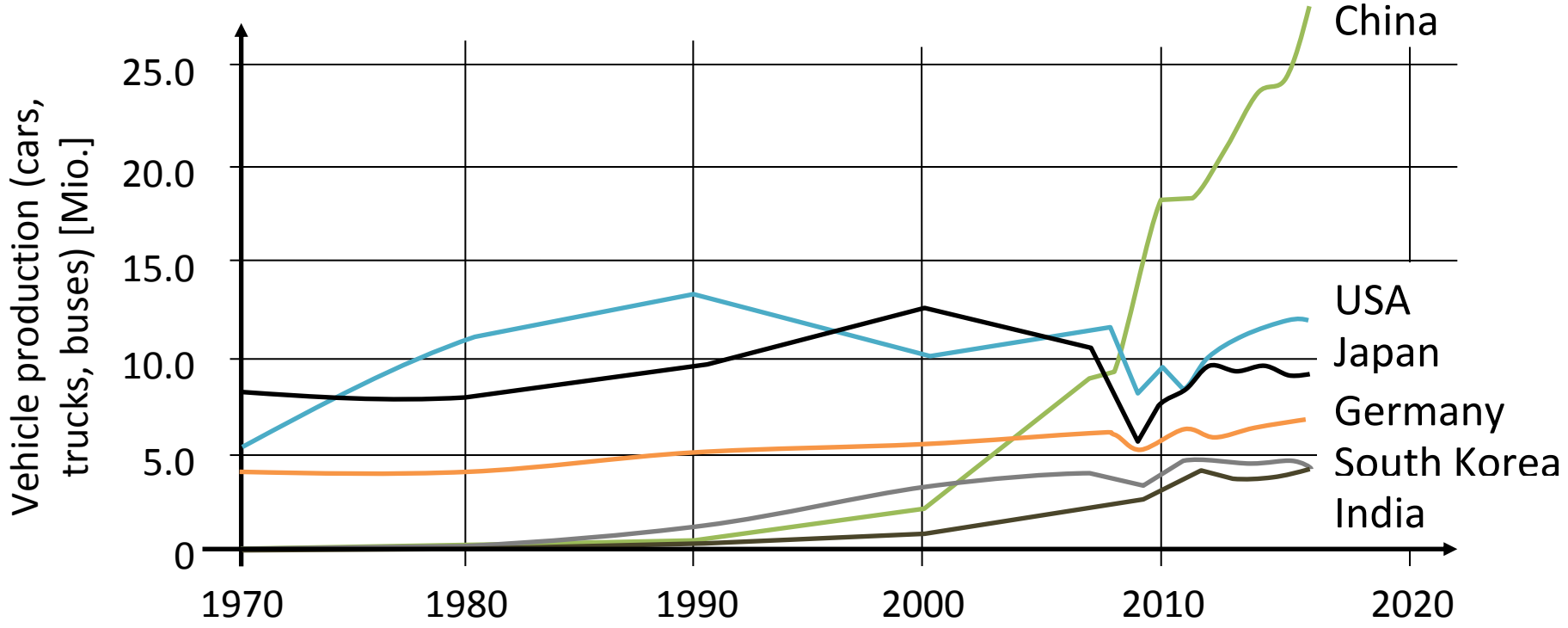
Dr.-Ing. Gerhard Kopp

NGC
Next Generation Car

DLR

Vehicle concepts - initial situation

- Development of **vehicle production** in selected countries



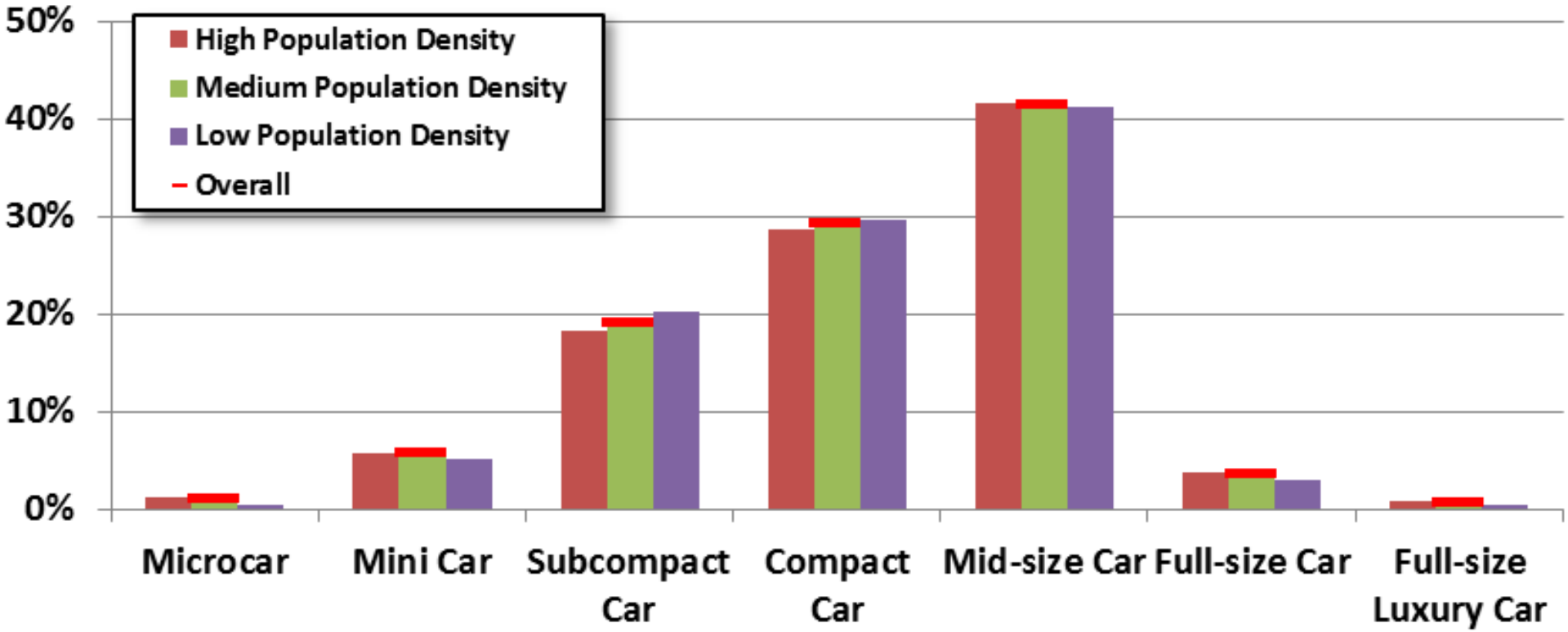
Other countries 2016:
2.2 Mio. Brazil
3.6 Mio. Mexico
2.9 Mio. Spain
2.0 Mio. France
2.4 Mio. Canada
1.3 Mio. Russia

=> Steadily growing vehicle production in China, South Korea, India, …

Source: HDI Global SE – Fachinformation 2017; https://www.hdi.global/downloadcenter/DE_de/Haftpflicht/Kfz-Zulieferer/171012_H-FI_1_12_Fachinfo_Haft_Kfz-Zulieferer.pdf; 29.01.2019

Vehicle concepts - initial situation

- Analyze of the proportion of **vehicle classes** according to **population density***



=> No specific vehicles for different purposes and population density

*Proportion of vehicle classes in new registrations for M1 vehicles in Germany 2016 according to population density; (Source: Own description according to approval data; M. Klötzke)

Global Trends and Challenges - Mobility

Traffic jam

- Population growth, urbanization and increase in freight traffic
- Every motorist spends 38 hours a year in traffic jams

Ecological damage

- 18 percent of CO_2 emissions from traffic
- 1,3 kg CO^2-emissions per parking space search

Accidents

- 3,177 fatalities and 388,200 injured in traffic (2017)
- 88 % of accidents due to mistakes of the driver

Mobility in older age

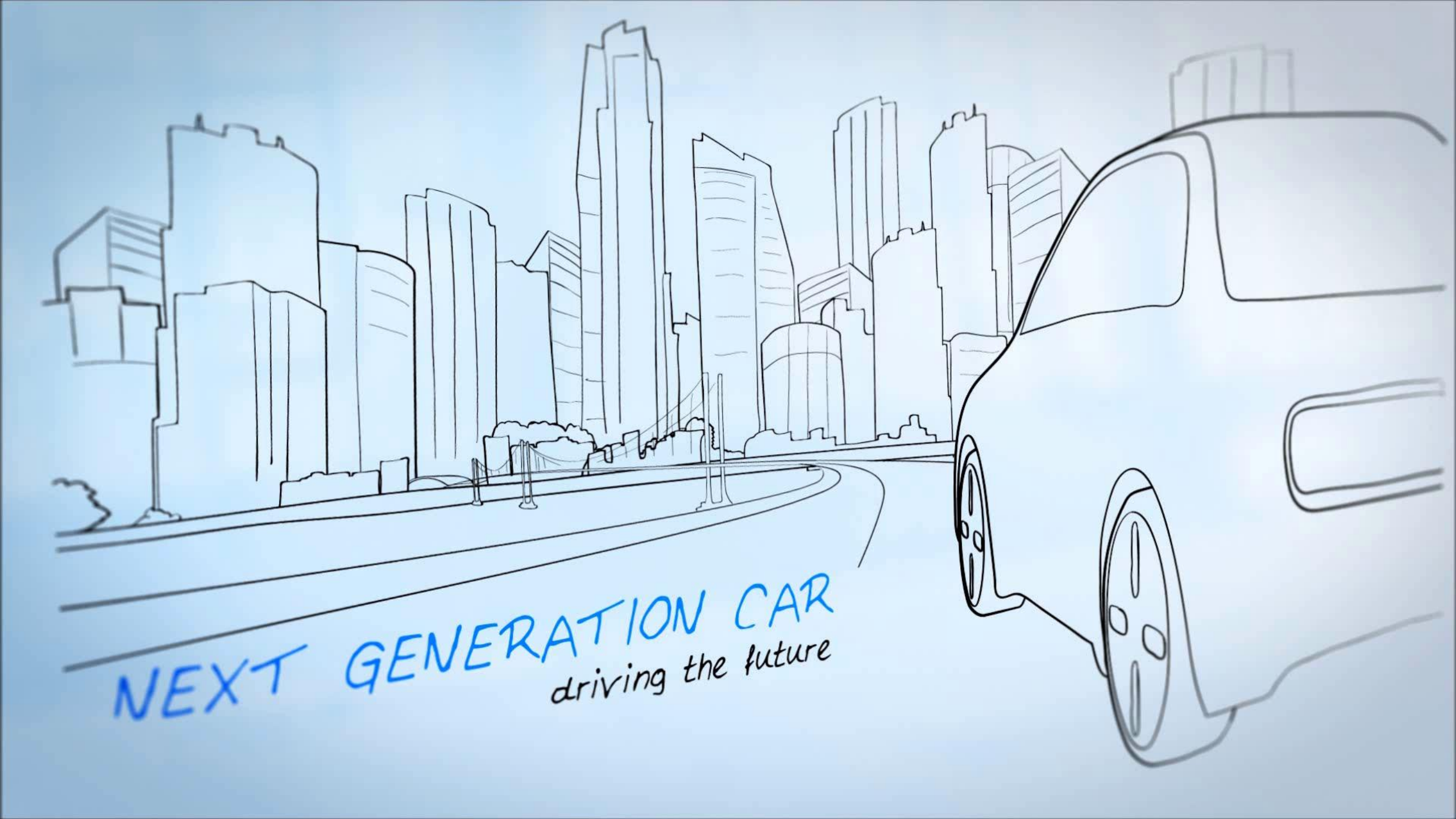
- Demographics: by 2030, the proportion of over-65s in our society will increase from 21 % today to 27.5 %
- More individual, intermodal and efficient through information & communication

Digitalization

- Business models: from product to user-oriented

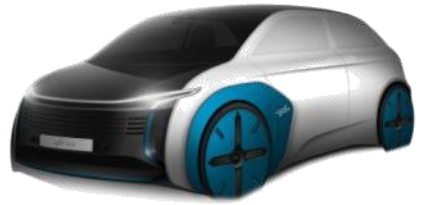
Source: Prof. Karsten Lemmer, DLR, (2016), "Questions of Future Mobility"

All other information for Germany. Sources: Traffic in Figures 2015/2016; Center for Economics and Business Research 2014; AP COA PARKING Parking Study 2013; Results of the 13th coordinated population projection, Federal Statistical Office; Presentation: especially acatech; Pictures: shutterstock.com: Khongkit Wiriyachan, Vinogradov Illya, OliverSved, Andresr


NEXT GENERATION CAR
driving the future

Systematic approach to solving the challenges

Decarbonization (energy and fuels)



Efficient vehicles (aerodynamic, friction, lightweight construction, …)

System approach for the future mobility

Improved logistics and passenger transport

Intelligent traffic management

Infrastructure (energy / information / ...)

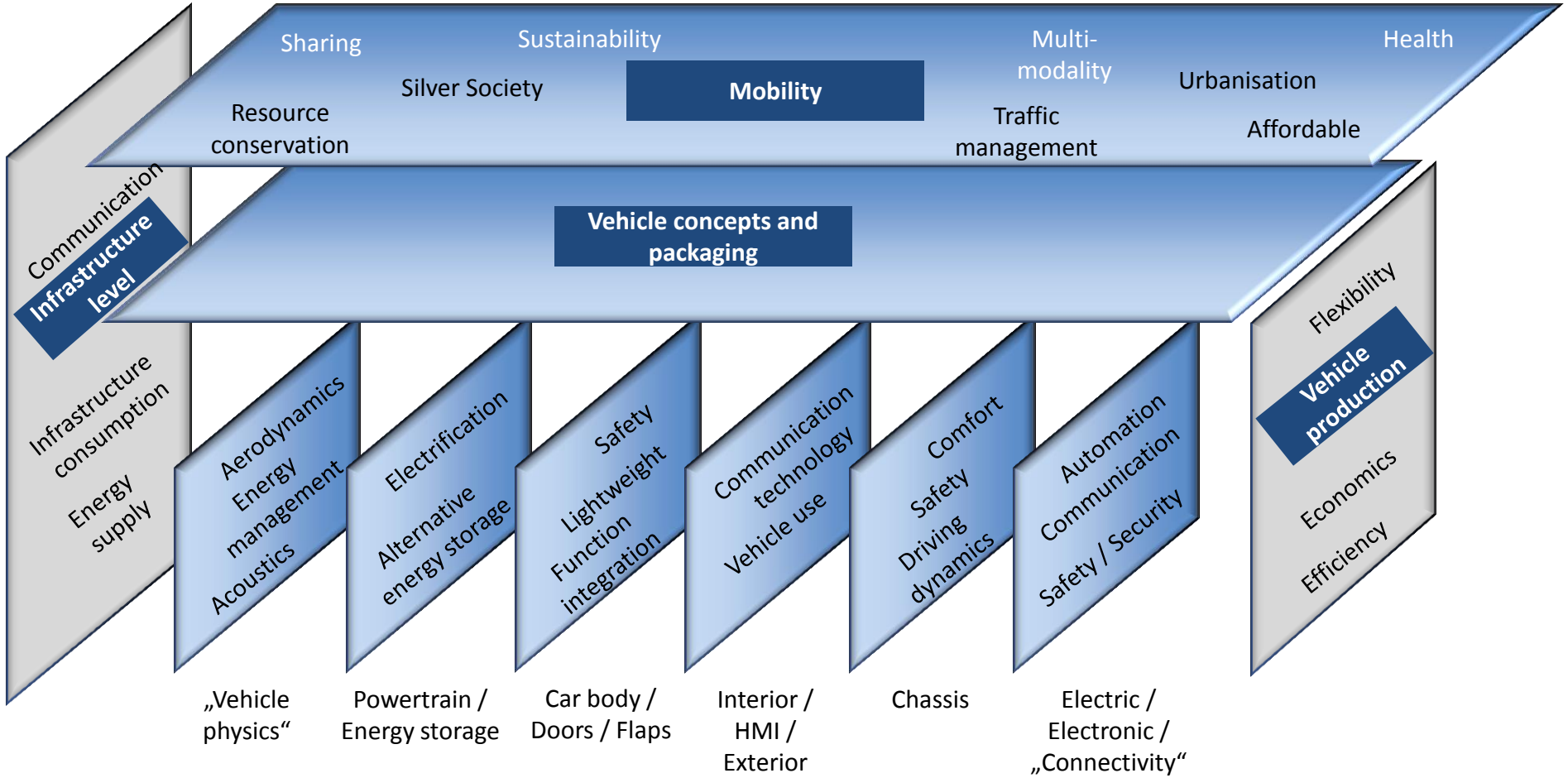
Flexible und shared mobility

Public transport and multimodality

Picture source: DLR

Challenge - Future Complexity

- Future influence on vehicle concepts



Mobility on the way to the future

1 **Social challenges and ecology**
Emission (NO_x,CO_2, etc.),energy, …

2 **Technological innovations**
Electrification drive train, safety, digitization and automation, lightweight construction, …

3 **New vehicle concepts and production technologies**
Example: Urban vehicle concepts, …

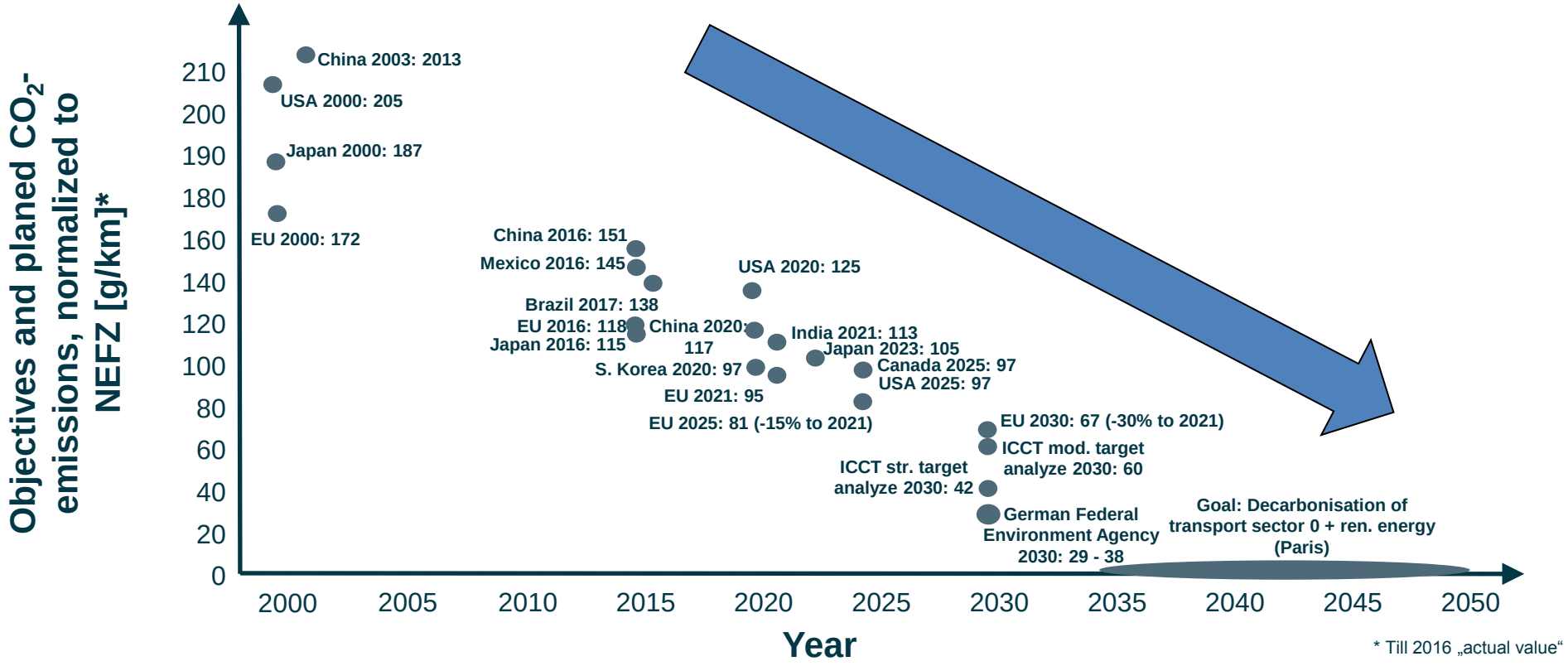
Mobility on the way to the future

1 Social challenges and ecology

Emission (NO_x,CO_2, etc.),energy, …

Social challenges and ecology

- **Emissions** and energy consumption

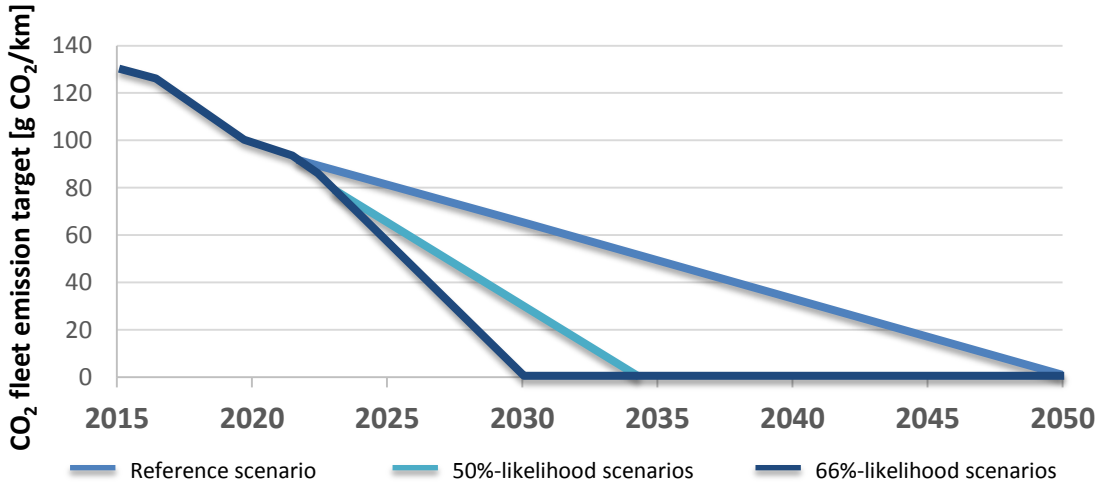


Source: based on: Friedrich, H.: Mobilität auf dem Weg in die Zukunft – Regulatorik, Nachhaltigkeit, Funktionen und Technologien, Keynote VDI Leichtbaukongress 13. Juni 2017, Leipzig / Puls, T.: Co2-Reulierung in Europa – Ein Kompendium – Version 4.0, Institut der Deutschen Wirtschaft, https://www.iwkoeln.de/fileadmin/publikationen/2017/228037/Verkehrssektor_CO2-Kompendium.pdf; 08.08.2018 / Miller, J.: Reducing CO2 emissions from road transport in the European Union: An evaluation of policy options, icct – The international council on clean transportation, working paper 2016-10, https://www.theicct.org/sites/default/files/publications/ICCT_EU-CO2-policies_201606.pdf, 02.07.2018 / Dornoff, J.; Miller, J.; Mock, P.; Tietge, U.: The European Comission regulatory proposal for post 2020 CO2 targets for cars and vans: A summary and evaluation, ICCT – The international council on clean transportation , Briefing, Januar 2018, https://www.theicct.org/sites/default/files/publications/ICCT_EU-CO2-proposal_briefing_20180109.pdf; 09.08.2018 / Prahl, A.; Umpfenbach, K.; Kron, K.: Welchen Beitrag leisten die europäischen CO2-Flottengrenzwerte für Pkw zum Klimaschutz? – ecologic – Kurzstudie im Auftrag von Greenpeace, August 2017, https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/2017-11-06_studie_ecologic_eu_flottengrenzwerte.pdf.; Internetabfrage am 09.08.2018 / Van den Adel, B.; Kugler, U.; Schmid, S.: Report : Development of the car fleet in EU28+2 to achieve the Paris Agreement target to limit global warming to 1.5°C, DLR e.V. - commissioned by Greenpeace Belgium, https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-29854/#/gallery/32032; 25.09.2018

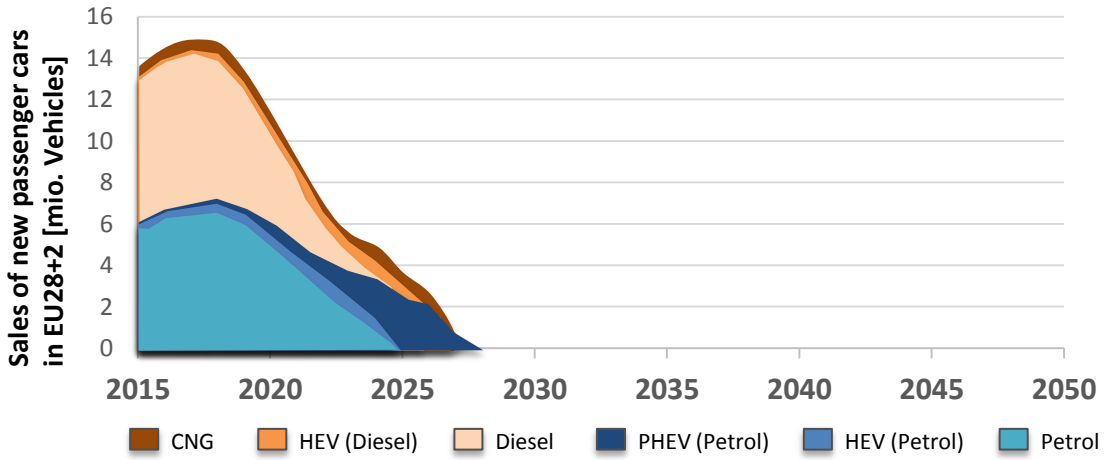
Social challenges and ecology

- **Emissions** and energy consumption

Assumption on development of CO_2 fleet emission target for new passenger cars in EU28



Scenario result from VECTOR21 for the new vehicle sales in EU28+2 in the 66%-likelihood scenario



=> Implementation of renewable energy sources for new vehicles to achieve the 1.5° C limit

Source: Van den Adel, B.; Kugler, U.; Schmid, S.: Report : Development of the car fleet in EU28+2 to achieve the Paris Agreement target to limit global warming to 1.5°C, DLR e.V. - commissioned by Greenpeace Belgium, https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-29854/#/gallery/32032; 25.09.2018

Social challenges and ecology

- **Emissions** and energy consumption

Greenhouse gases: significant share of cities[1]
Pollutants: burden often far above limits

Restrictions:

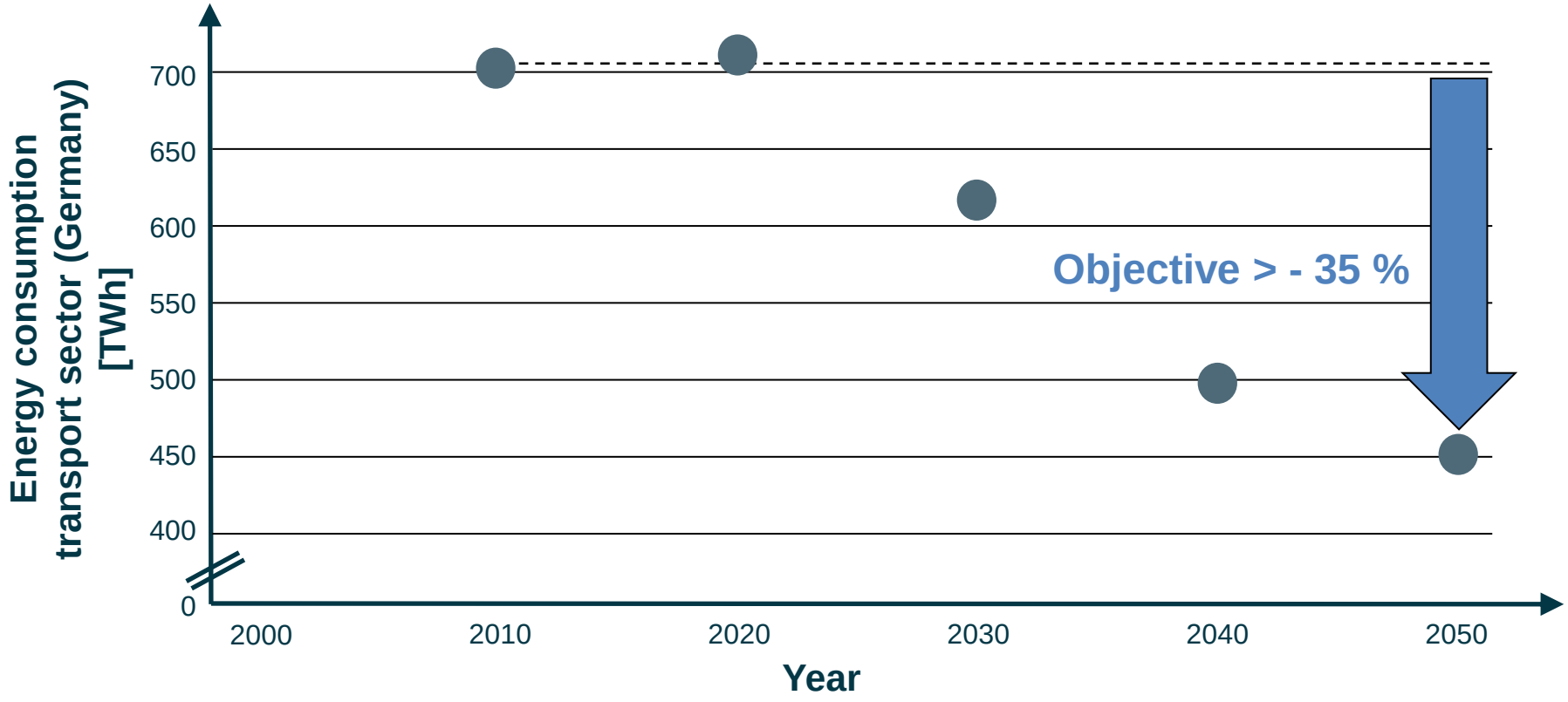
- Europe: 500 measures in 40 cities
- 15 cities with city toll today
- China (for example Beijing, Guangzhou)
  Issuing license plates as an inventive for new energy vehicles
- London: “Ultra Low Emission Zone“ from 2020
- Paris: Low Emission Zone is tightened
- Stuttgart: From 2018 - driving bans for diesel vehicles[2]

Handelsblatt from 11.05.2017

[1] C40 http://www.c40.org/researches/deadline-2020
[2] https://www.stadtklima-stuttgart.de/index.php?luft_grundlagen_grenzwerte, http://mnz.lubw.baden-wuerttemberg.de/messwerte/aktuell/spotstatDEBW118.htm

Social challenges and ecology

- Emissions and **energy consumption**



Source: THGNV-Szenario des Energiebedarfs im Verkehrssektor; Szenario für einen treibhausgasneutralen Verkehr im Jahr 2050, Treibhausgasneutrales Deutschland im Jahr 2050, Umweltbundesamt 2014, https://www.umweltbundesamt.de/publikationen/treibhausgasneutrales-deutschland-im-jahr-2050-0; 15.06.2018

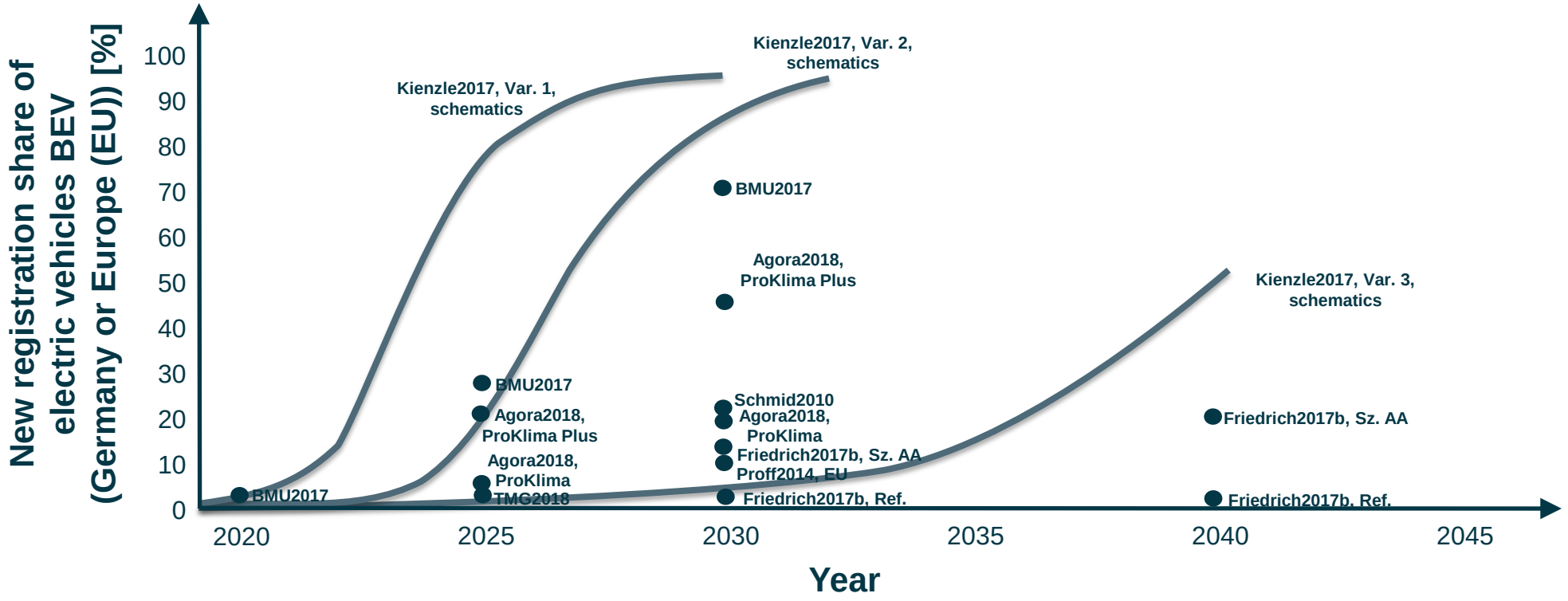
Mobility on the way to the future

1 Social challenges and ecology
Emission (NO_x,CO_2, etc.),energy, …

2 Technological innovations
Electrification drive train, safety, digitization and automation, lightweight construction, …

Technological innovations

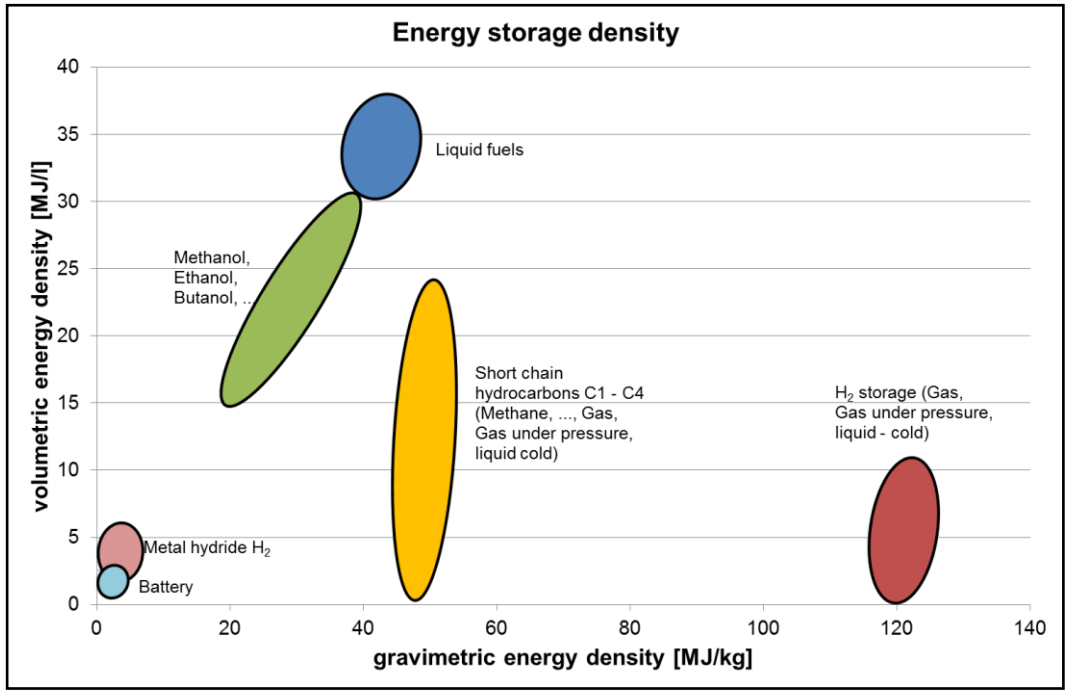
- **Electrification** drive train



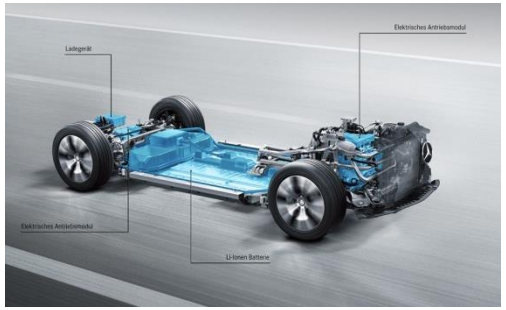
Source: Own compilation from different sources, in the context of the study "„Ökonomischer und ökologischer Nutzen des Konzept-Leichtbaus: Ungenutzte Potentiale heben"" for the Landesagentur Leichtbau BW, 2018/2019

Technological innovations

- **Electrification** drive train - Lower specific energy densities of alternative storage media and novel vehicle architectures / platforms



Daimler: electric concept



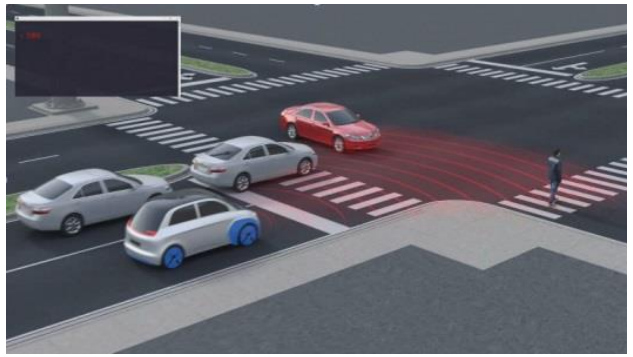
VW: MEB platform

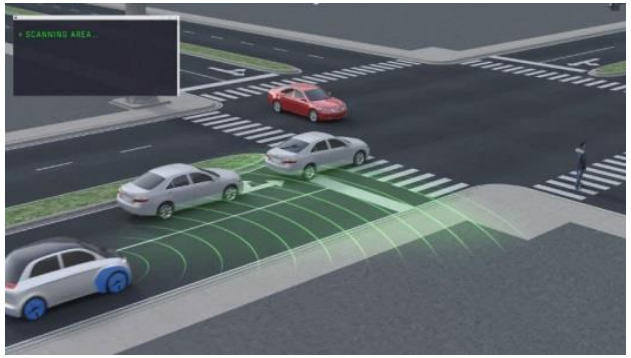
=> Variety of drive train and energy storage rises

Picture source left: own graph based on literature sources, right: Jordan, M.: Daimler AG geht mit Elektroauto auf Langstrecke: 500 km-Studie im Herbst in Paris, http://blog.mercedes-benz-passion.com/2016/06/daimler-ag-geht-mit-elektroauto-auf-langstrecke-500-km-studie-im-herbst-in-paris/, 10.02.2017 / N.N.: Automobil Industrie, 11-12 2016, S. 39

Technological innovations

- **Safety** - example of road vehicle structures

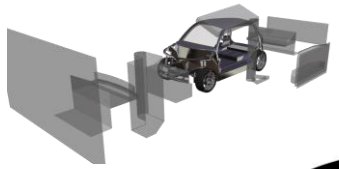




100% rigid wall
Full Width Euro NCAP

40% Barriere ODB
Euro NCAP

Rollover test



Sidecrash MDB
Euro NCAP/IIHS

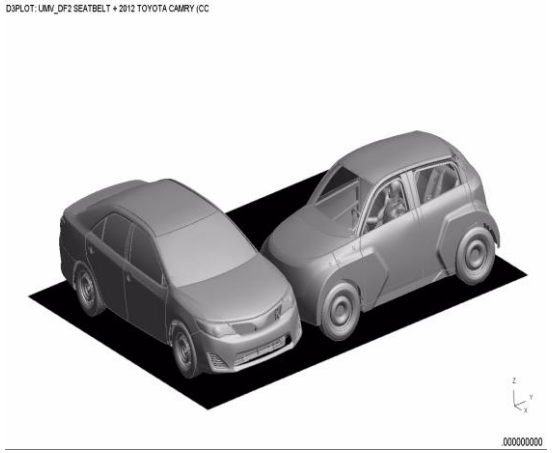
Pole Euro NCAP

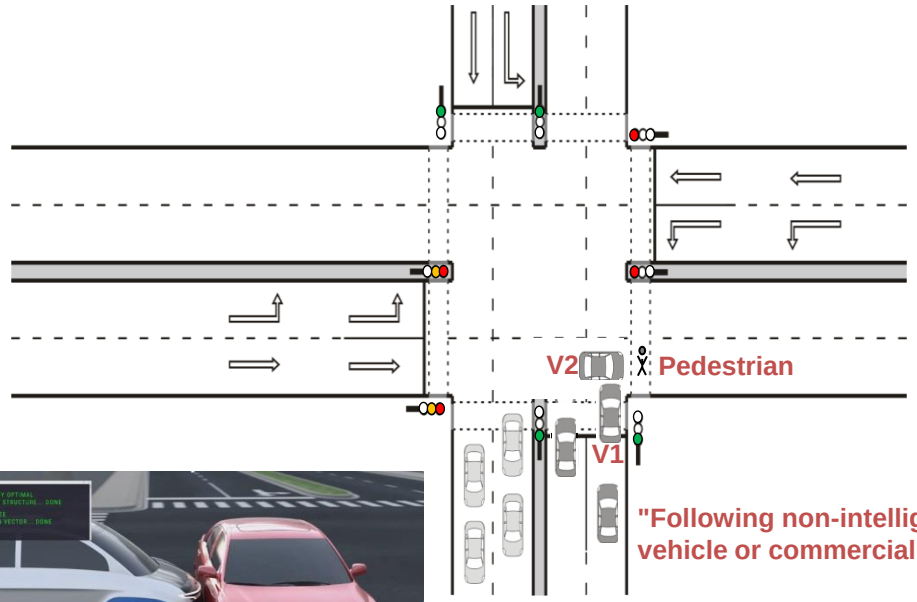
Active safety

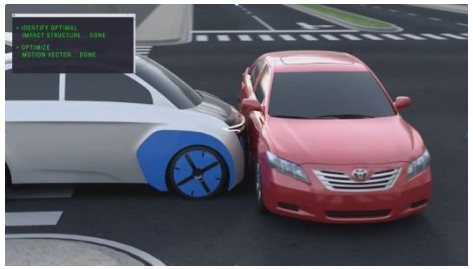
Passive safety

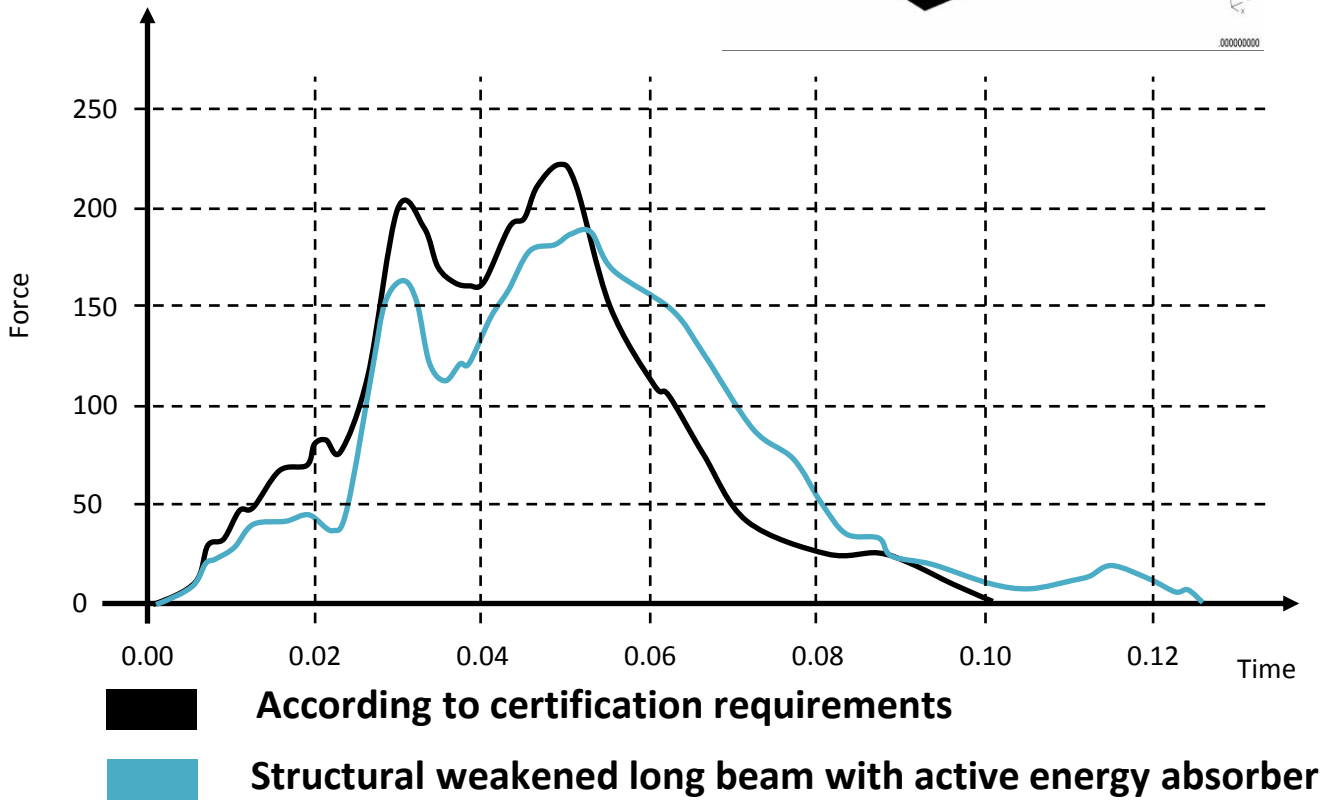
Technological innovations

- Safety - combination of active and passive safety – scenario side impact



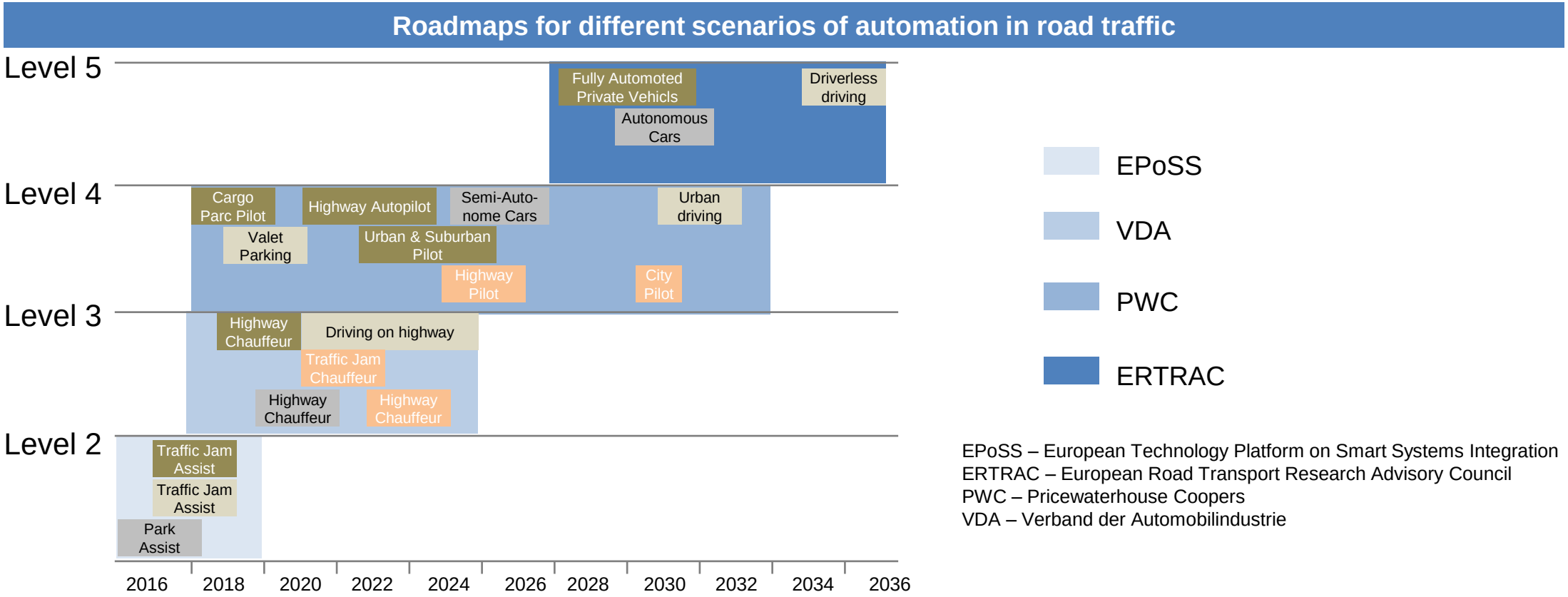






Technological innovations

- Digitization and automation

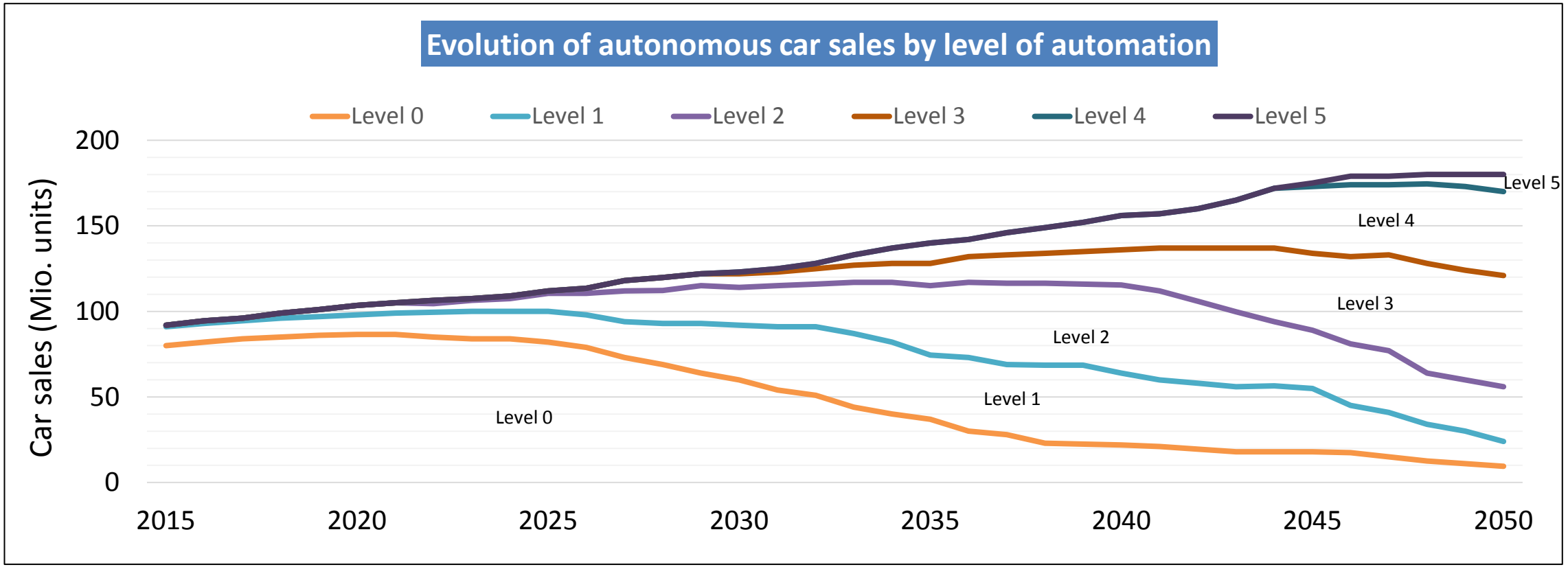


EPoSS – European Technology Platform on Smart Systems Integration
ERTRAC – European Road Transport Research Advisory Council
PWC – Pricewaterhouse Coopers
VDA – Verband der Automobilindustrie

Source: N.N.: Automatisiertes Fahren im Personen- und Güterverkehr, - Auswirkungen auf den Modal-Split, das Verkehrssystem und die Siedlungsstrukturen, e-mobil, Landesagentur für Elektromobilität und Brennstoffzellentechnologie Baden-Württemberg GmbH, August 2017, https://www.e-mobilbw.de/files/e-mobil/content/DE/Publikationen/PDF/PDF_2017/Studie_AutomatisiertesFahren.pdf, 21.03.2018

Technological innovations

- Digitization and automation



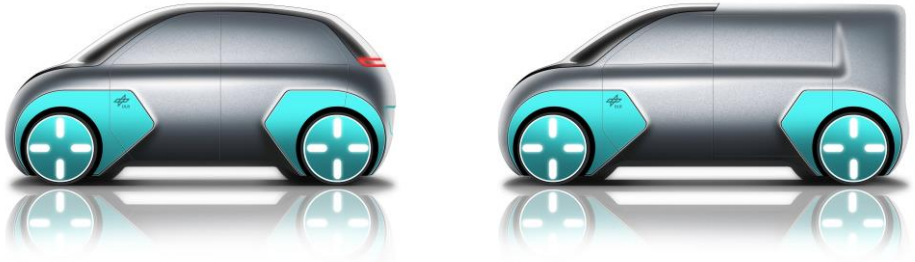
Source: Yole 2015 - Sensors and Data Management for Autonomous Vehicles; https://de.slideshare.net/Yole_Developpement/sensors-and-data-management-for-autonomous-vehicles-report-2015-by-yole-developpement; 13.02.2019

Technological innovations

- Digitization and automation

Highly automated with driver's workplace

Rinspeed Oasis

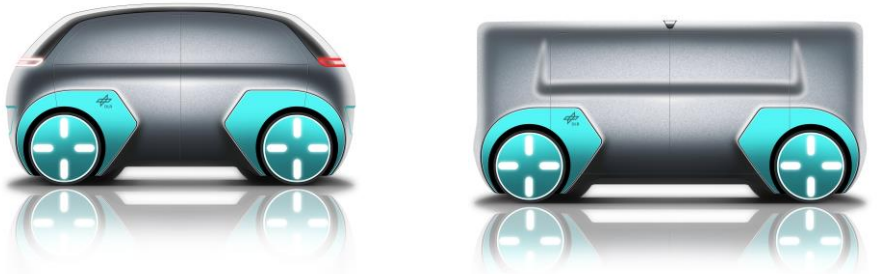


NGC UMV Basic und Cargo Long

Autonomous, driverless

Local Motors Olli

Navya Arma



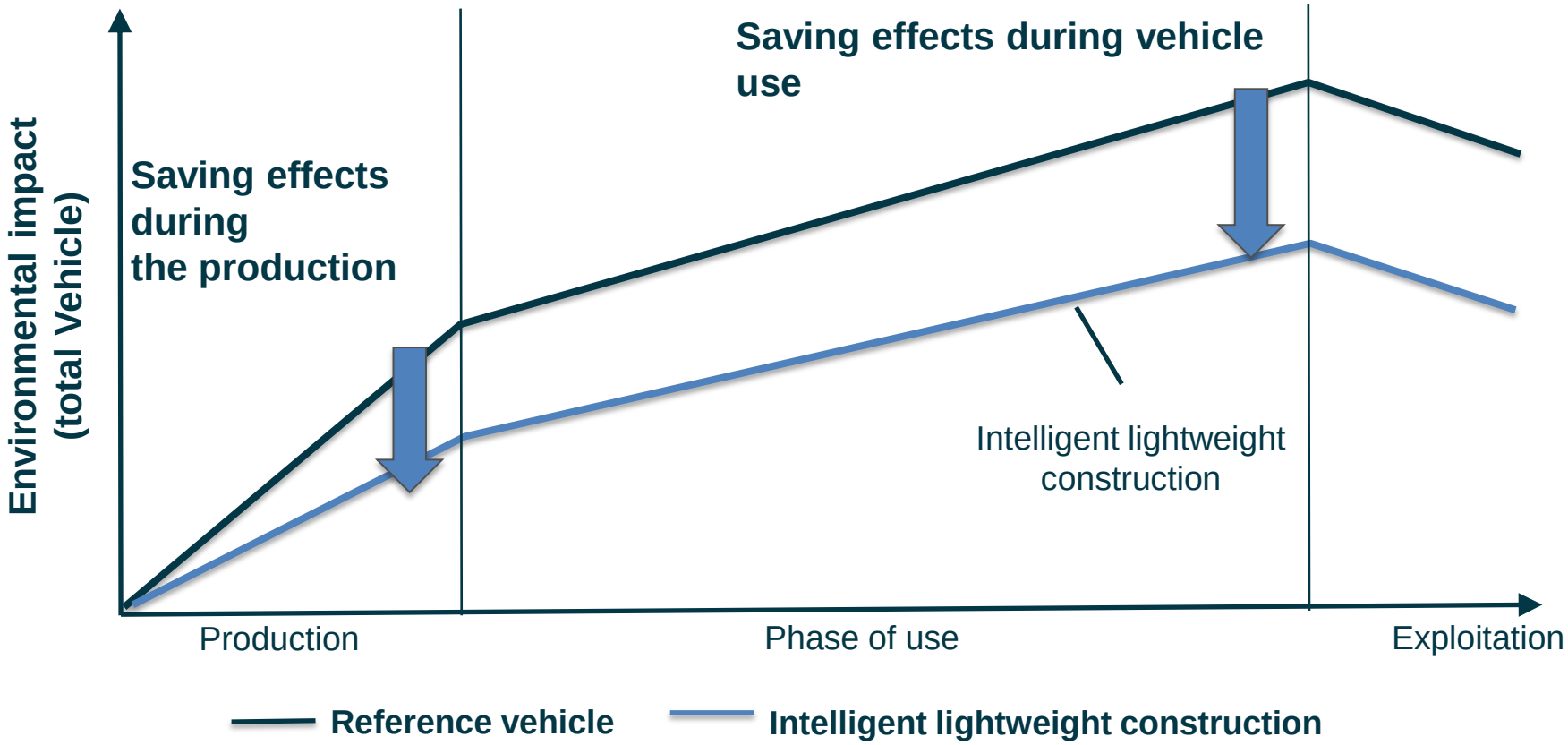
NGC UMV People- und Cargomover Long

=> Increasing architecture diversity (derivatives) for different use cases (sharing, pubic transport, …).

Source: N.N.: Rinspeed Oasis, http://www.rinspeed.eu/aktuelles.php?aid=20, 10.02.2017 / N.N.: Local Motors Olli, https://localmotors.com/posts/2016/06/local-motors-debuts-olli-first-self-driving-vehicle- tap-power-ibm-watson/, 10.02.2017'/ N.N.: Navya Arma, http://navya.tech/?lang=de, 10.02.2017

Technological innovations

- Resource protection / light construction



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Technological innovations

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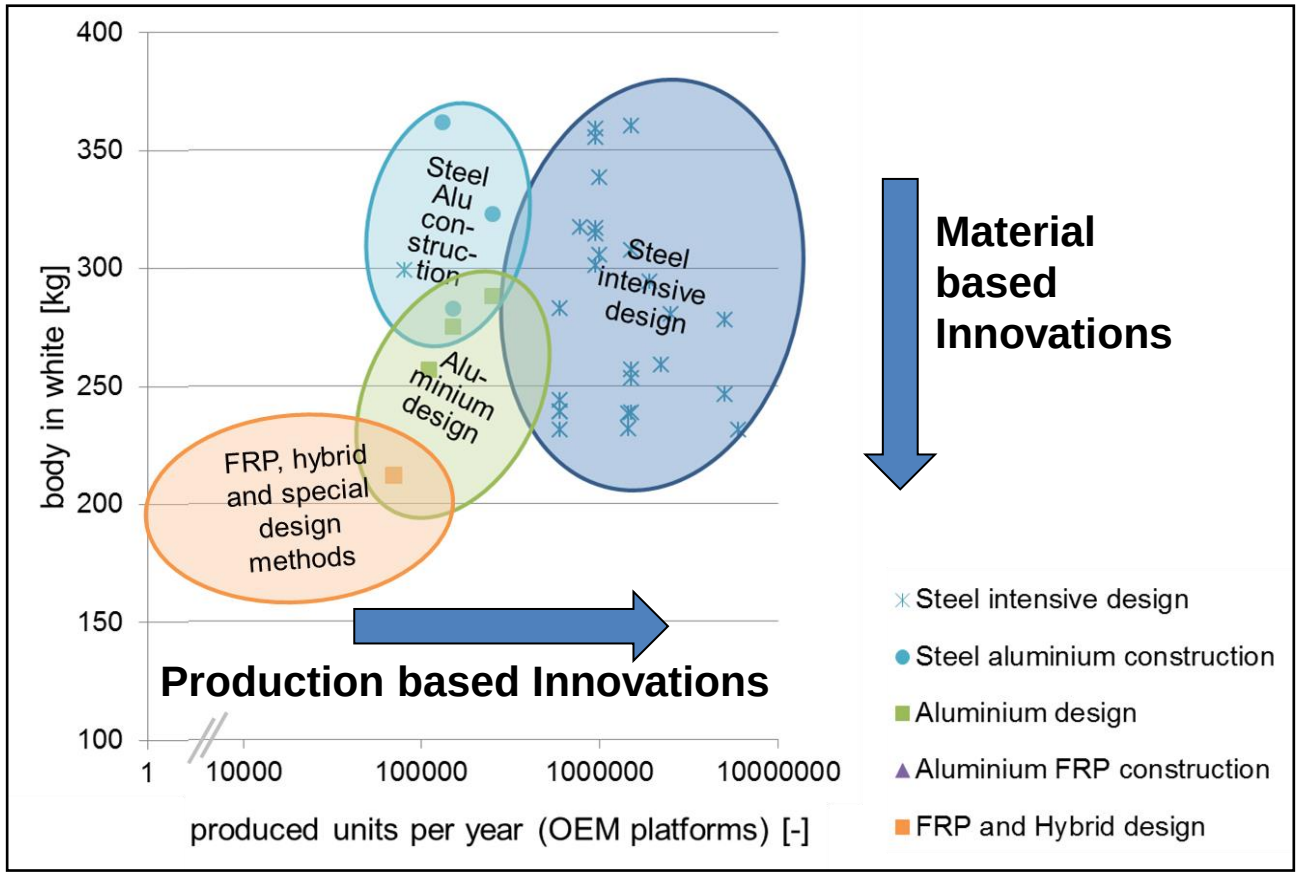
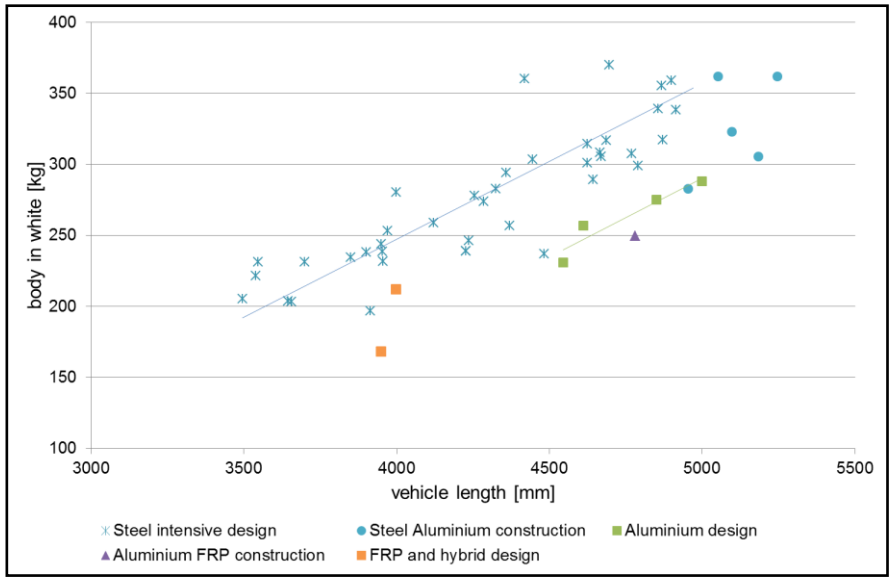




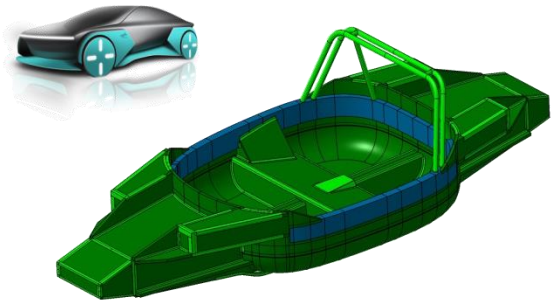
=> The combination with an intelligent lightweight design (change of topology) with the right system boundary is necessary

Source: own graph based on literature and manufacturer data 2005 - 2016 in combination with N.N.: Im Focus, Automobil Produktion Sonderausgabe, September 2006 / N.N.: Internationale OEM im Fokus, Sonderausgabe, Oktober 2010 / N.N.: Global Automotive Business, Automobil Produktion, Sonderausgabe, November 2016

Technological innovations

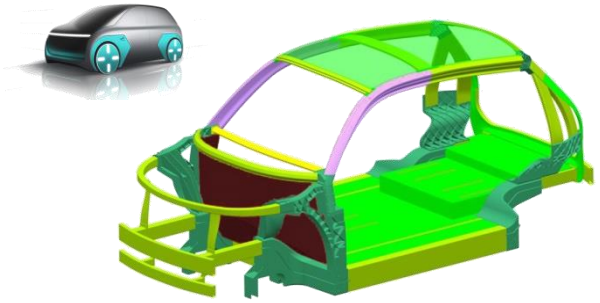
- Resource protection / light construction

NGC Save Light Regional Vehicle (SLRV)



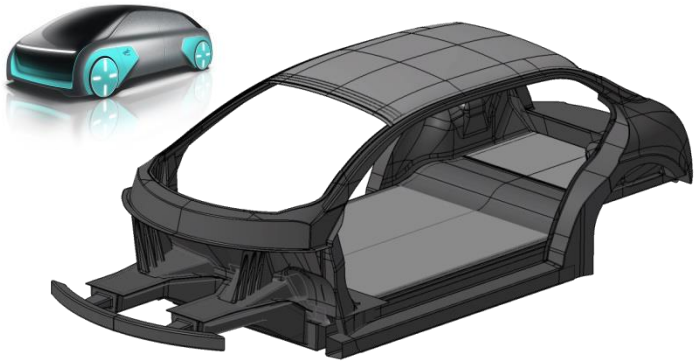
- Metal-foam-sandwich body in white
- Crash safety state of the art of today automotive vehicles (M1 class)
- Body in white mass lower than 90 kg

NGC Urban Modular Vehicle (UMV)



- Modular multi-material-design body in white
- Adaptable safety structure with combination of active and passive safety
- Body in white mass lower than 180 kg

NGC Interurban Vehicle (IUV)



- Fiber reinforced intensive body in white
- Function integrated FRP (e.g. structure integrated sensors)
- Body in white mass lower than 250 kg

Mobility on the way to the future

1 **Social challenges and ecology**
Emission (NO_x,CO_2, etc.),energy, …

2 **Technological innovations**
Electrification drive train, safety, digitization and automation, lightweight construction, …

3 **New vehicle concepts and production technologies**
Example: Urban vehicle concepts, …

New vehicle concepts and production technologies

Multiple Urban Use Cases

- Urban / suburban use field
- Concept for different Urban Use-Cases
- Private up to Shared
- People up to Cargo
- Variable interior, ergonomic opening concept, 4 doors

Peer-Group	Seats	Length [m]	Electric range [km]	Cargo capacity [l]	NGC UMV Derivate
	2+2	3,7	400	210	
	4	4,1	460	550	
	2+2	3,7	300	280	
	2+x	3,7	400	2700-3800	
	x	3,7	200	3800	

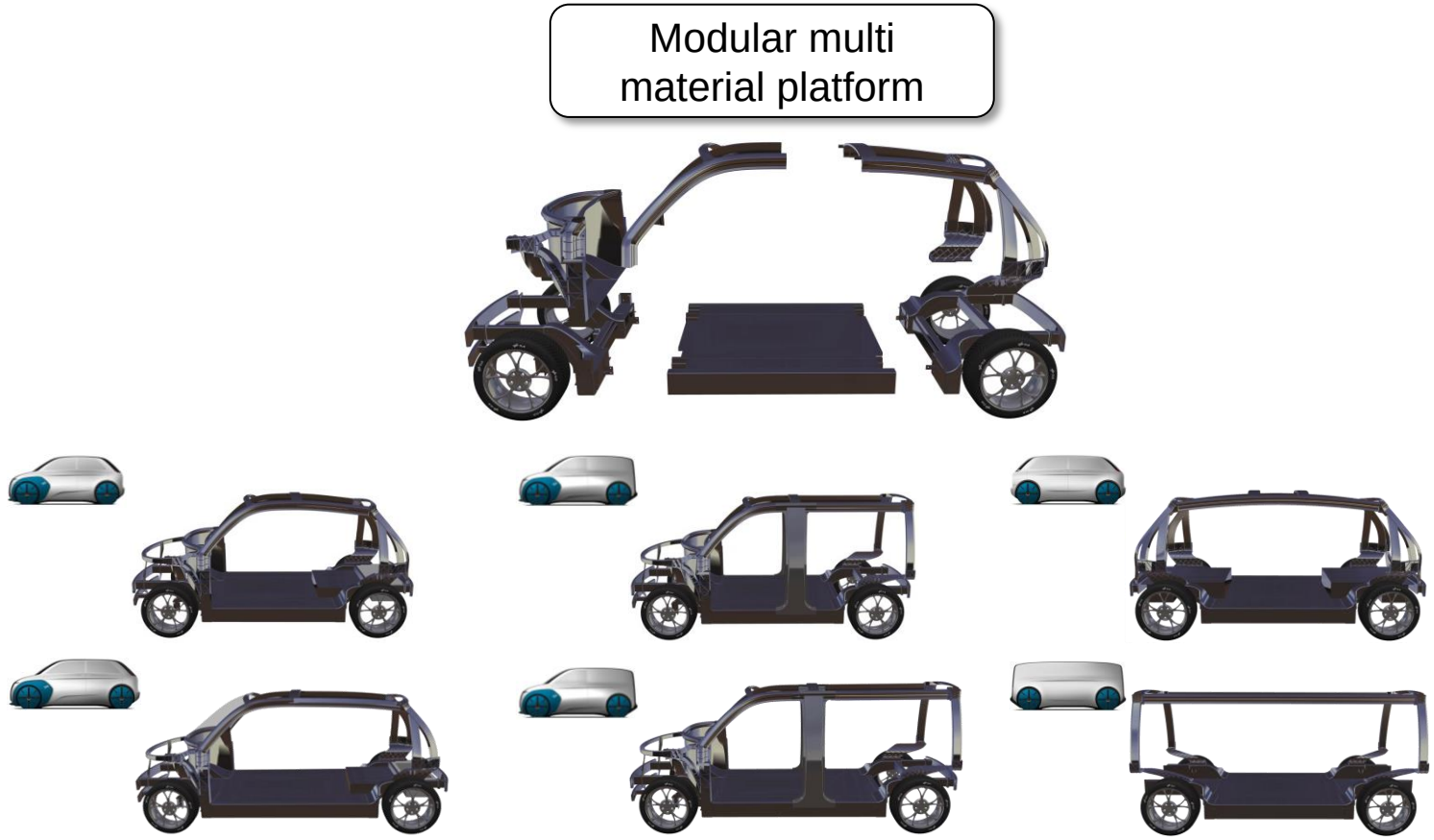
Source: Münster, M.; Kopp, Ge.; Schäffer, M.; Sturm, R.; Deißer, O.; Kopp, Gu.; Friedrich, H.: Future Urban Vehicle Architectures and Body in White Structures - Challenges and Potentials. FutureCarBody 2018, 13.-14.06.2018, Bad Nauheim, Deutschland

New vehicle concepts and production technologies

- **Modular MMD body in white**

- **Modular multi material platform**
- **Optimized body structures for electric vehicles in the sense of purpose-design**

- **Innovative floor crash module**
- **Combined active and passive safety concepts**

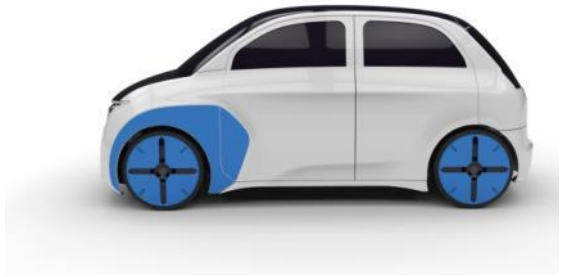


=> Urban Modular's six main modules build together different vehicles across a number of different classes and open up new potential for synergies

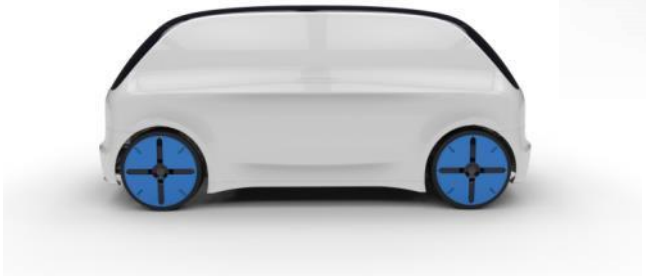
Source: Münster, M.; Kopp, Ge.; Schäffer, M.; Sturm, R.; Deißer, O.; Kopp, Gu.; Friedrich, H.: Future Urban Vehicle Architectures and Body in White Structures - Challenges and Potentials. FutureCarBody 2018, 13.-14.06.2018, Bad Nauheim, Deutschland

Modular and safe body design – Modularization Strategy

UMV Basic



UMV Peoplemover

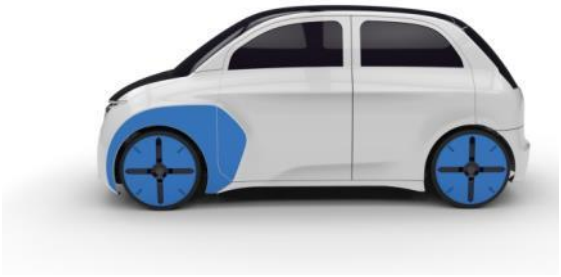


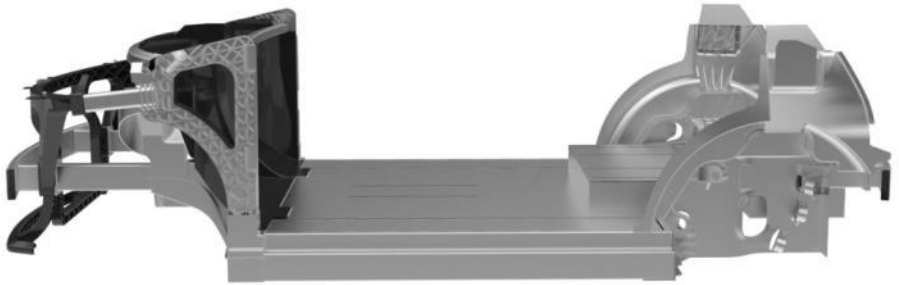
=> Aluminum intensive frame structure with profiles and nodes with functionally integrated sandwich surfaces and flat components in FRP

Source: Münster, M.; Kopp, Ge.; Schäffer, M.; Sturm, R.; Deißer, O.; Kopp, Gu.; Friedrich, H.: Future Urban Vehicle Architectures and Body in White Structures - Challenges and Potentials. FutureCarBody 2018, 13.-14.06.2018, Bad Nauheim, Deutschland

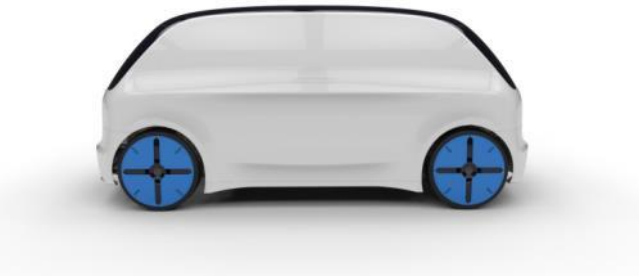
Modular and safe body design – Modularization Strategy

UMV Basic





UMV Peoplemover



=> Aluminum intensive frame structure with profiles and nodes with functionally integrated sandwich surfaces and flat components in FRP

Source: Münster, M.; Kopp, Ge.; Schäffer, M.; Sturm, R.; Deißer, O.; Kopp, Gu.; Friedrich, H.: Future Urban Vehicle Architectures and Body in White Structures - Challenges and Potentials. FutureCarBody 2018, 13.-14.06.2018, Bad Nauheim, Deutschland

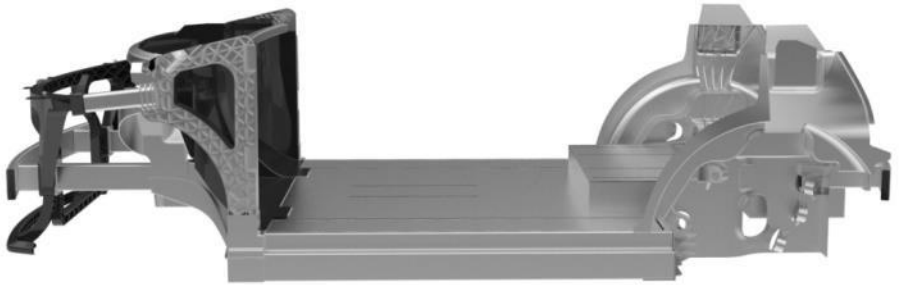
Modular and safe body design – Modularization Strategy

UMV Basic

Variable greenhouse front

Variable greenhouse rear

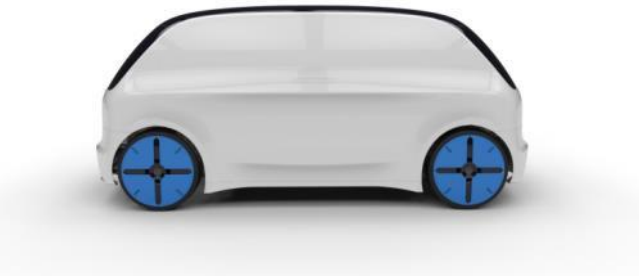
Scalable front modules



Scalable rear modules

Length variability

UMV Peoplemover



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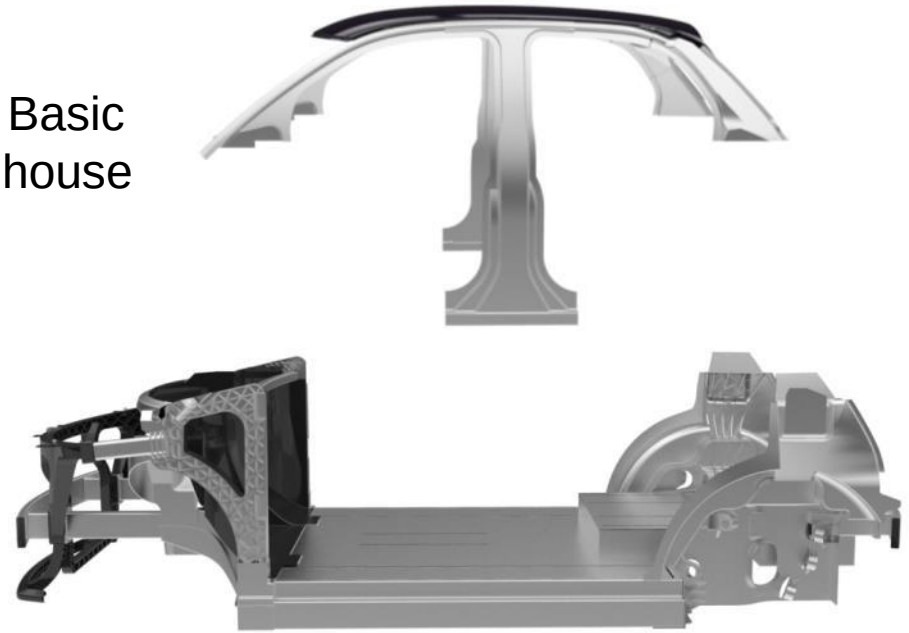
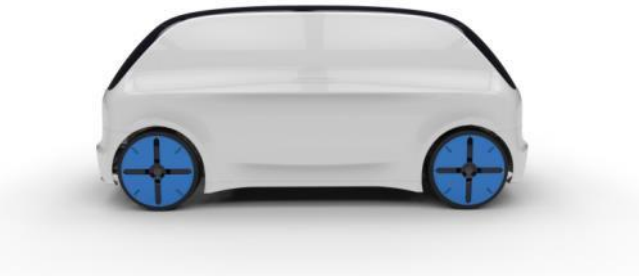
Modular and safe body design – Modularization Strategy

UMV Basic

UMV Basic greenhouse



UMV Peoplemover



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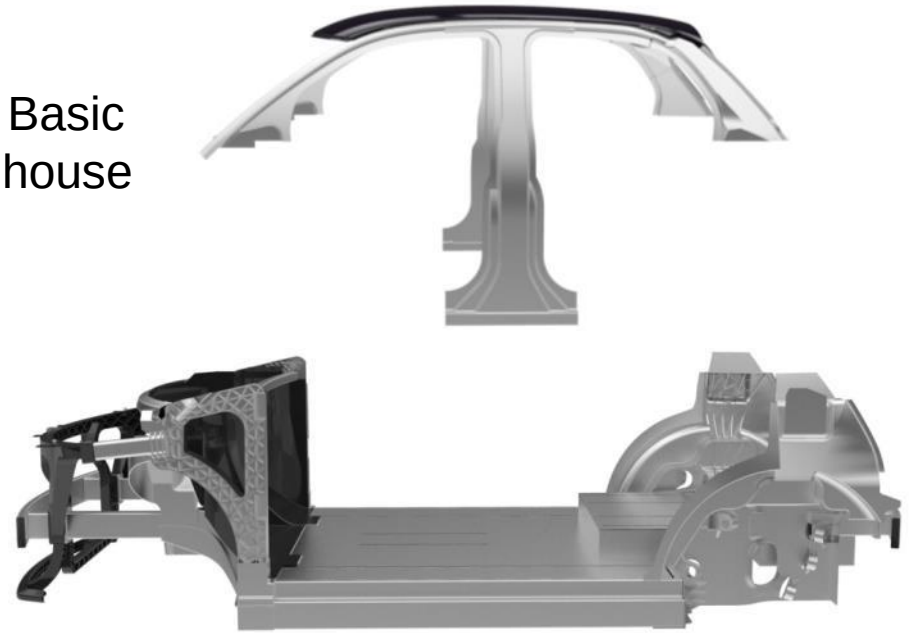
Modular and safe body design – Modularization Strategy

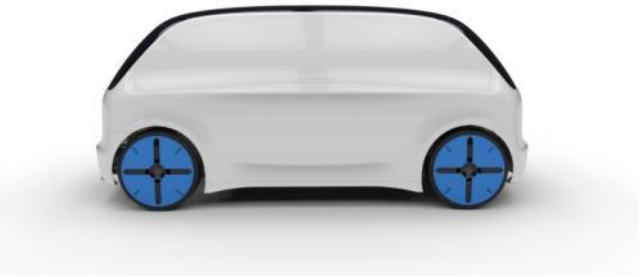
UMV Basic

UMV Basic greenhouse



UMV Basic BIW

UMV Peoplemover



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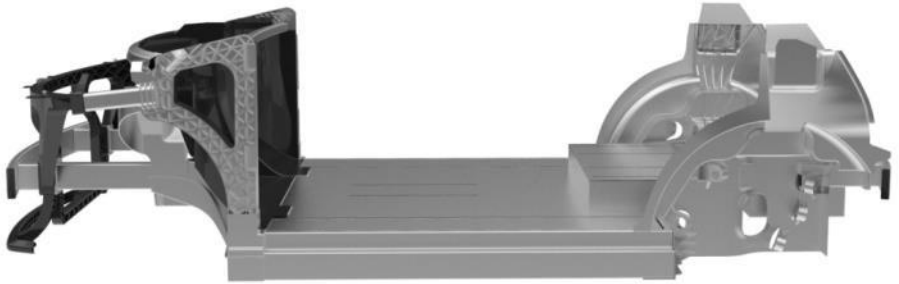
Modular and safe body design – Modularization Strategy

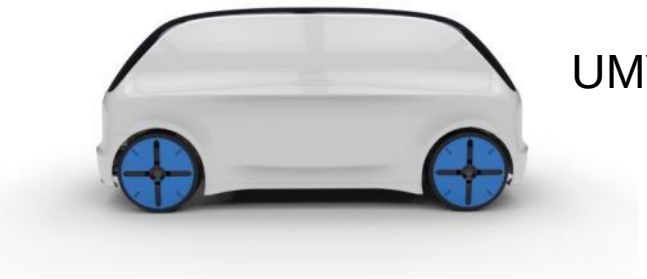
UMV Basic

UMV Basic greenhouse



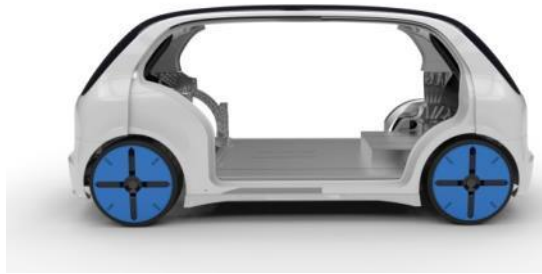
UMV Basic BIW

UMV Peoplemover



UMV Peoplemover greenhouse

UMV Peoplemover BIW



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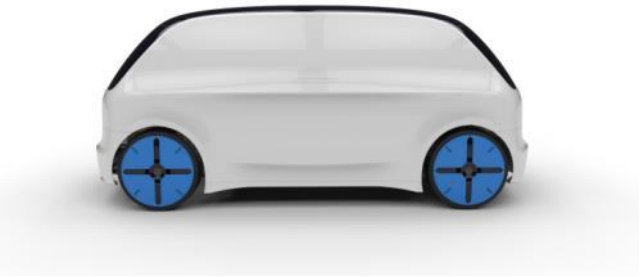
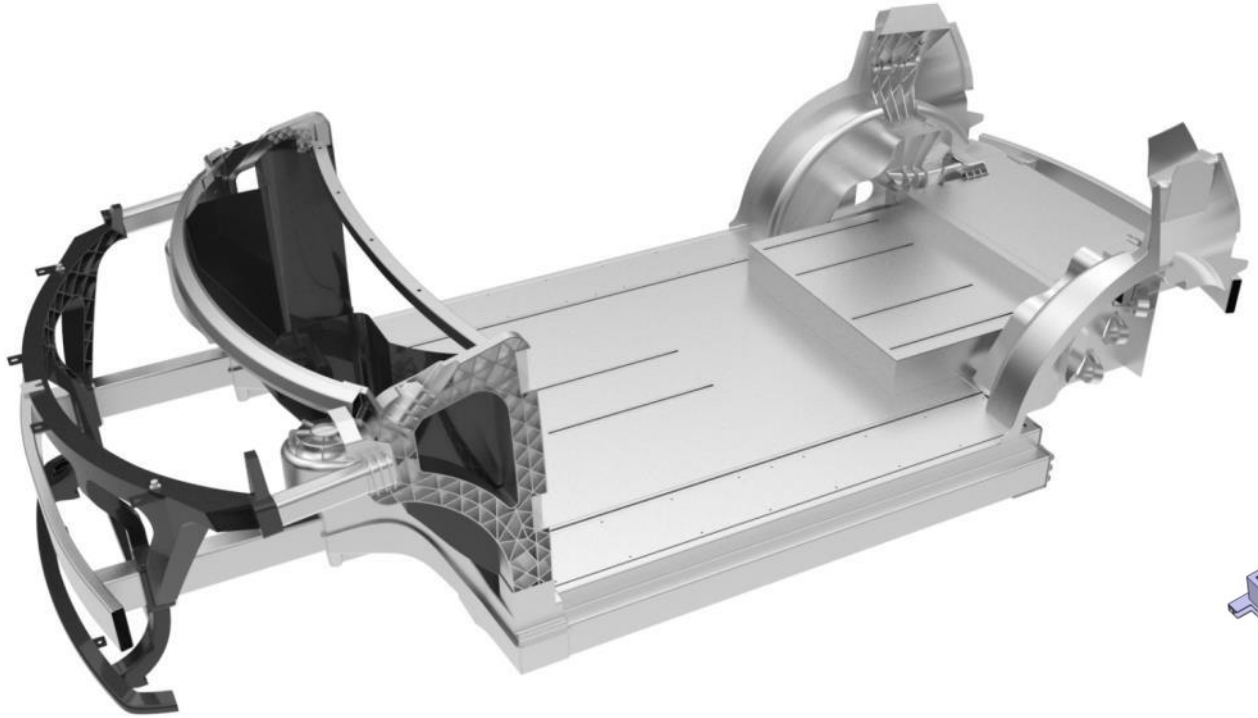
Modular and safe body design – Modularization Strategy

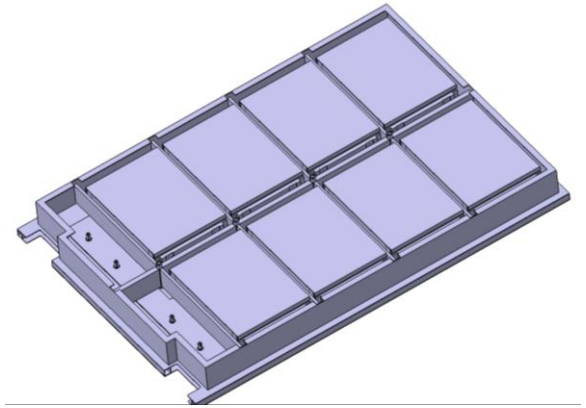
UMV Basic

UMV Peoplemover





Battery-Box



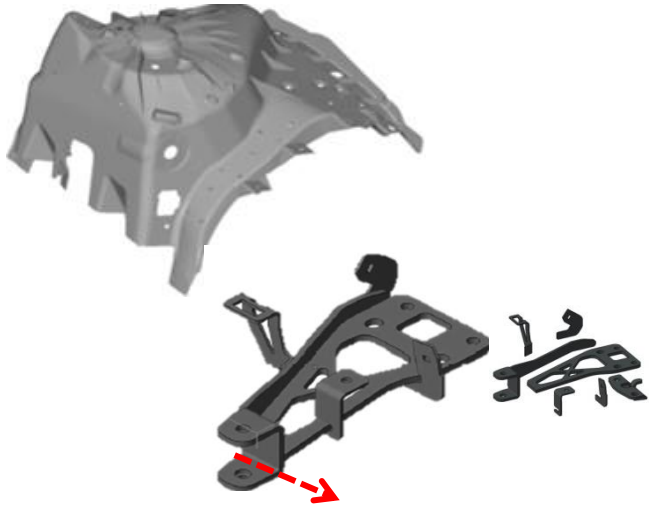
Source: Münster, M.; Kopp, Ge.; Schäffer, M.; Sturm, R.; Deißer, O.; Kopp, Gu.; Friedrich, H.: Future Urban Vehicle Architectures and Body in White Structures - Challenges and Potentials. FutureCarBody 2018, 13.-14.06.2018, Bad Nauheim, Deutschland

New vehicle concepts and production technologies

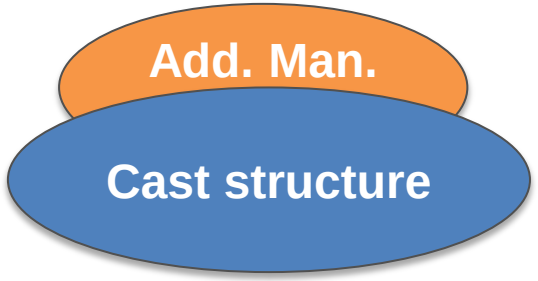
- Lightweight optimized and flexible structures for vehicle construction

Example strut dome and damper attachment

Conventional approach

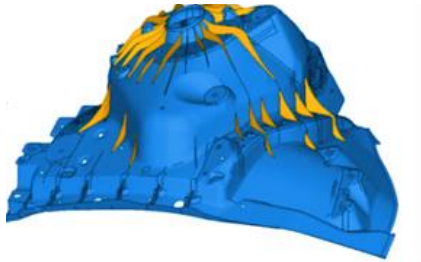


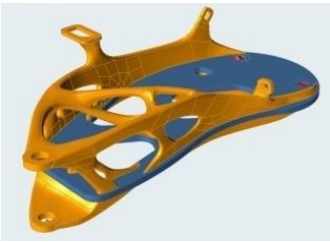
Variable component elements



Basic component elements

Hybrid approach





=> Optimized geometry and material used to adapt to different load requirements and vehicle configurations

Source: Chamoun, M.; Kopp, Gu.; Friedrich, H.; Schuster, M.; Müllerschön, O.: Methode zur Entwicklung von variablen Strukturkonzepten durch Kombination additiver und konventioneller Fertigungsverfahren. WerkstoffPlus Auto, Stuttgart, 2018

Trends in the area of future vehicle concepts

Current vehicles and possible, future developments

VW Käfer

VW Golf (MQB A / B)

Mass motorization with standard vehicles

Variety and concept variety through platforms, modules and modularization (Customization)

Flexible and adaptable concepts („Modular-on-the-fly“)

Use-Case optimized vehicle concepts

Electrified, highly automated, safe vehicles on optimized platforms („Modular 2.0“)

Airbus Pop.up

Rindspeed Snap

Navya Arma

StreetScooter / DHL

Mercedes F015

Vehicle development

Picture source: Volkswagen, Airbus, Rinspeed, Navya, Streetskooter, Daimler

Summery

Requirements

- Future mobility must be ecologically compatible (sustainable)
- Technologies must be energy efficient
- Vehicles will be electrified, automated and protecting resources

Summery

Requirements

- Future mobility must be ecologically compatible (sustainable)
- Technologies must be energy efficient
- Vehicles will be electrified, automated and protecting resources

Approach

- Increasing efficiency in the field of drive train and energy storage
- Alternative fuels
- Resistance reduction and resource protection (including lightweight construction)
- New approaches in the field of vehicle development and flexible manufacturing processes / production to accommodate the significantly increasing product diversity

Thank you for your attention