The Data-defined Vehicle Architecture

The AUTOmobile becomes the autoMOBILE

Dr. Sebastian Wedeniwski

IBM Distinguished Engineer, CTO Global Industrial Sector

Agenda

- **Software-defined vehicles surrounded by historical structures**
- The mobility revolution shifts the vehicle to a software-defined service
- Critical business competencies in a globally transforming autoMOBILE
- Fundamental challenges to master data-defined vehicles
- Outlook of a data-driven architecture for mobility as a service

Patent No. 37435 “Vehicle powered by gas engine” of 29 January 1886 is the birth certificate of the automobile

KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 2. NOVEMBER 1886.

PATENTSCHRIFT

№ 37435

KLASSE 46: Luft- und Gaskraftmaschinen.

BENZ & CO. in MANNHEIM.

Fahrzeug mit Gasmotorenbetrieb.

Patentirt im Deutschen Reiche vom 29. Januar 1886 ab.

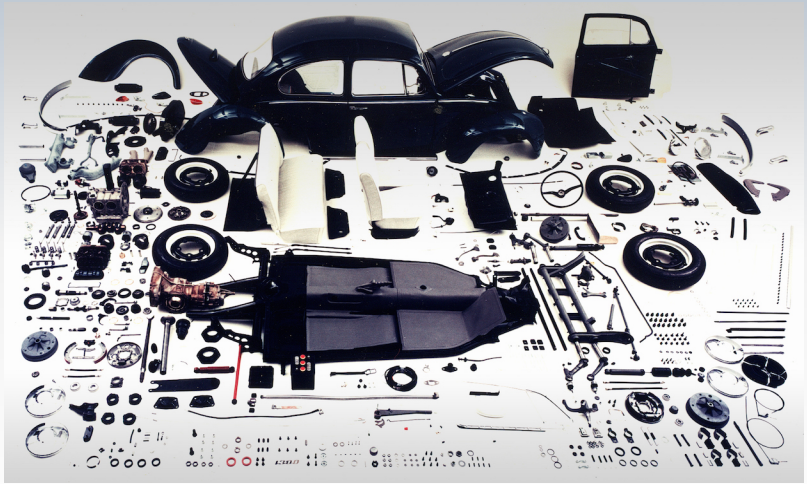
Vorliegende Construction bezweckt den Betrieb hauptsächlich leichter Fuhrwerke und kleiner Schiffe, wie solche zur Beförderung von 1 bis 4 Personen verwendet werden.

Auf der beiliegenden Zeichnung ist ein kleiner system 1, werden dort zum gröfsten Theil condensirt und treten wieder als Wasser unten in den Cylinder ein. Der nicht condensirte Dampf entweicht durch die Oeffnung 2.

Das zum Betrieb des Motors nöthige Gas

Absolutely no software!

In the mid-1960s, a Volkswagen Beetle contained only very few electrical parts – BUT no software-defined hardware



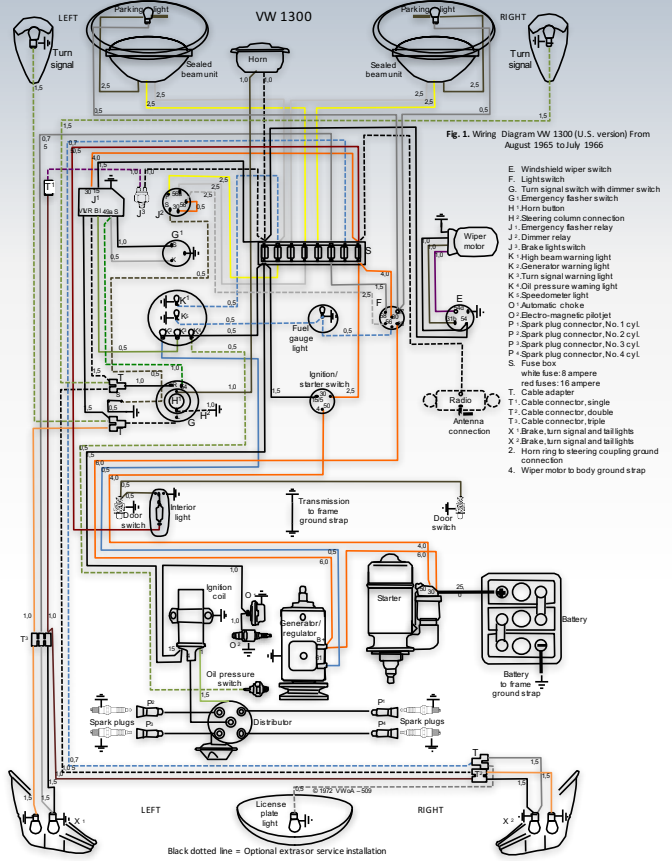


Fig. 1. Wiring Diagram VW 1300 (U.S. version) From August 1965 to July 1966

E. Windshield wiper switch
F. Light switch
G. Turn signal switch with dimmer switch
G1. Emergency flasher switch
H. Horn button
H1. Steering column connection
J1. Emergency flasher relay
J2. Dimmer relay
J3. Brake light switch
K. High beam warning light
K1. Generator warning light
K2. Turn signal warning light
K3. Oil pressure warning light
K4. Speedometer light
O. Automatic choke
O1. Electro-magnetic pilot jet
P. Spark plug connector, No. 1 cyl.
P1. Spark plug connector, No. 2 cyl.
P2. Spark plug connector, No. 3 cyl.
P3. Spark plug connector, No. 4 cyl.
S. Fuse box
white fuse: 8 ampere
red fuses: 16 ampere
T. Cable adapter
T1. Cable connector, single
T2. Cable connector, double
T3. Cable connector, triple
X. Brake, turn signal and taillights
X1. Brake, turn signal and taillights
2. Horn ring to steering coupling ground connection
4. Wiper motor to body ground strap

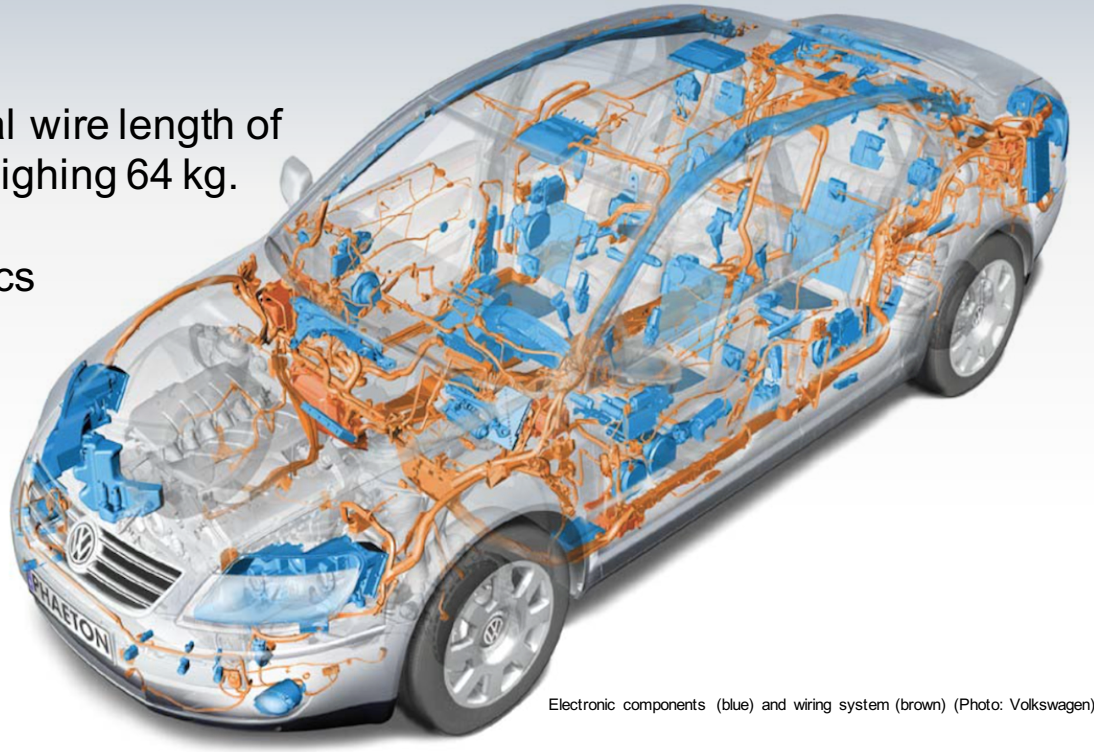
Some electrical parts in mass production

Parts		
Battery	generator	fuses
Ignition	ignition starter switch	main light switch
Lighting system	indicator switch	indicator relay
Registration plate light	dimmer/full beam/foot switch	brake light switch
Horn	horn actuator	door contact switch
Windscreen wiper motor	windscreen wiper switch	oil pressure switch
Speedometer indicator lamps		
…		

As early as the beginning of the 2000s, there were 45 connected Electronic Control Units (ECUs) made by different manufacturers in the Volkswagen Phaeton

Cabling in the Phaeton has a total wire length of 3,860 m with a cable harness weighing 64 kg.

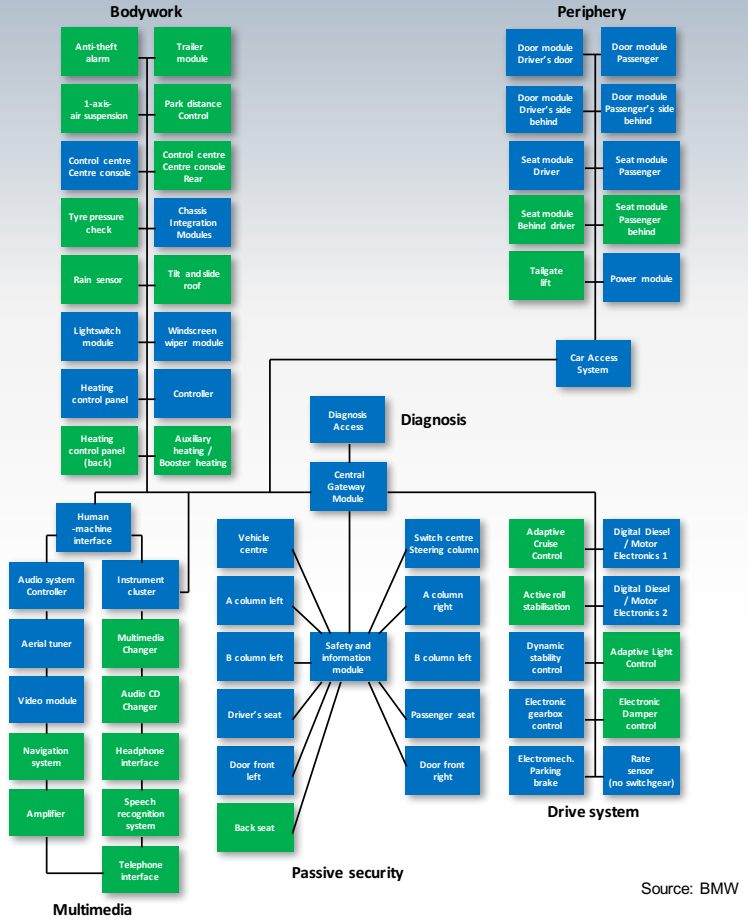
The bill of materials of the electrics consist of 11,136 parts.



Electronic components (blue) and wiring system (brown) (Photo: Volkswagen)

Only embedded software defined by hardware!

In 2005, high variation of possible ECUs in the BMW 7 series (E65)



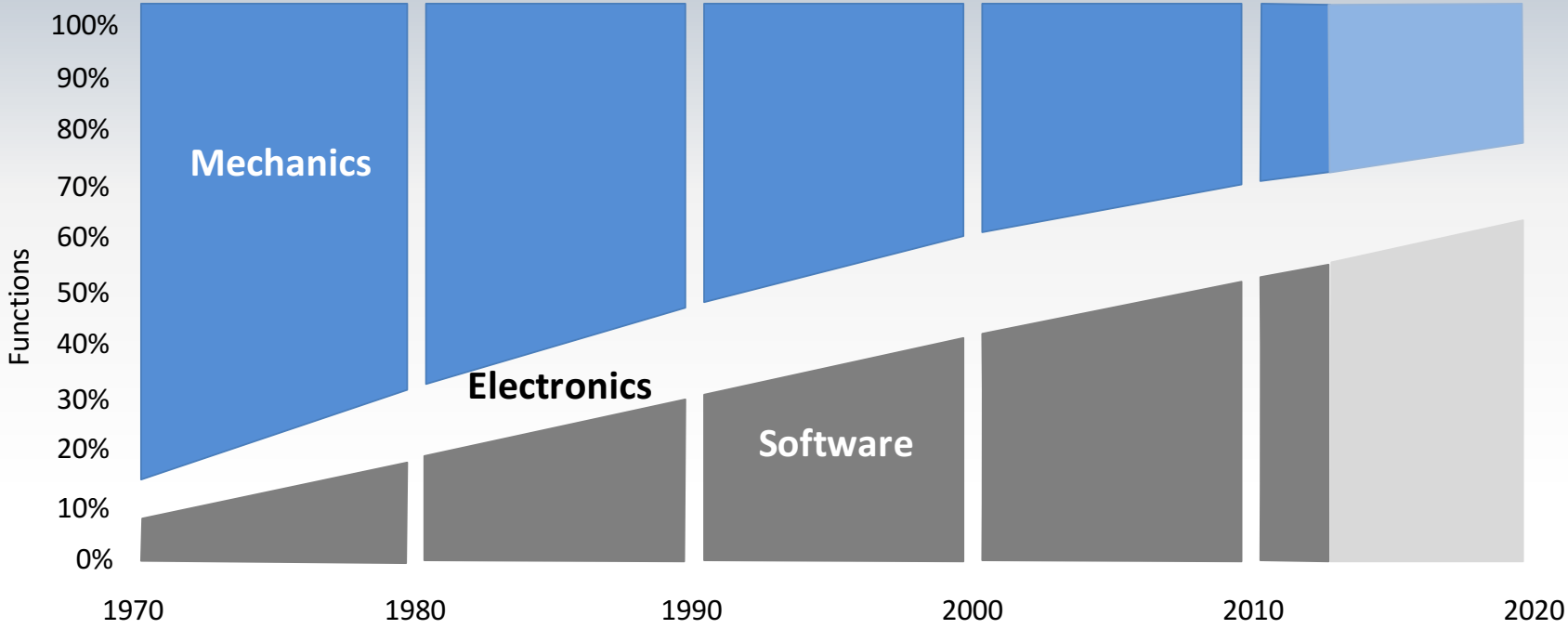
Source: BMW

BMW 7 series from 2005 contained around 65 ECUs, connected via five bus systems with an embedded software scope of around 115 megabytes.

Every car gets an own fingerprint just by ECUs and software for standard equipment (green) and optional equipment (blue).

Source: S 400 HYBRID - own photo, Attribution, https://commons.wikimedia.org/w/index.php?curid=11526833

Today, the share of software is already higher than that of mechanics



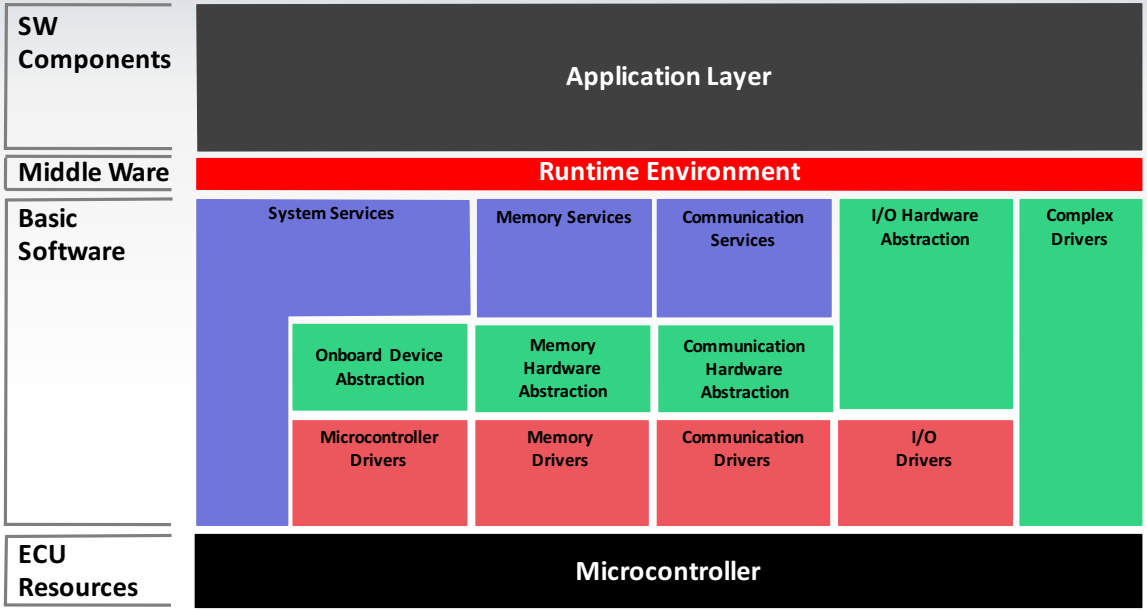
Source: ITQ GmbH (2014) Kompetenz in Mechatronik. München https://www.itq.de/files/itq_unternehmensbrosch_re_online.pdf

AUTOSAR (AUTomotive Open System ARchitecture)
Electrical/Electronic architecture concept towards software-defined hardware

Over the past 20 years, there have been a number of efforts to standardize operational systems, bus systems, basic software and functional interfaces for the architecture of embedded systems.

Similarly to AUTOSAR, the JasPar is a consortium run primarily by Japanese companies, which also has other focuses

Aim to decouple the software in the embedded systems from the underlying hardware!



Source: AUTOSAR

Short summary…
Growing importance of Information Technology in Automotive

1886
Benz Patent Motor Car

Product	0% IT
Research & Development	Calculation support
Production	0%
Marketing & Sales	0%
Aftersales	0%
Administration	Calculation support

Digital Transformation of the product and supporting processes

Photos: Daimler AG

2016
New Mercedes-Benz E-Class

Connected Product	>60% (Software)
Research & Development	>70% (Computer-Aided Engineering)
Production	>60% (Computer-Aided Manufacturing)
Marketing & Sales	>40% (Internet)
Aftersales	>30% (Diagnostics)
Administration	>70% (HR, Finance, Procurement)
…	

Vehicle Architecture

Enterprise Architecture

IBM

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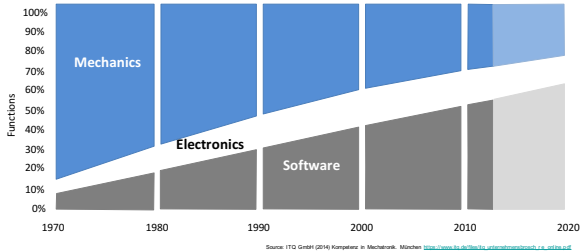
How has the car changed in a full development cycle since 2007?

Too many improvements to summarize all…



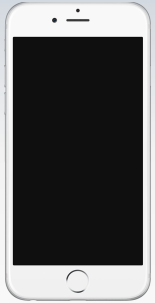
Source: ITQ GmbH (2014) Kompetenz in Mechatronik. München https://www.itq.de/files/itq_unternehmensbroschure_online.pdf

Is now really software or still hardware driving the new vehicle design?

How has the mobile, mobility and IoT changed since 2007?

The smartphone is a software-defined key to mobility!

iPhone (1st generation)
first released June 29, 2007



iPhone 6
first released Sept 19, 2014

Accelerating advances in technology…
are transforming every part of business

- **Advanced analytics**
- **Product lifecycle**
- **Cloud**
- **Pervasive connectivity**
- **Embedded sensors**

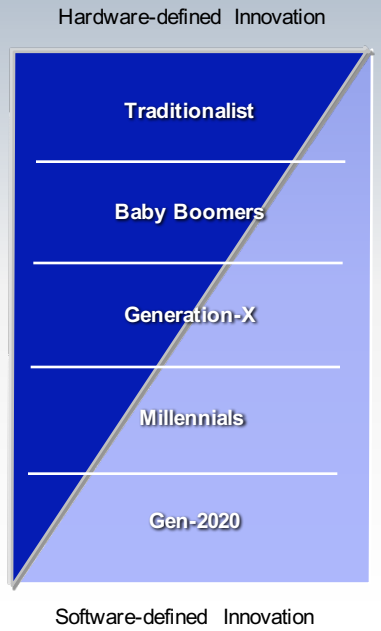
Creating new products and business models

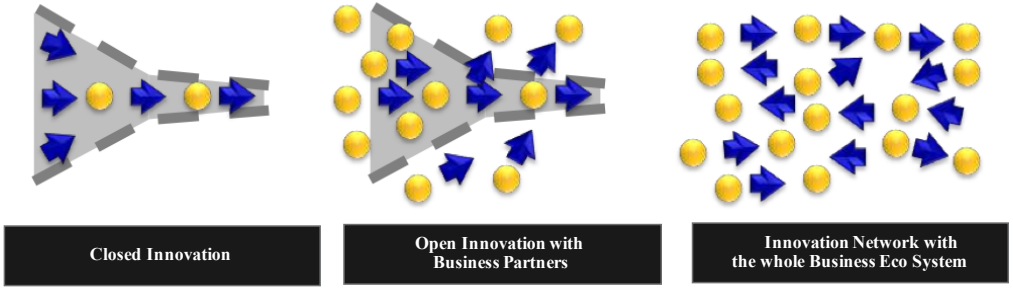
Driving engagement and customer experience

New hardware landscape defined completely by software!
The automotive industry is still not there.

…because the nature of the consumer is changing

Generation	2010	2020	Grown up	Defines Invent
Traditionalist (born <1946) Silent Generation	4%	1%	Books	Fax
Baby Boomers (1946-1964) Growth Economies Generation	38%	22%	TV	PC
Generation-X (1965-1976) Tales for an Accelerated Culture	21%	20%	PC	Mobile Phone
Millennials (1977-1997) Digital Natives (Gen-Y)	37%	50%	PC & Internet	Google & Facebook
Gen-2020 (born > 1997) Hyper connected	0%	7%	Mobile Media	iPhone Apps

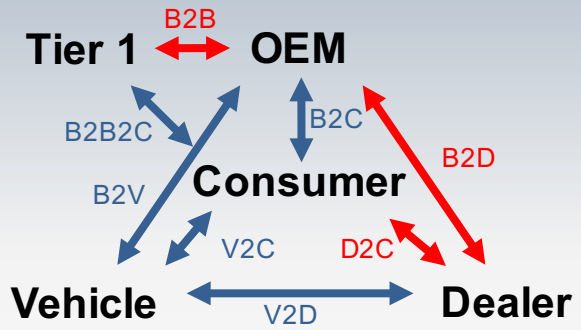




A new value network is evolving that is defined by software and data

Make and sell	→	**Sell and make**
Product-centricity	→	**Customer-centricity**
Output	→	**Performances**
Transaction	→	**Relationship**
Value delivery	→	**Value co-creation**
Competition	→	**Co-supply**
Value chain	→	**Value network**

Miraglia and Davies 2009



The Opportunity

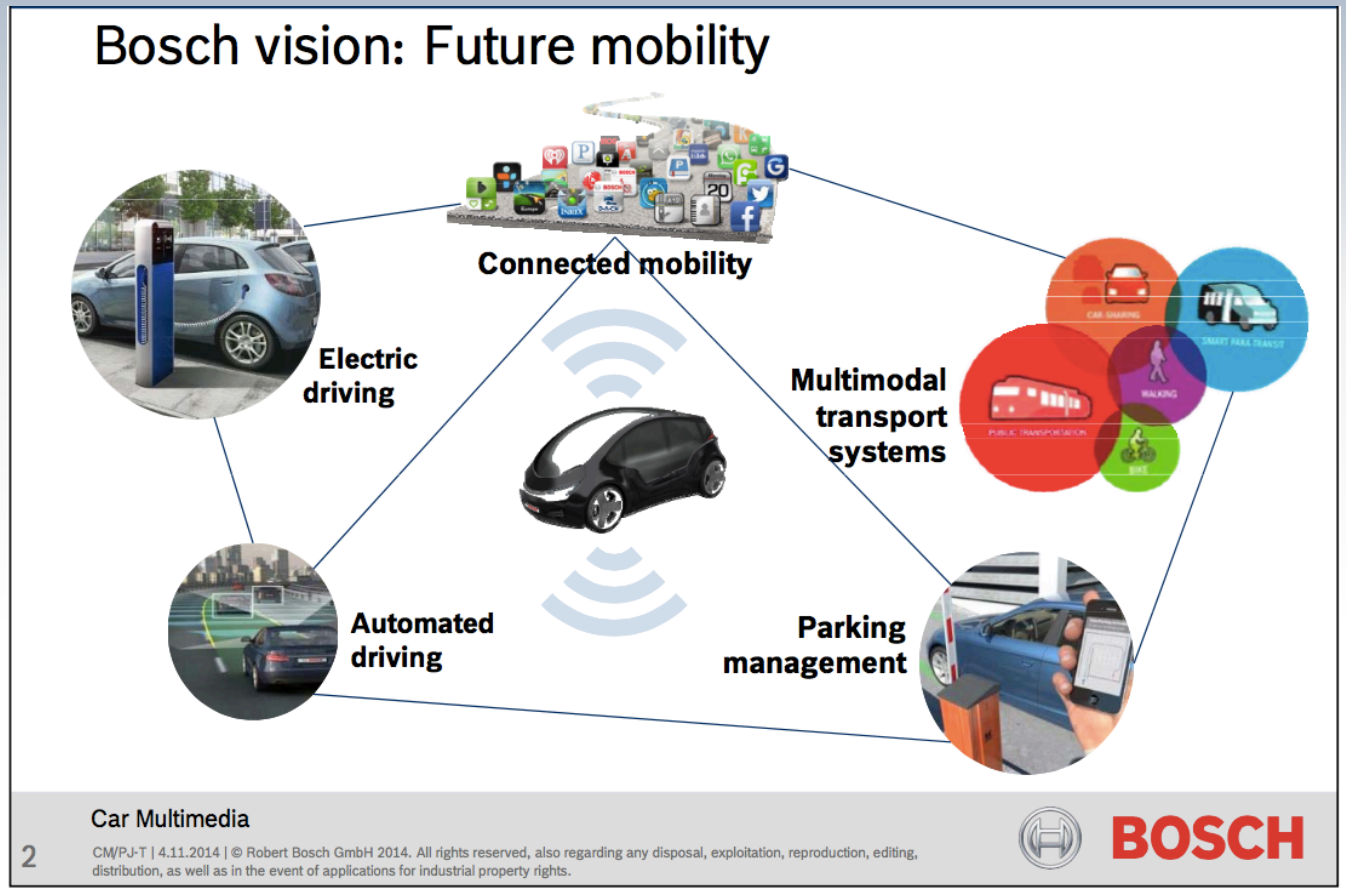
1.Digital technologies will enable OEMs to establish a much closer customer relationship.

2.In addition the "Connected Car" opens up new "Vehicle to Consumer" (V2C) and "Vehicle to Business" (B2V) relationships.

The History

Historically the Dealer-to-Consumer relationship, supported by the Business-to-Dealer relationship have been the key relationships in the automotive industry.

Example Tier 1 Supplier is changing their position in the value chain



Source: Bosch

autoMOBILE Cognitive Vehicles now and in the Future of the IoT

People and Mobility are changing, a roadmap on how to get the cognitive technologies into existing vehicles, plus design for the future

IBM

Panasonic

autoMOBILE - Moving Through Life -

All industries

The Cognitive Vehicle and the innovations in the Automotive Industry are only part of story as Cognitive moves to driving a completely new personalized Lifestyle.

All lifestyles

Just like the Dongle and Smartphone now, some type of token in the future will take your personalized experience to shopping, health, air travel, vehicle travel, recreation and more.

All brands

OEMs will use these technologies to create completely different Brand experiences, personalized to a person's preferences they carry. How you buy services, how marketing works, what you sell, and how its service will all change.

All mobility

Connecting "personal lifestyle" elements of analytics at the right time, place and context to enable the Cognitive Area with personal edge devices for vehicles.

Henry (38)

Life and work are an adventure, Henry enjoys his hectic work environment but also likes to get outdoors and face the challenges of nature.
Henry has grown up in a tech friendly world and embraces technology as long as its secure and his privacy is protected.

Henry is married and has two daughters which creates a difficult situation when it comes to the types of transportation needs he requires.

Henry is texting with friends and is excited about all the **new mobility features** coming out in vehicles, but he is struggling to see how his current model can participate.

Henry is reading on Facebook that Panasonic and IBM have an **aftermarket solution** that can enable his current AUTOmobile vehicle to gain most of the mobility features of new models.

On the way home Henry also configures OneConnect and can stream his **personalize content** into the vehicle.

On his next trip to a Quick Service Restaurant the Cognitive Dongle securely syncs and configures with the Speaker System at the Drive Thru so he doesn't need to roll the windows down while its raining and he can confirm the **mobile payment** as well.

Henry is really excited since he wants to participate in a new business model around car sharing so he can use a Jeep for outdoor fun but have the Lincoln Black Label for business and family uses and he struggles why he cannot have one vehicle that can be easily **configured with an IoT token to an outdoor Lifestyle or a luxury Lifestyle.**

The vehicle also securely syncs with Henry's Smartphone and now when he walks up to his car the doors unlocks, with **dual factor authentication.**

Online he purchases the **Panasonic and IBM Cognitive Device** which features Car Sharing, Personalized Vehicle Profile, Personalized Music, and much more.

After the simple installation and downloading the Smartphone App, Henry configures all the settings in his vehicle, from his radio to his seat. Henry also reads that in future rentals cars with this OEM he can **use the dongle to transfer the settings.**

Innovation
Cognitive IoT

A few weeks have past and the Cognitive Device has learned a lot about Henry **driving habits** and common destinations. Its also monitoring Henry's health and integrating with the health monitoring app on his smartphone. The vehicle's health is also monitored and has setup an appointment at the dealership for a quick check up.

Its Monday morning and Henry is enjoying his morning coffee while watching personalize OneConnect content on his Panasonic TV. His Device is thinking about his past journeys and can now estimate his **predicted departure time.**

Innovation
Digital Retail

OEMs are reducing recall expenses and keeping vehicle systems up to date using the **OTA** update feature.

Panasonic and IBM have built out a larger **ecosystem of partners** providing integrated mobility and personalization services for new vehicles.

Some OEMs already are working with Panasonic and IBM take the settings and configurations from the device and apply it to the new vehicle and create a more **personalized customer experience.**

For a few years now Henry and his family have enjoyed the services provided by Panasonic and IBM. As they start shopping for a new vehicle, they expecting these features are **integrated with the vehicle.**

Henry's wife is using the Car Sharing app to reserve a sports car for the afternoon so her and the girls can enjoy a day off. The Cognitive Dongle also checks the **weather and traffic** to suggest the best suited vehicle to the circumstances.

Based on Henry's work schedule and his drive time to a meeting downtown, his content is interrupted with a message to get ready to leave for his meeting. On the way to the meeting the device discovers that an event downtown has caused a parking issue and **recommends an alternative spot** for Henry's meeting.

Internet of Things is Changing the Automotive Value Chain

Core processes of the classic business model in the **AUTOMOTIVE industry.**

Development → Production → Sales → After - sales support

Digitalization of the industry

A MOVE from the AUTOmobile to the autoMOBILE

Core processes of the business model in the **MOBILITY industry.**

Procurement & Production → Sales & Digital Access → Digital Product Integration → Value - added Service & Mobility

Innovation
Connected LifeStyle

The Mobility Revolution in the Automotive Industry

Advanced analytics · Product lifecycle · Cloud · Pervasive connectivity · Embedded sensors

Innovation
B2B2C and New Business Models

Key Technologies

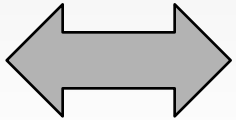
OneConnect · Watson · MobileFirst · Security

Self Socializing | **Self Configuring** | **Self Learning** | **Self Integrating**

Short summary...
Short term aim is to enable services in the vehicle as a device
Long term aim is to enable the vehicle as a personalized service space

The internet is an institution of the connected vehicle

Different business models



Different business competences

Vehicle is an integral part of the customer's personal network

Hardware-driven AUTOmobile

Software-driven autoMOBILE

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Five Key Challenges

1 Unprecedented Data Volumes

- Sensors generating new kinds of data, as well as volumes 1000's of times higher than not connected vehicles.
- Big data and machine learning required to complement traditional reporting and analytics.

2 Fundamental Shifts in Business Models

- One-time purchases being transformed into 'pay as you grow' long term revenue streams.
- Traditional manufacturing and place-based businesses must become digital-centric organizations.

3 Incompatible Standards

- **Proliferation in competing platforms and incompatible standards raises costs and complexity,** security **risks, and time-to-market for data-driven innovators.**

4 Entirely New Security Threats

- Unknown devices connecting vehicles.
- Automobiles and connected plants are under growing attack.

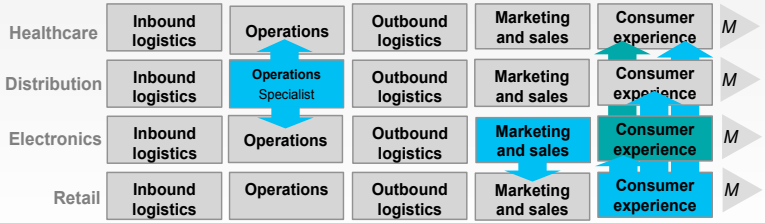
5 New Privacy Landscape

- **Collecting physical world data on people and objects.**
- **Market is slow grasping implications - stiffer regulations are likely.**

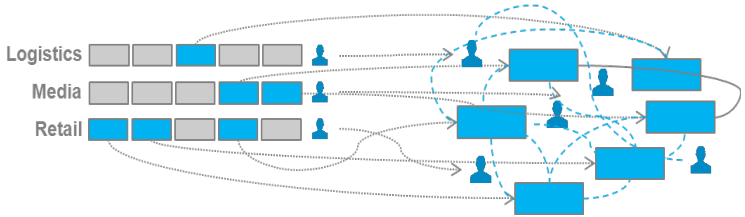
New and emerging technologies will combine to transform industries

Value chains will fragment

Industries will converge



Ecosystems will emerge

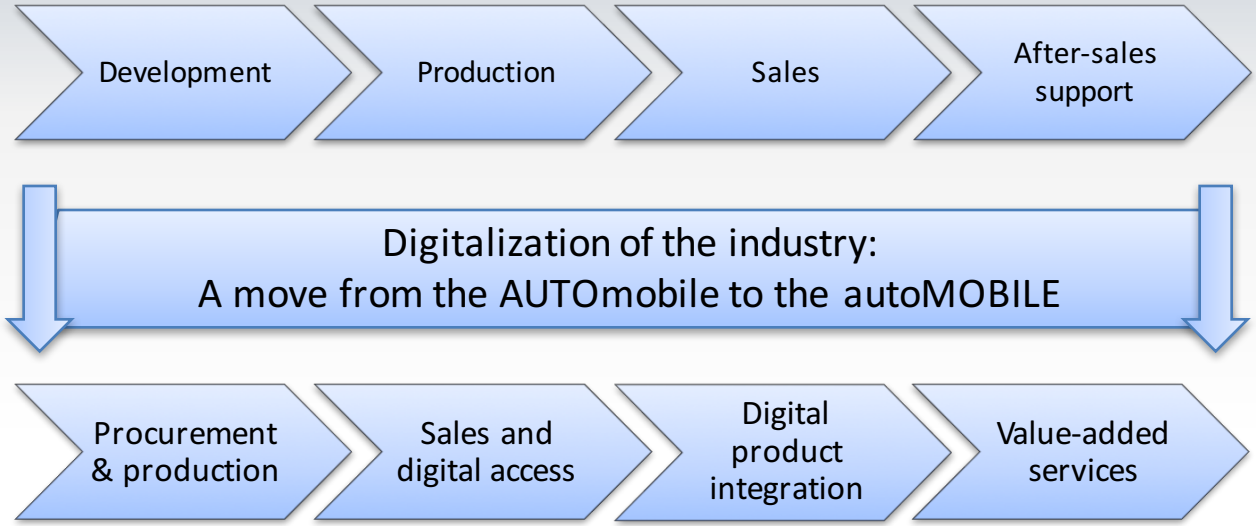


Source: IBM Institute for Business Value – Digital Reinvention

The value chain is changing

AUTOmobile in order to emphasize 'Auto' – the German word for car

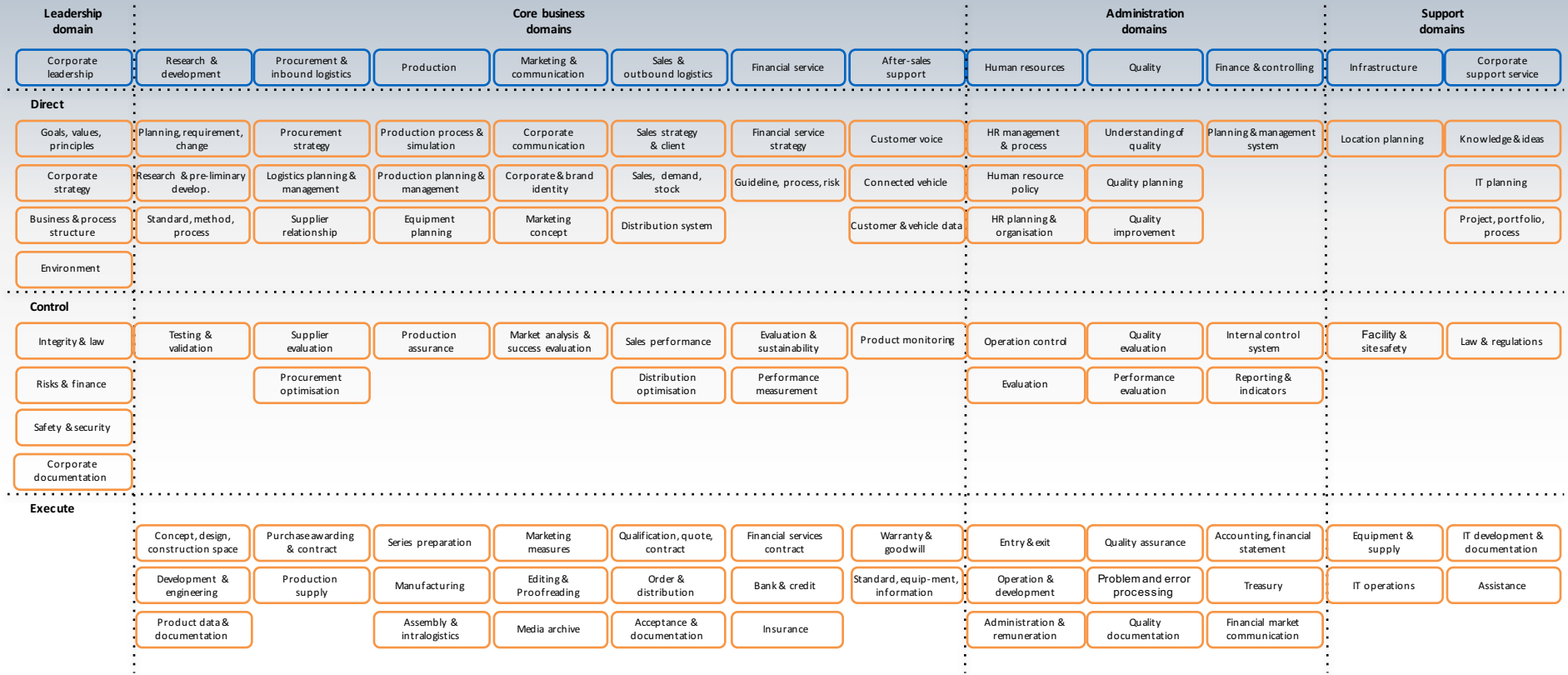
Core processes of the classic business model in the automotive industry



Core processes of the business model in the mobility industry

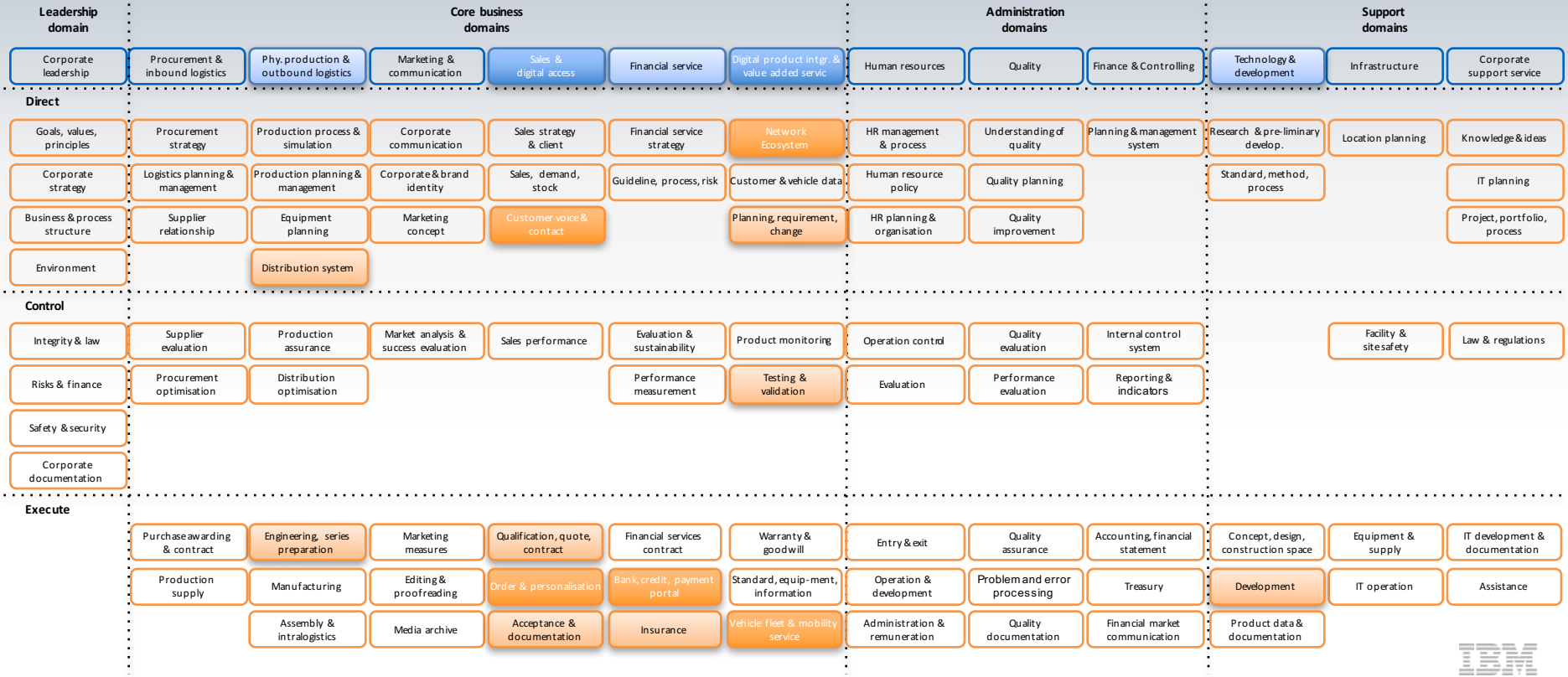
autoMOBILE to emphasize the mobility of travelling from one place to another

Today, 89 business competencies in the automotive industry



Business competencies of the changing business architecture for the autoMOBILE value chain

Primary focus on building up digital and mobility competencies



…further details

The Mobility Revolution in the Automotive Industry: How not to miss the digital turnpike!

The Internet of Things, Cloud Computing, Connected Vehicles, Big Data, Analytics – what does this have to do with the automotive industry? This book provides information about the future of mobility trends resulting from digitization, connectedness, personalization and data insights. The automotive industry is on the verge of undergoing a fundamental transformation. Large, traditional companies in particular will have to adapt, develop new business models and implement flexibility with the aid of appropriate enterprise architectures. Transforming critical business competencies is the key concept. The vehicle of the digital future is already here –who will shape it?

http://www.amazon.co.jp/dp/4627486316
http://www.amazon.com/dp/3662477874
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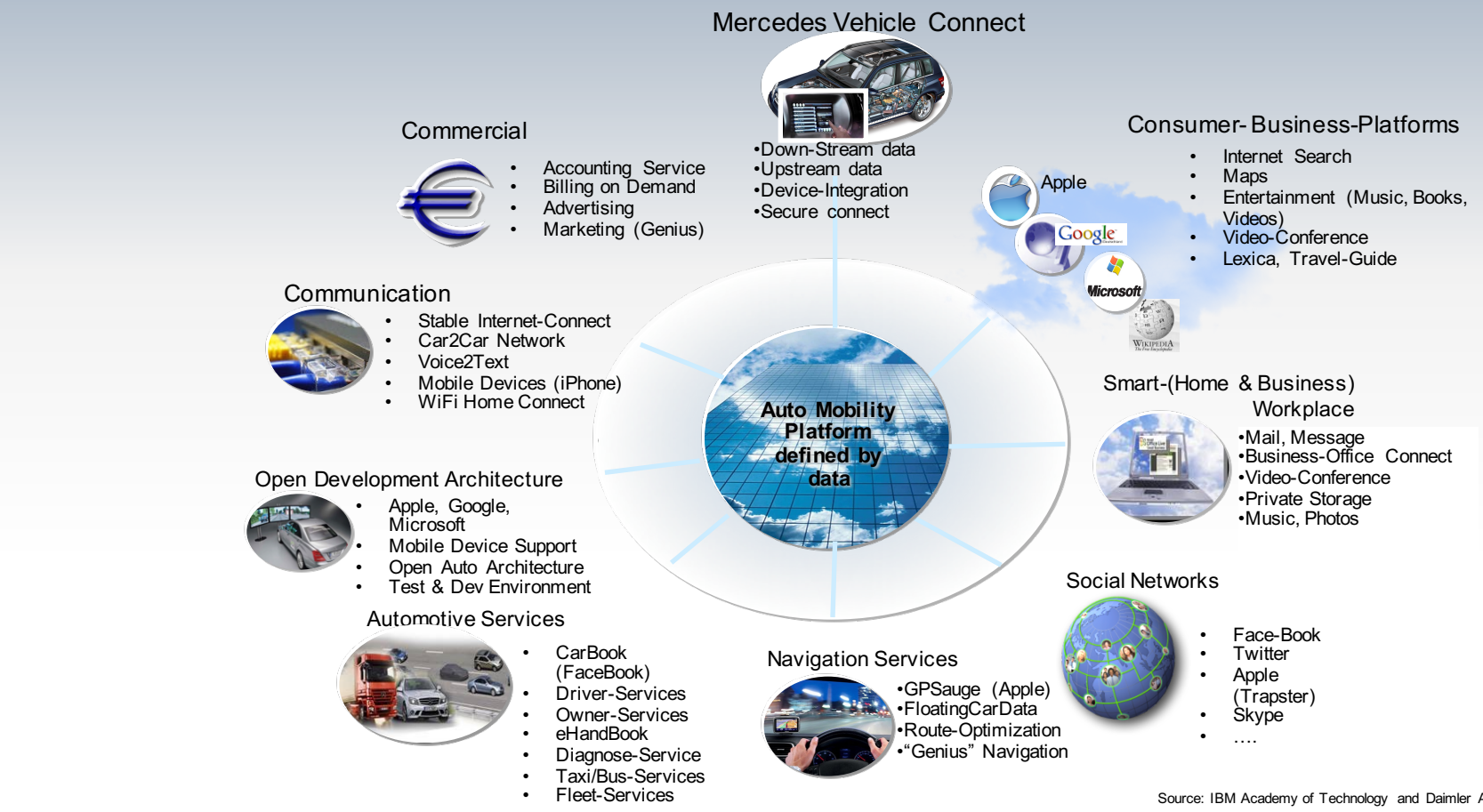
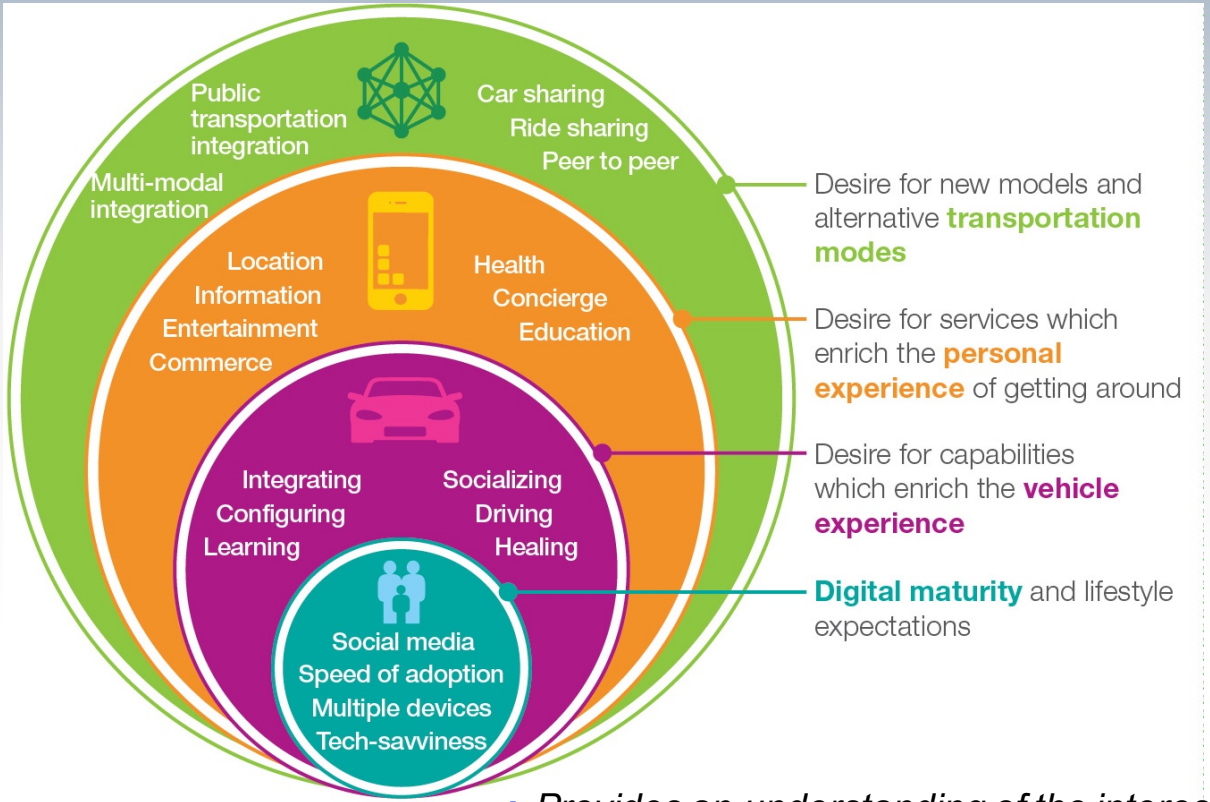
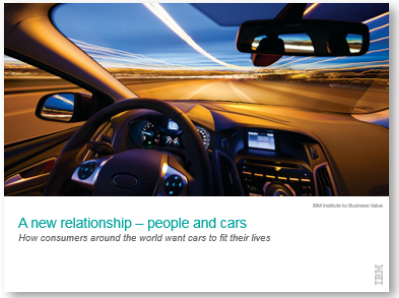
Potential Mercedes services defined 2009 – Common is data



Source: IBM Academy of Technology and Daimler AG

Technologies & data trends which were NOT discussed in 2009





Provides an understanding of the interest, attitudes and expectations consumers will have for future mobility solutions

Source: IBM Institute of Business Value

IBM

June 9th, 2016 – Daimler Chief Executive Dieter Zetsche and Uber Chief Executive Travis Kalanick were interviewed together

Photo: dpa

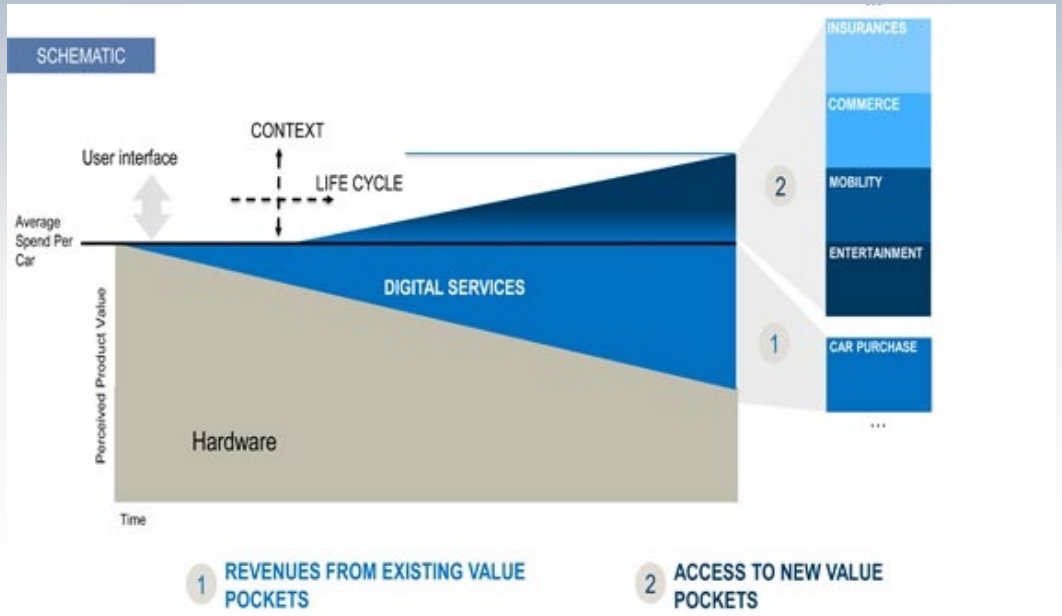
Now roughly equal in value (stock market capitalization):
German luxury car maker Daimler $70B
Silicon Valley ride-sharing firm Uber $62.5B

Daimler AG (Karl Benz) invented the first automobile
Uber disrupted taxi business through new mobility services

Uber founded 2009
Daimler predecessor Daimler-Benz founded 1926
(1883-1926 Benz & Company, 1890-1926 Daimler Motoren Gesellschaft AG)

The challenge: *How is Uber organized? How is Daimler organized?*
Where is the Chief Digital Officer aligning the product integration to a data-defined vehicle?

Relevance of digital experiences is continuously increasing

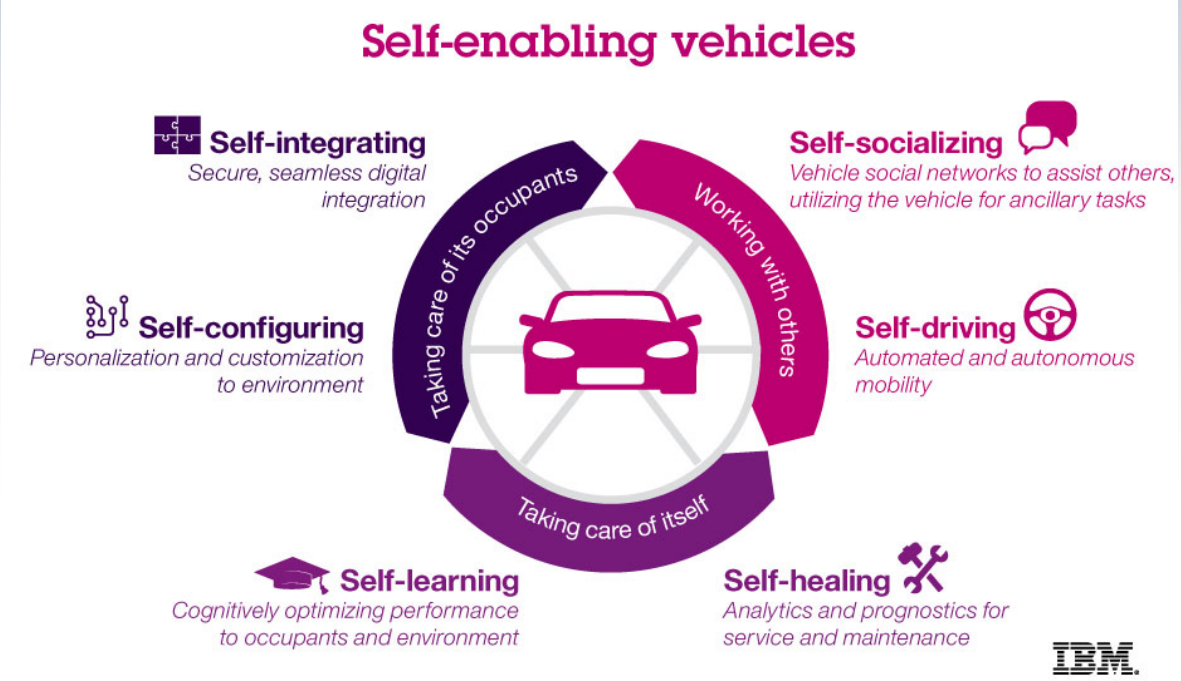


Source: BMW

The challenge:

Where is the Chief Digital Officer aligning the product integration to a data-defined vehicle?

Short summary…
The Chief Digital Officer aligns the *digital product integration* to a data-defined vehicle



IBM Institute for Business Value, "The New Hero of Big Data and Analytics, The Chief Data Officer", June 2014

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Computers and the brain are different and complementary

~5 GHz, sequential, linear	10 Hz, parallel, high fan-out
100 W/cm^2	10 mW/cm^2
Separates memory, computation, communication	Integrates memory, computation, communication

Eras of computing

System Intelligence

Tabulating

Punch cards

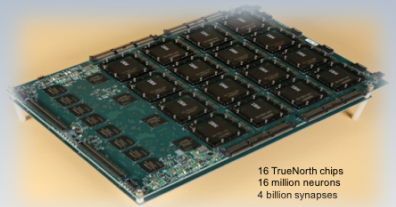
Time card readers

1900

Programmable

Search	Discovery
Deterministic	Probabilistic
Enterprise data	Big Data
Machine language	Natural language
Simple outputs	Intelligent options

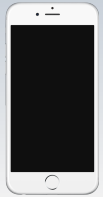
1950



Cognitive

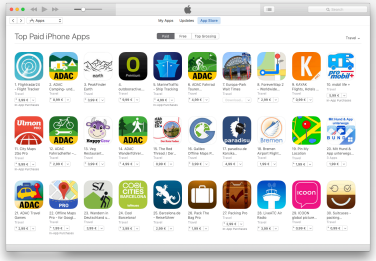
2011

The digitalization is changing the product architecture in 3 different data areas to make it more intelligent



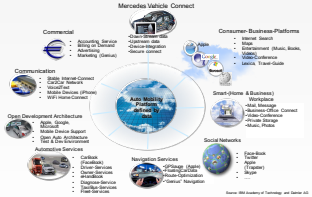
iPhone

Drive architecture



Apps

Ecosystem



iCloud

Life architecture

Photos: BMW, Daimler

IBM

Data-defined Vehicle: Risks regarding endangering reputation / brand value

Google Executive Chairman Eric Schmidt said:

"Google's policy is to get right up to the creepy line but not to cross it"

CONSUMER DATA INSIGHTS

Customer data

Vehicle as a personalized space

Driving as a service

Photos: Google

Why do I need to own a car?

Why do I need a separate vehicle insurance?

Why do I need parking?

Can I change the individualization of the car per ride?

Getting from A to B might be free of charge

Patent 8.630.897
Transportation-aware physical advertising conversations

My creepy line "buy product" vs. "use product and support data business"

Vehicle data

Drivers

PRODUCT INSIGHTS

Safety is critical

Engineering challenge

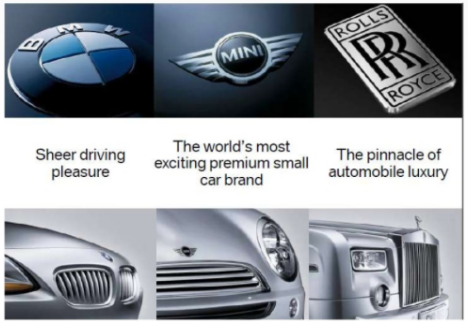
Driving remains with the car

Photos: BMW

Durable & reliable engines

Advanced Driver Assistance Systems

Source: BMW – Redefining Premium Brand Identity



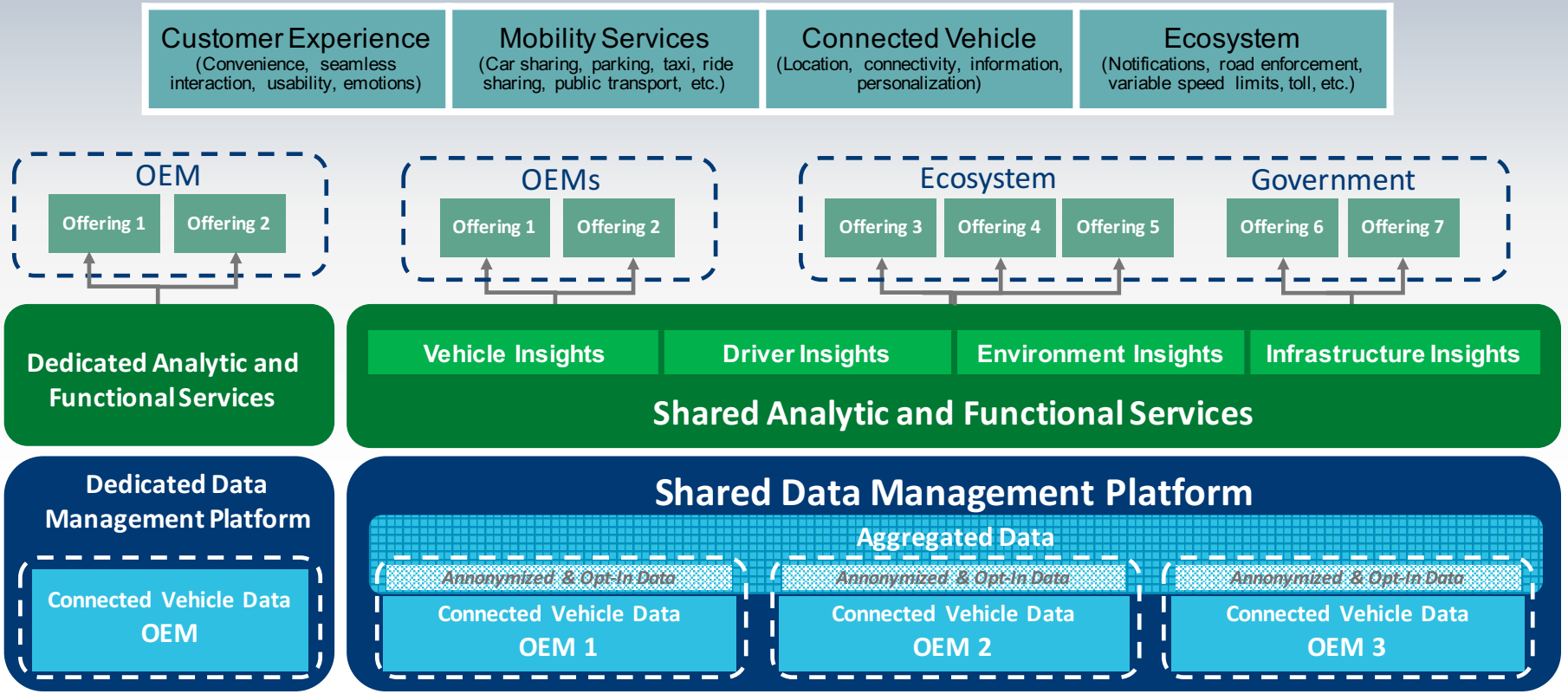
Traditional brand values: comfort, safety, longevity, reliability, …

IBM

How will a data-defined vehicle be produced?
“Road Ready 3D-Printed Car”

Photo: Local Motors

OEM need to create the data-defined vehicle themselves or together with new types of partners



Short summary…
Guiding principles of a data-driven architecture to provide mobility as a service in a cognitive era

AUTOmobile	→	autoMOBILE
business rely on selling an integrated product	→	business designed for relationship to consumer
designed by market	→	designed to be globally available
build as an integrated system	→	continuously integrate services
one product lifecycle	→	three separate lifecycles
defined by the mechanical engine	→	defined by the personal space to overcome spatial distances
capture data for engineers to improve product	→	data designed to serve consumers
real vehicle bill of material	→	virtual vehicle bill of material
components and systems programming	→	machines are learning

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AEA Association of Enterprise Architects