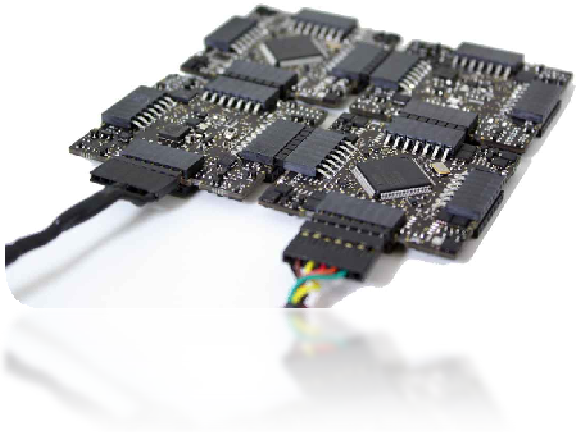

Embedded Electronic Systems

A success story for the German job market

Michael Römer

Münchner Kreis, November 17th, 2010

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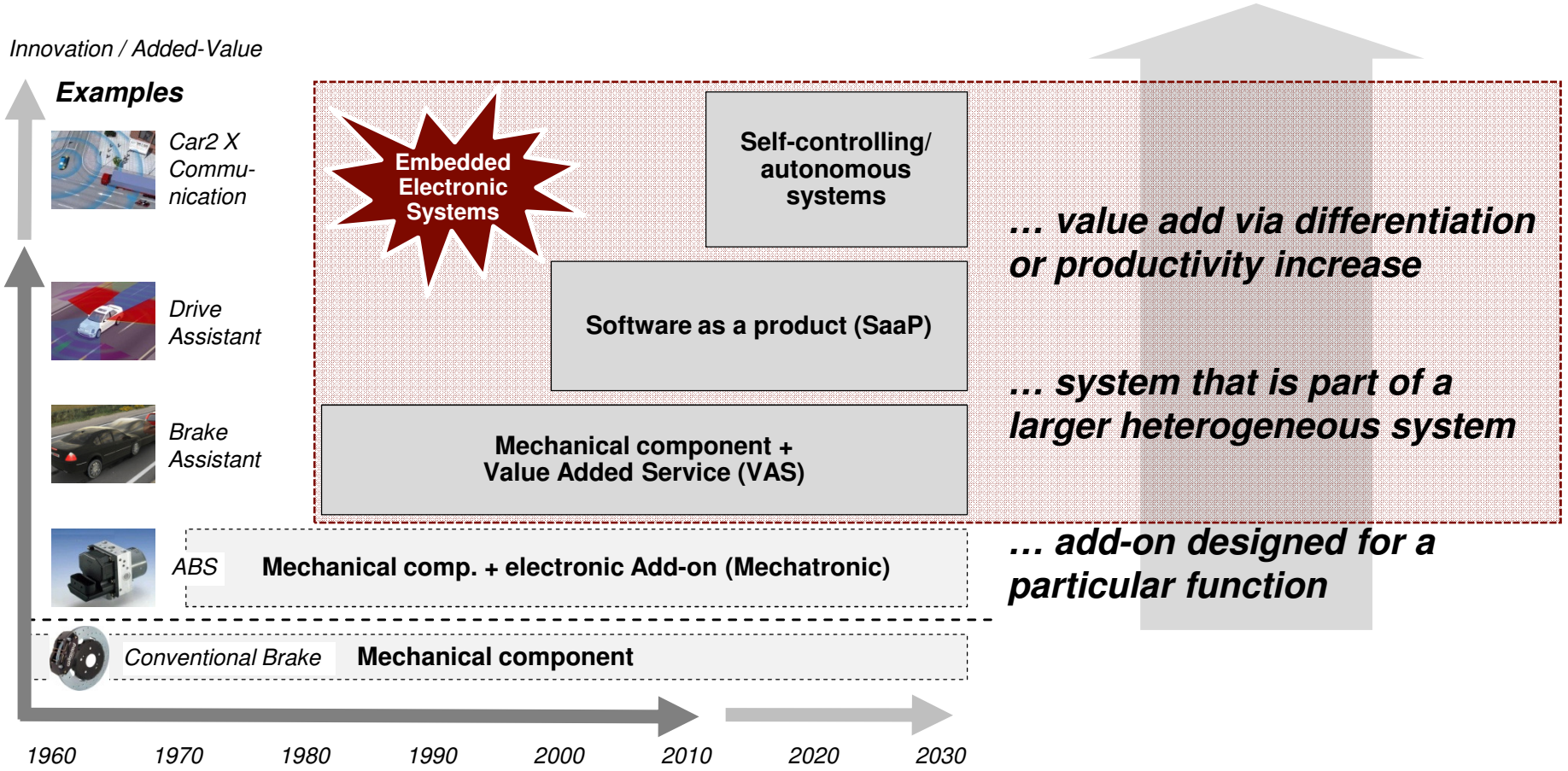
Embedded Electronic Systems (EES) stand for a wide variety of devices and services

Characteristics of embedded electronic systems (EES)



Source: A.T. Kearney Embedded Systems Study 2010

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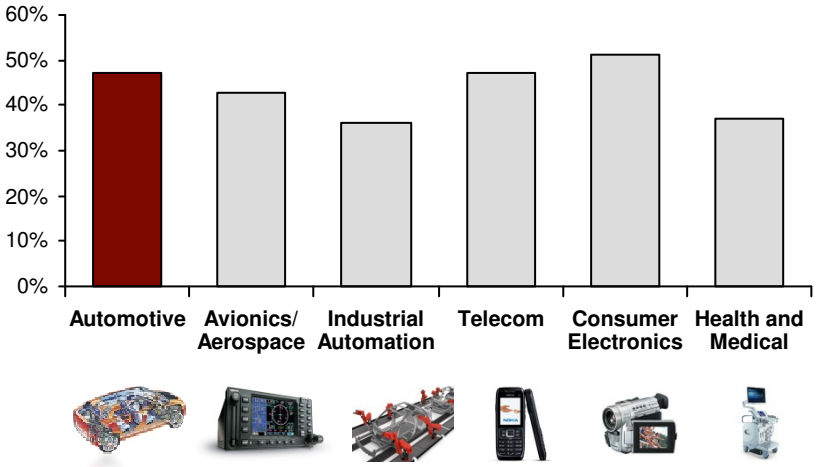
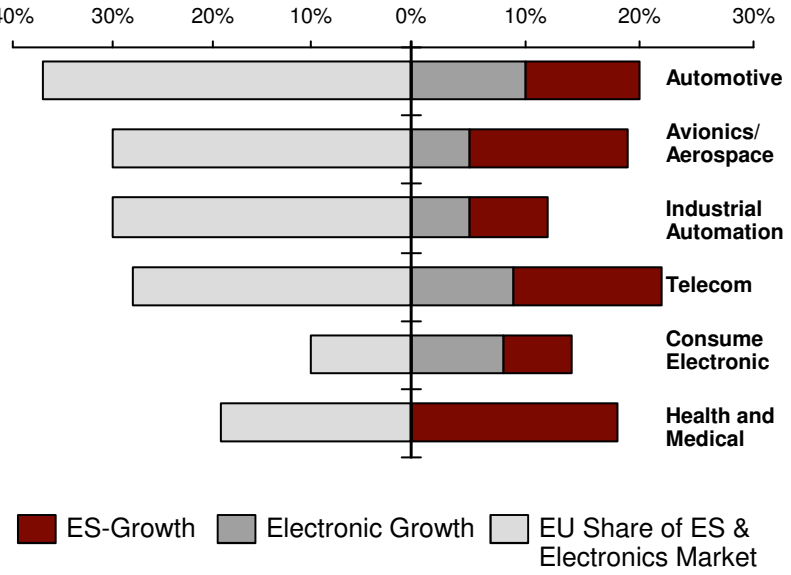
The growth potential across all sectors is above 10%

Share of EES in the cost of the final product or service



European share in the electronic market and market growth of electronic compared with growth of ES



A high share of the final products' price is represented by the costs of Embedded Systems' development and implementation.

Source: FAST-TUM; A.T. Kearney Embedded Systems Study 2010

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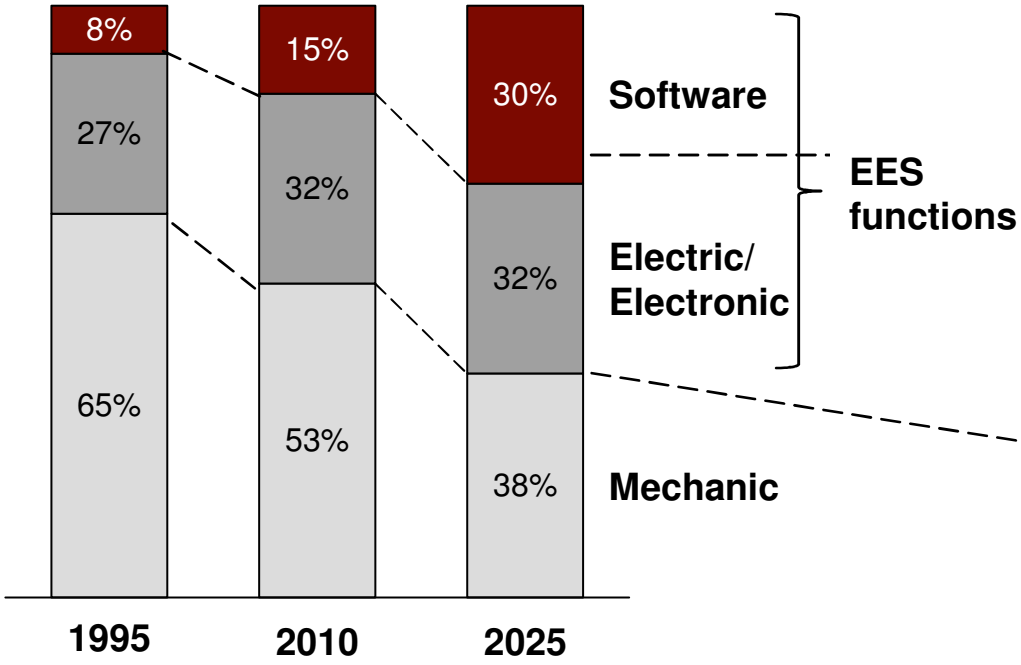
In Automotive EES functions increase in share of value add per vehicle to 60% in 2025

Development of share in EES cost of the final product for automotive

Automotive Case Example



- Software instead of hardware
- Software offerings will enable new revenue streams (e.g. pay per use, product add-on via remote update)
- Electric & Electronic (E&E) components as essential precondition for software components and -mobility
- Currently ~€ 150 bn of E&E components are build each year with a prospect growth of 6% p.a.
- Not anymore the key differentiator
- Will be sourced as commodity

Source: A.T. Kearney Embedded Systems Study 2010

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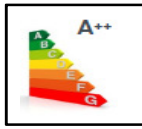
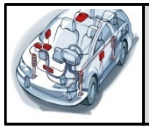
Especially high performing cars are characterized through a strong growth of EES components

Embedded systems development in Automotive



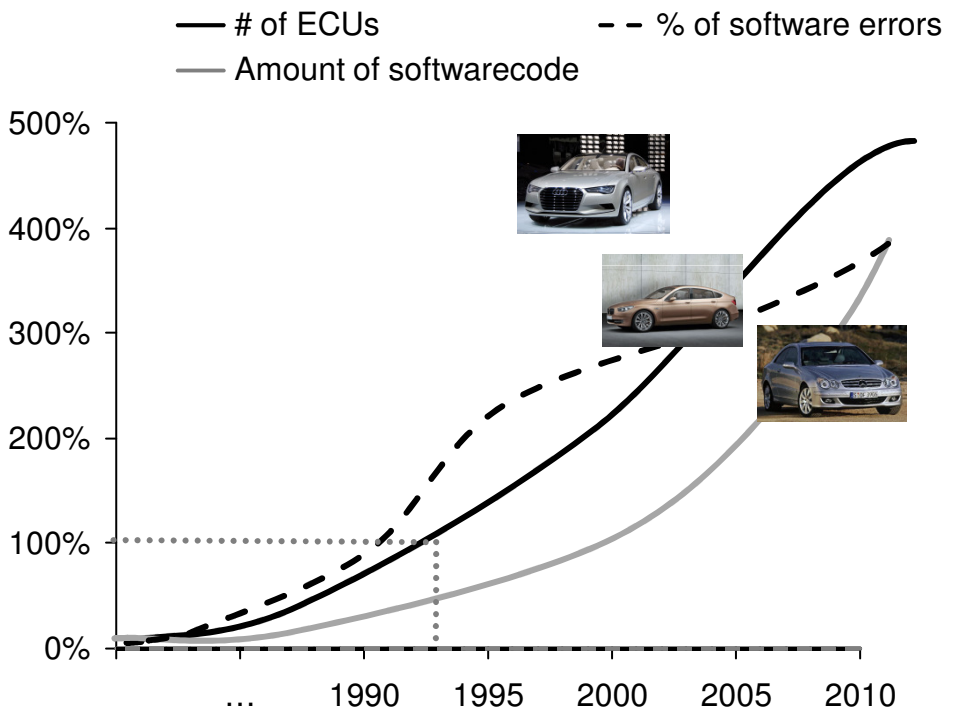
Efficiency control systems

Car Multimedia (Navigation system, …)



Control units (Throttle & break control, …)

Drive assistance systems (Lane assist, ACC, …)



More than 80% of innovation, and therefore of added value, will be obtained thanks to Embedded Electronic Systems

Source: A.T. Kearney Embedded Systems Study 2010

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The need for system integration, new car services and sustained mobility will drive further growth

Growth drivers for Embedded Electronic Systems

New Consumer Services

- Convergence between personal and mobility service
- Growing importance for young consumer
- **Example:** Convergence of Telco, Utility and Auto Services

Sustainability Services & Mobility Concepts

- Conservation of natural resources. Sustained mobility.
- Growing demand for individual mobility - smaller city cars
- **Example:** E-Mobility, Hybrid Cars, Fuel Cell, energy efficiency

New Car Services

- Car efficiency and security is product differentiating
- Growing number of innovative product offerings
- **Example:** park assistance, Car2x, autonomous vehicles

Integration Service

- 10-15% growth within a car software code each year
- 80% supplier issues are software and hardware related
- **Example:** System modularization, “0”-Bug-Development- Processes

Source: A.T. Kearney Embedded Systems Study 2010

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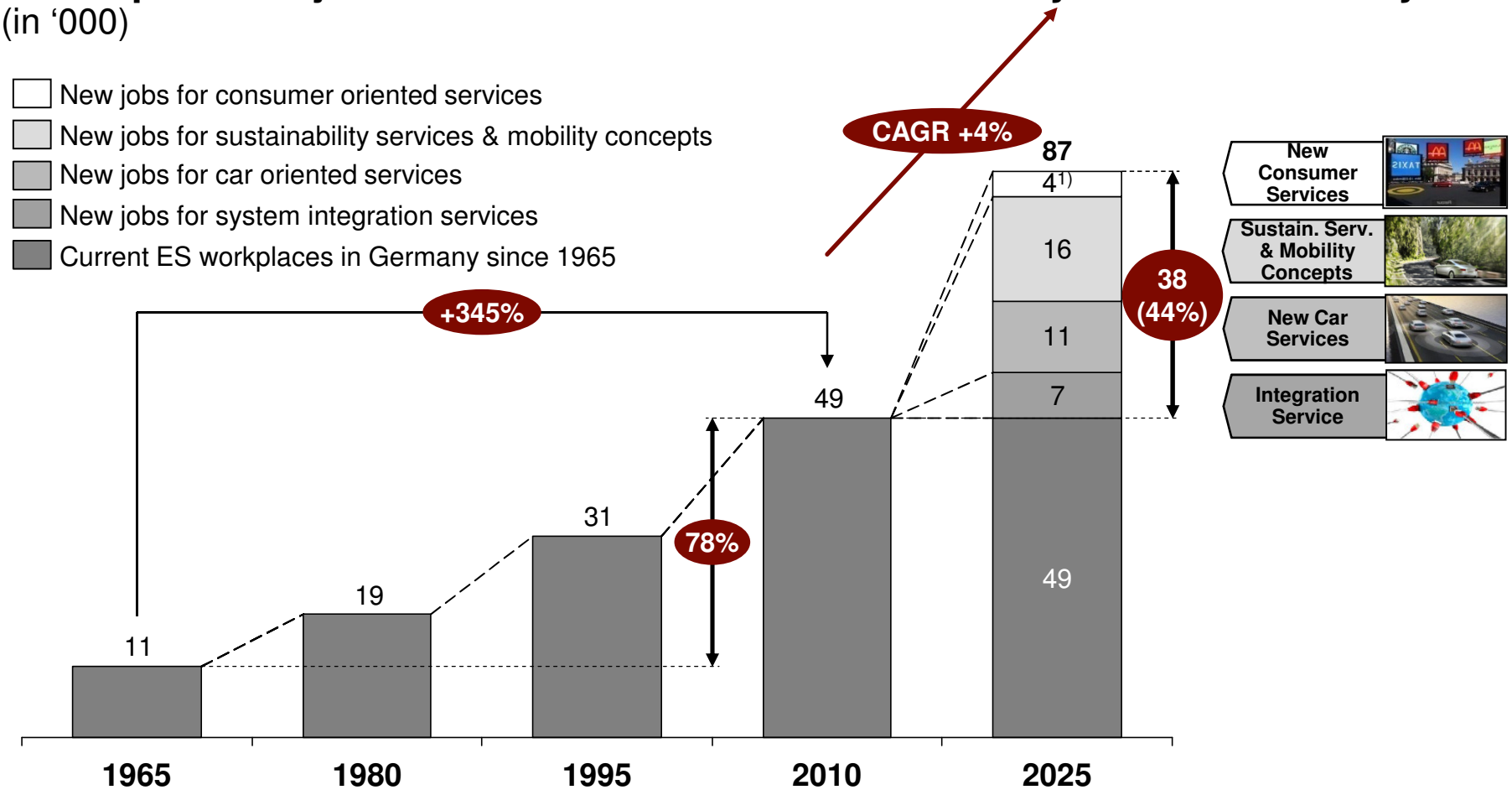
We expect that this growth can create ~40,000 new jobs in the German Auto industry by 2025

Development of jobs related to Embedded Electronic Systems in Germany
(in '000)

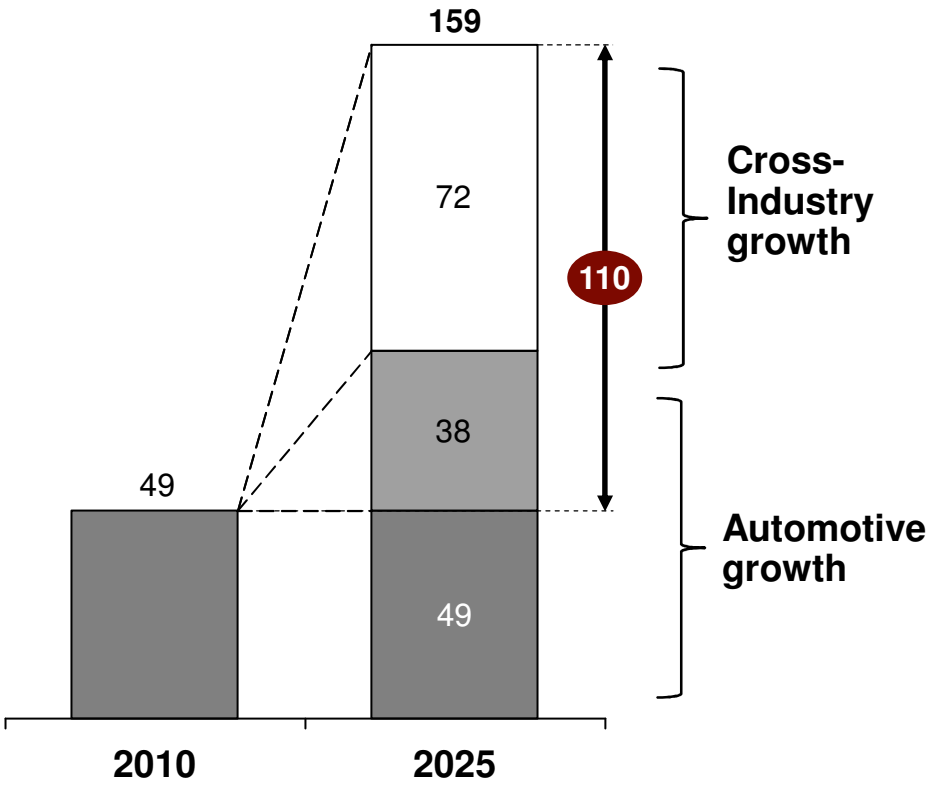


1) New jobs for "New customer services" may not only be created in automotive industry but also industries with access to customers
Source: A.T. Kearney Embedded Systems Study 2010, Bitkom

ATKEARNEY

Across industries we estimate a potential in Germany of ~110,000 new jobs

Expected cross-industry job development through Embedded Systems
(in '000)



Exemplary growth fields

Medical appli-cations		Strong growth in new diagnostic tools or telemedicine
White goods		• Intelligent programs in washing machines, etc. • Network access for selected appliances
Facility manage-ment		• Intelligent facility mgt. • Energy management through smart metering
Home entertain-ment		Strong growth in functionality (e.g. Internet via TV)

Source: A.T. Kearney Embedded Systems Study 2010

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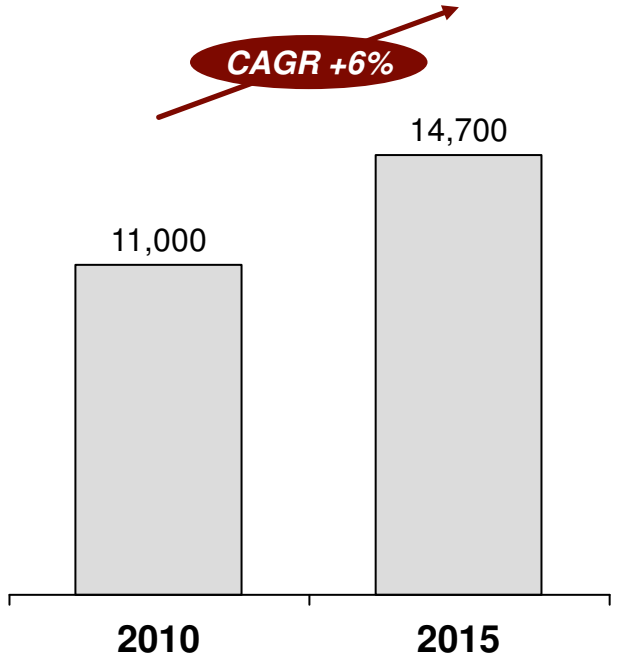
Healthcare is leading and investing significantly in new diagnostic tools and telemedicine systems

Example growth in medical applications

- Importance of EES has significantly increased over the last years: **48% of R&D activities** in Medical Technology
- Various application areas and services could be **primary enabled by EES**:
  - New diagnostic tools
  - High-frequency surgery
  - Ambient assisted living
  - Health insurance cards
- Revolutionary shift to Embedded Systems has initiated **job boost of highly skilled personnel**

Embedded Systems R&D related jobs in German Medical Technology



Source: A.T. Kearney Embedded Systems Study 2010, ZVEI, SafeTrans

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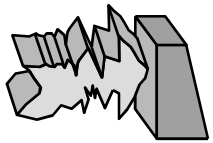
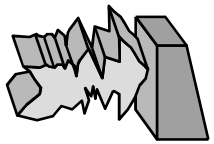
However there are still barriers that delay the breakthrough

Major EES growth barriers

A Consumer Perspective	Example
■ Unclear use cases, complex services	■ Many functionalities are confusing/not needed, usability not intuitive
■ Security of data	■ Storage of personal data especially with access to internet
■ Only for premium products	



B Company Perspective	Example
■ Lack of architecture standards and product modularization	■ R&D budget for Embedded Systems not adequate
■ Limited number of experienced architects and developers with industry know-how	■ Lack of architecture standards leads to not manageable complexity
■ Products consumer are willing to pay for?	



Source: A.T. Kearney Embedded Systems Study 2010

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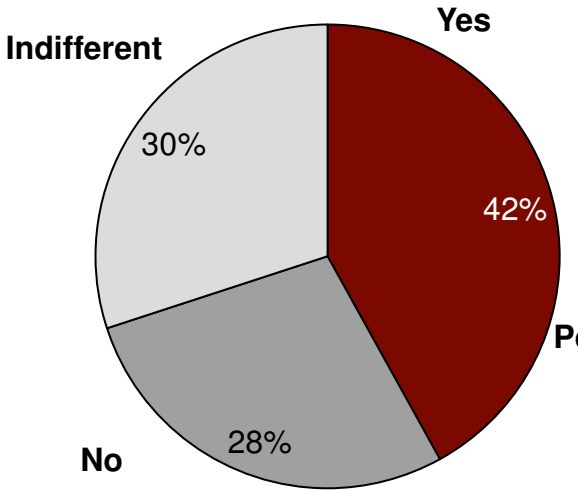
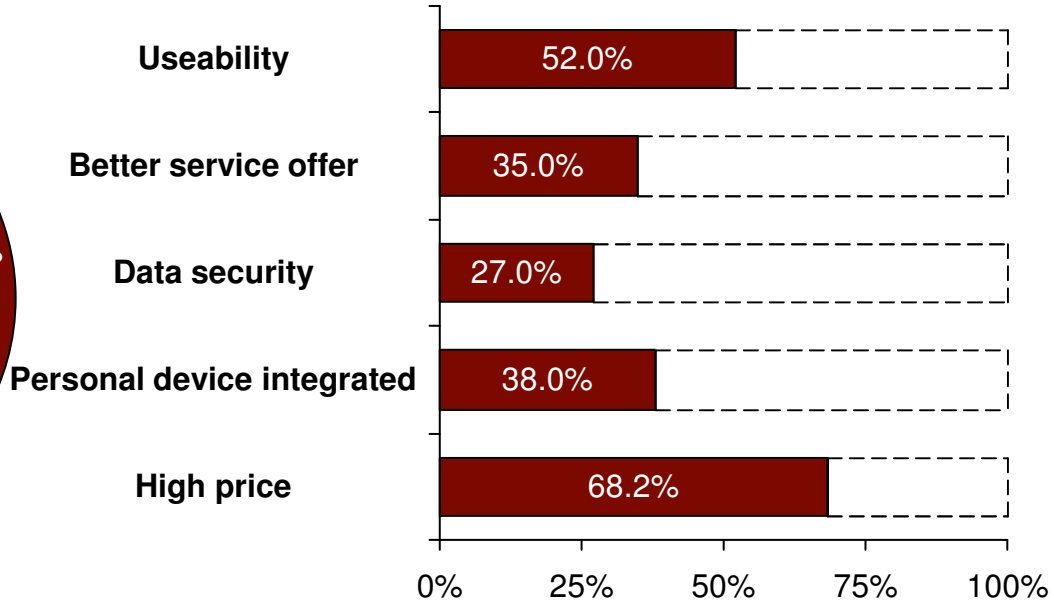
Consumer mainly perceive the EES offerings as to complex and to expensive

A Consumer perspective on Embedded Electronic Systems

Willingness to pay an extra fee per service?



How could consumer oriented services be improved?



There is a lack of consumer awareness on what's possible

Source: A.T. Kearney Embedded Systems Study 2010

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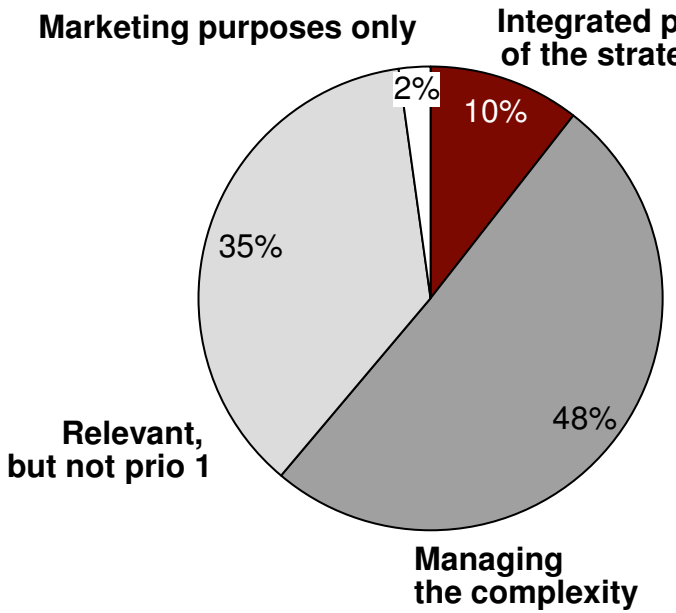
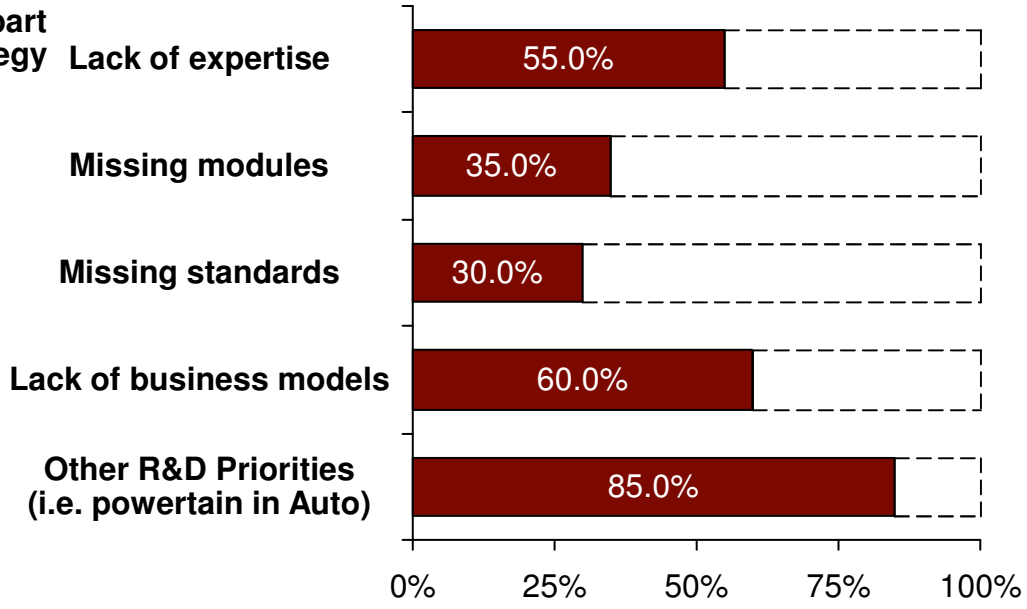
Embedded systems are on the CXO agenda, however R&D priorities are still not under the Top 3

B Company perspective on Embedded Electronic Systems

How do you rank the Embedded Systems' role in your strategy?



What prevents OEMs to invest more in Embedded systems?



There is still a lack of awareness, as the business case is not clear

Source: A.T. Kearney Embedded Systems Study 2010

ATKEARNEY

Additionally, job growth requires the right skill set starting with a strong academic and practical industry background

Status quo: Training the right resources

- Some graduate programs in Germany offer special courses or whole master studies for EES with a **limited number of places**
  - HS Aschaffenburg
  - OFFIS e.V.- Oldenburger Institut für Informatik
  - Fraunhofer FIRST – Berlin
- However, **only a few graduate schools offer a full study program** for EES, e.g. HS Mittweida
- Besides hard- and software design the programs also focus on getting **practical industry background**

Source: A.T. Kearney Embedded Systems Study 2010

A.T. KEARNEY

The German industry should leverage it‘s starting position and participate from strong growth of Embedded Systems

Call for action

- **Focus**
  - Drive customer-centric innovation and develop new products and services in two areas
    - Integration services
    - New product/consumer related services
  - Focus on value add of the customer
- **Collaborate**
  - Develop innovative business models and position correctly within the value chain
  - Collaboratively develop applications even outside from the industry i.e. automotive
- **Education**
  - Industries and Universities should collaborate closer to improve the relevant academic and practical industry background of students
  - Go further and start image campains at schools

Source: A.T. Kearney Embedded Systems Study 2010

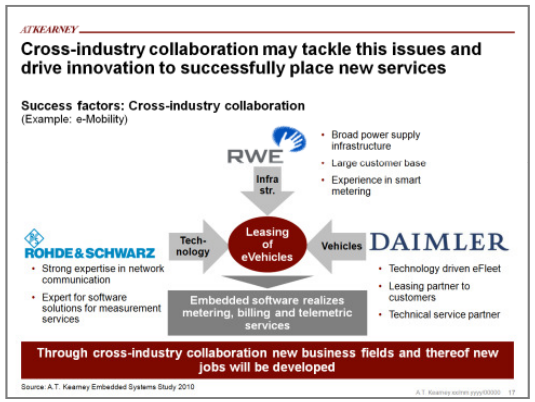
A.T. KEARNEY

Backup

To tackle these issues an innovative and collaborative industry set-up should be targeted

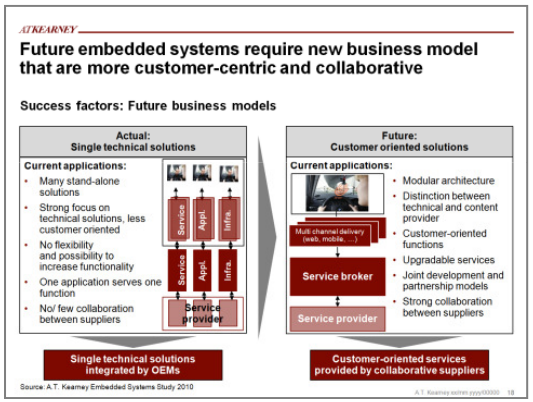
Success factors for future growth

Cross industry collaboration



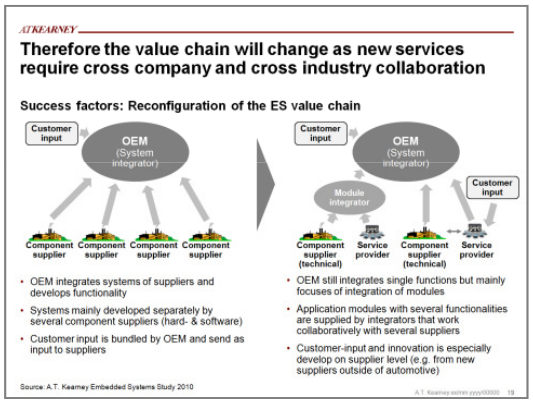
- Development of innovative services through cross industry expertise

New business models



- Development of new business models/ players with strong focus on consumer needs

Right value chain



- Define whats core and foster cross company and cross industry collaboration

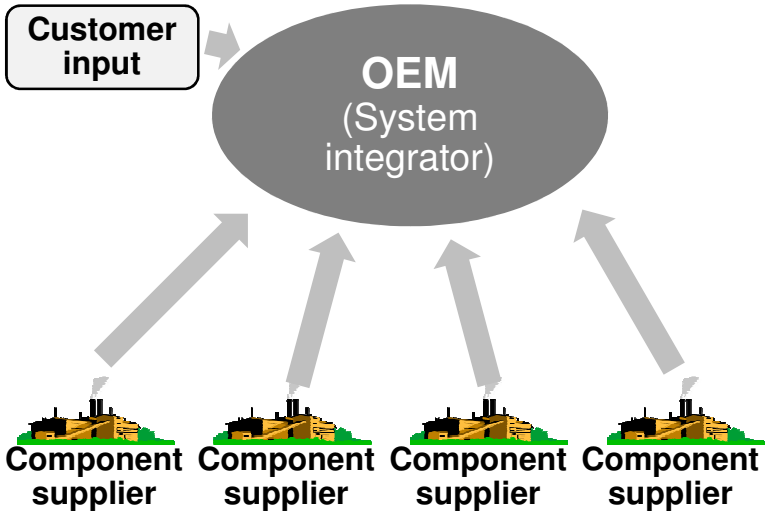
Strong focus innovation and consumer-centric development is key

Source: A.T. Kearney Embedded Systems Study 2010

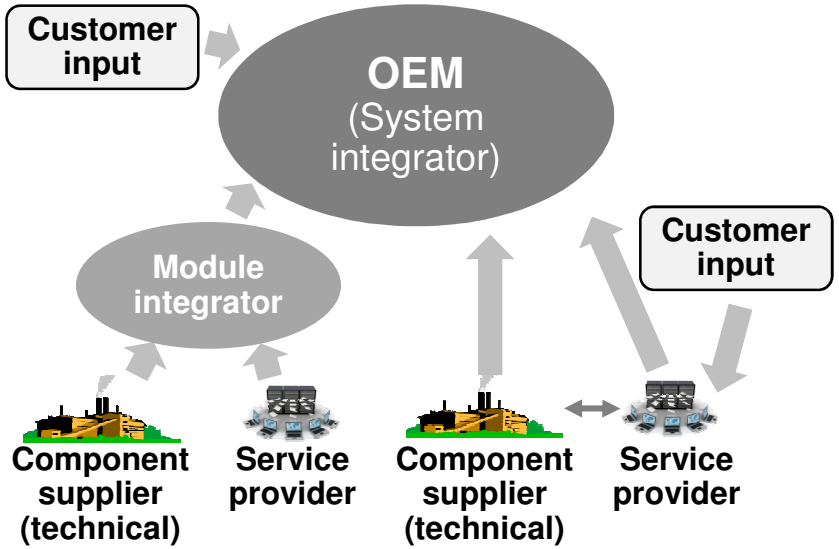
A.T. KEARNEY

Therefore the value chain will change as new services require cross company and cross industry collaboration

Success factors: Reconfiguration of the ES value chain



- OEM integrates systems of suppliers and develops functionality
- Systems mainly developed separately by several component suppliers (hard- & software)
- Customer input is bundled by OEM and send as input to suppliers



- OEM still integrates single functions but mainly focuses of integration of modules
- Application modules with several functionalities are supplied by integrators that work collaboratively with several suppliers
- Customer-input and innovation is especially develop on supplier level (e.g. from new suppliers outside of automotive)

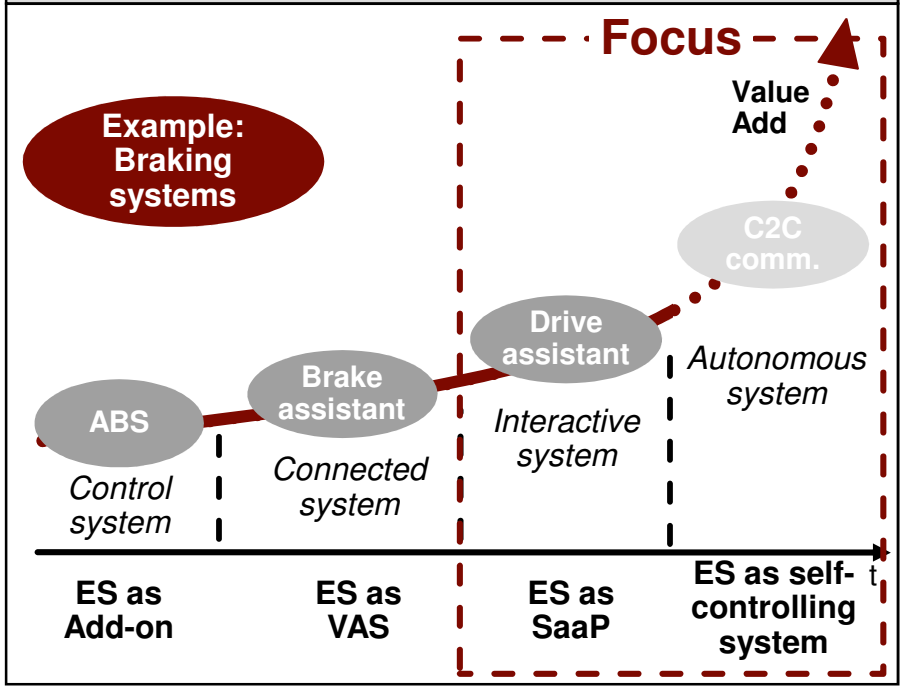
Source: A.T. Kearney Embedded Systems Study 2010

ATKEARNEY

The notion of Embedded Systems is rather diverse – This study focuses on interactive- and autonomous systems

Scope and Definition

Development of Embedded Systems



Characteristics of Embedded Systems

- Embedded systems are designed to do some specific task, rather than be a general-purpose computer for multiple tasks.
- Some also have real-time performance constraints that must be met, for reasons such as safety and usability;
- Others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs.
- Embedded systems are often part of a complete device including software, hardware and mechanical components

What are the opportunities for the German job market?

Source: BITKOM; A.T. Kearney Embedded Systems Study 2010

The notion of Embedded Systems is rather diverse and stands for a very wide variety of devices and systems

Characteristics of Embedded Systems

- Embedded systems are some combination of computer hardware, software and mechanical components, either fixed in capability or programmable.
- It is a dedicated system that is often an important part of a larger heterogeneous system.
- Embedded systems are designed for a particular function, rather than being a general-purpose computer for multiple tasks.
- Some also have real-time performance constraints that must be met, for reasons such as safety and usability;
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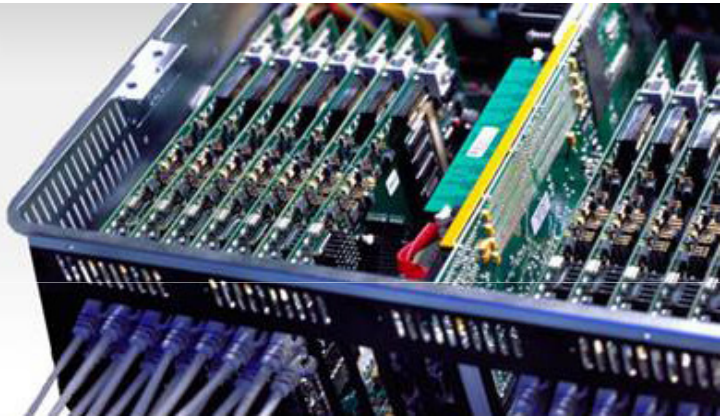

As the word "Embedded" implies, these systems are "hidden" in a hosting system and their impact is therefore often not immediately measurable.

Source: BITKOM; A.T. Kearney Embedded Systems Study 2010

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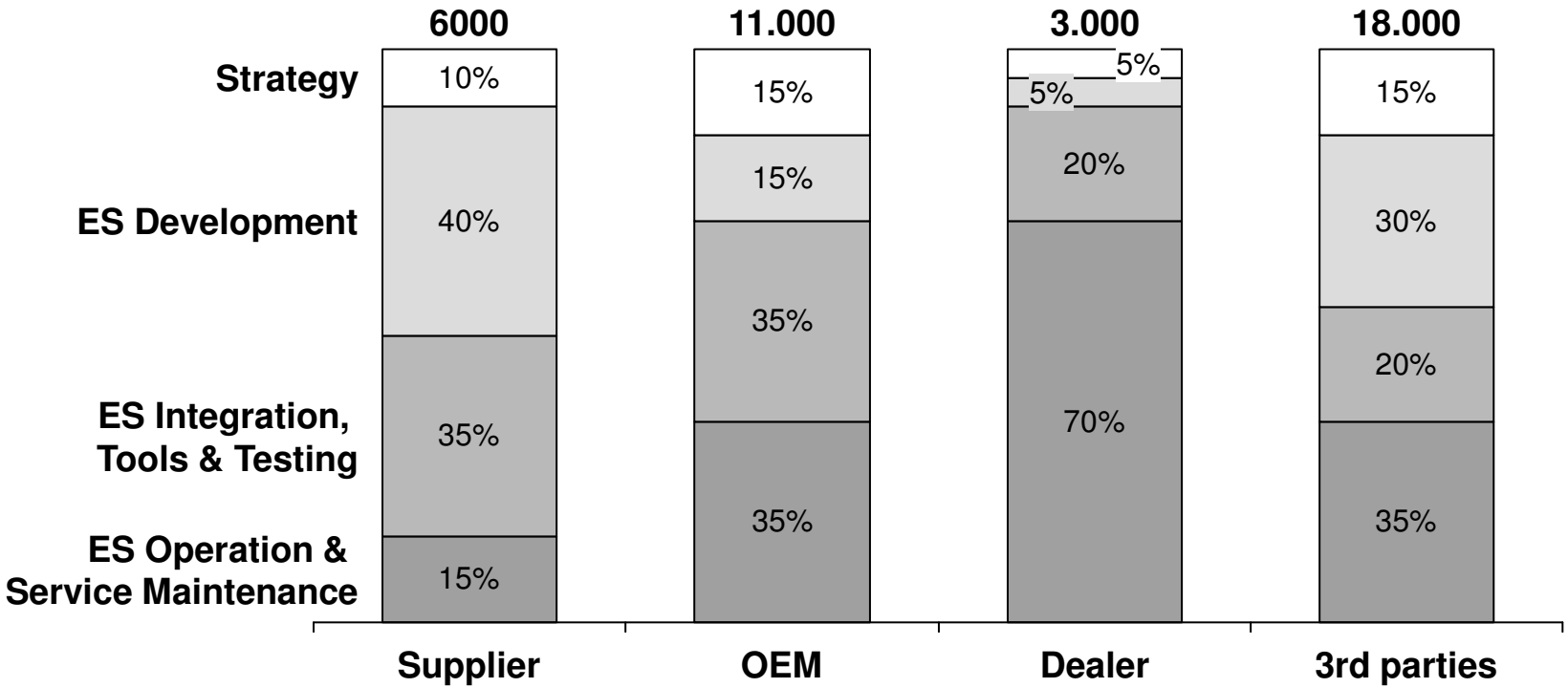
Related jobs will be created among the whole value chain especially at non-automotive 3rd party companies

New Embedded Electronic Systems jobs in Germany until 2025

Illustrative



About 40,000 new jobs related to ES development and integration will be provided in Germany till 2025

Source: A.T. Kearney Embedded Systems Study 2010

A.T. KEARNEY

The study considers CXOs' views as well as external expert experiences and covers multiple industries and countries.

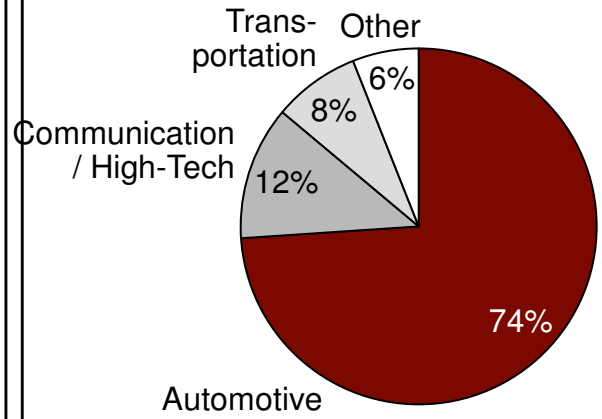
Scope of the Study

Method

- >40 interviews with Embedded Systems management representatives from business units and IT and based on a detailed questionnaire (45 – 60 minutes)
- Interviewees from top (80%) – and middle (20%) management
- 60 consumer feedbacks
- Enhanced by research of relevant press releases and studies

Geographic scope

Industry scope



Selected participants

Continental
BOSCH
DAIMLER
T · · Systems
AIRBUS
PORSCHE
Audi
SIEMENS

Source: A.T. Kearney Embedded Systems Study 2010

The notion of Embedded Systems is rather diverse and stands for a very wide variety of devices and systems

Characteristics of Embedded Systems

- Embedded systems are some combination of computer hardware, software and mechanical components, either fixed in capability or programmable.
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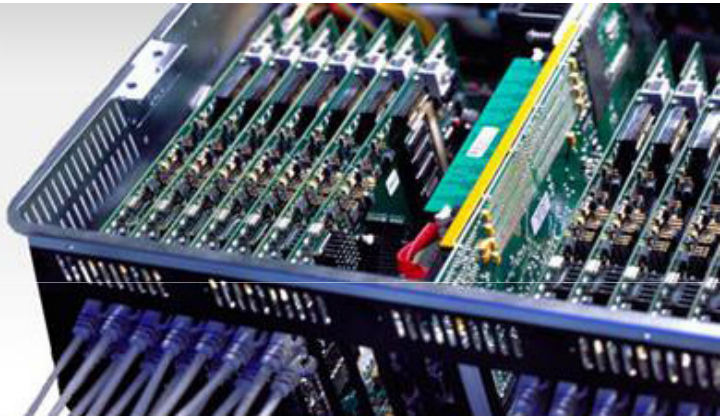


As the word "Embedded" implies, these systems are "hidden" in a hosting system and their impact is therefore often not immediately measurable.

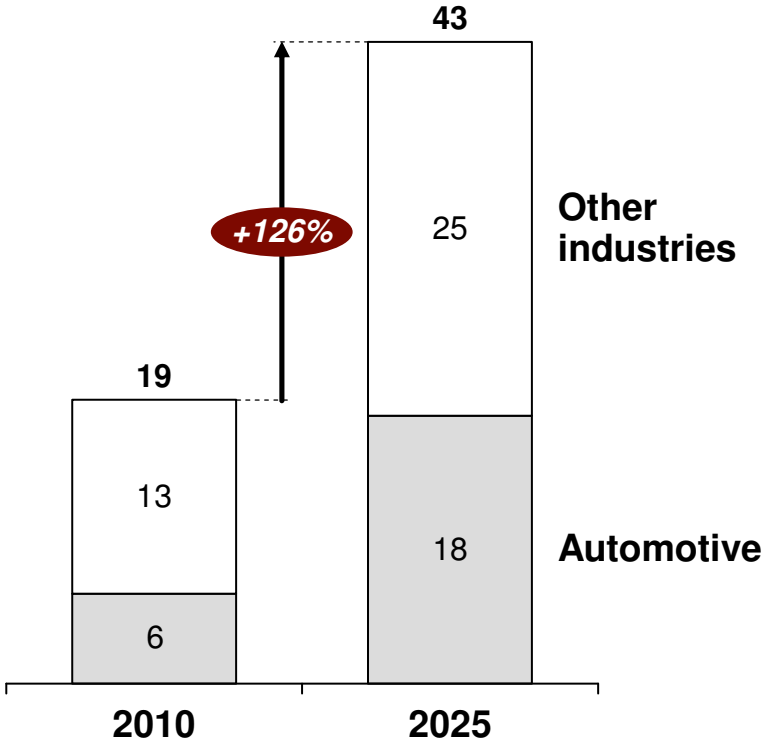
Source: BITKOM; A.T. Kearney Embedded Systems Study 2010

ALL: Zahlen plausibilisieren (€ 19bn kommen von BITKOM)

Through the strong growth in automot… industries, the market for Embedded Systems will double

Development of ES demand of the German Automotive industry

Expected turnover development of Embedded System in Germany
(in € bn)



- Today, a turnover of ~€ 19bn is generated through development of embedded systems in Germany
- Besides automotive (~€ 6bn) embedded system are heavily used in the engineering industry, facility management, home appliances and others
- Automotive will strongly grow the demand for embedded systems through Integration Services, New Car Services, Sustainability Services & Mobility Concepts and New Consumer Services
- Also in other industries, embedded systems will experience significant growth such as in
  - Engineering, e.g. increased connectivity of machines
  - Utilities, e.g. smart energy networks

Source: A.T. Kearney Embedded Systems Study 2010, BITKOM

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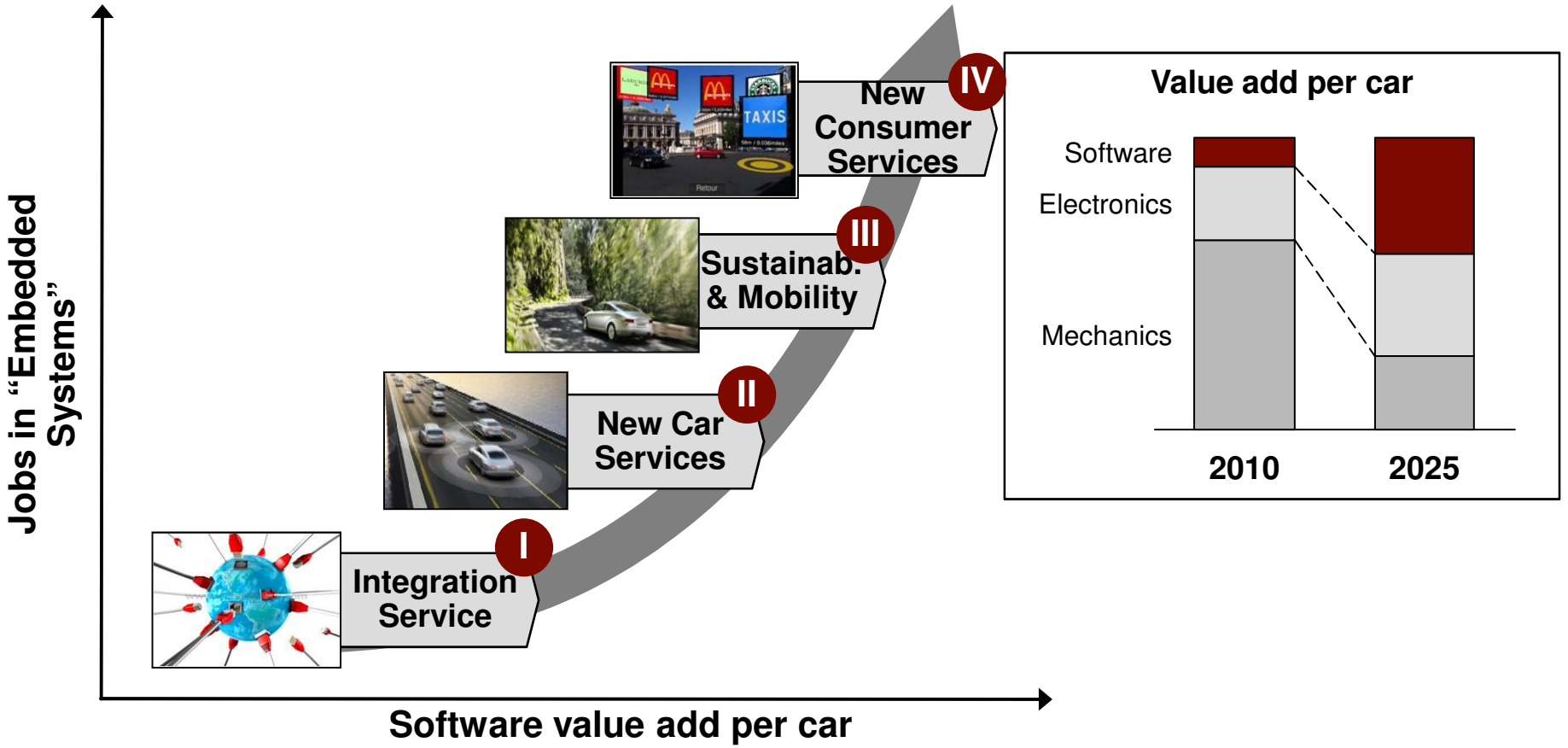
To overcome barriers all four growth areas must develop clear business cases to increase the value add per vehicle

Role of embedded services in future vehicles



Source: A.T. Kearney Embedded Systems Study 2010

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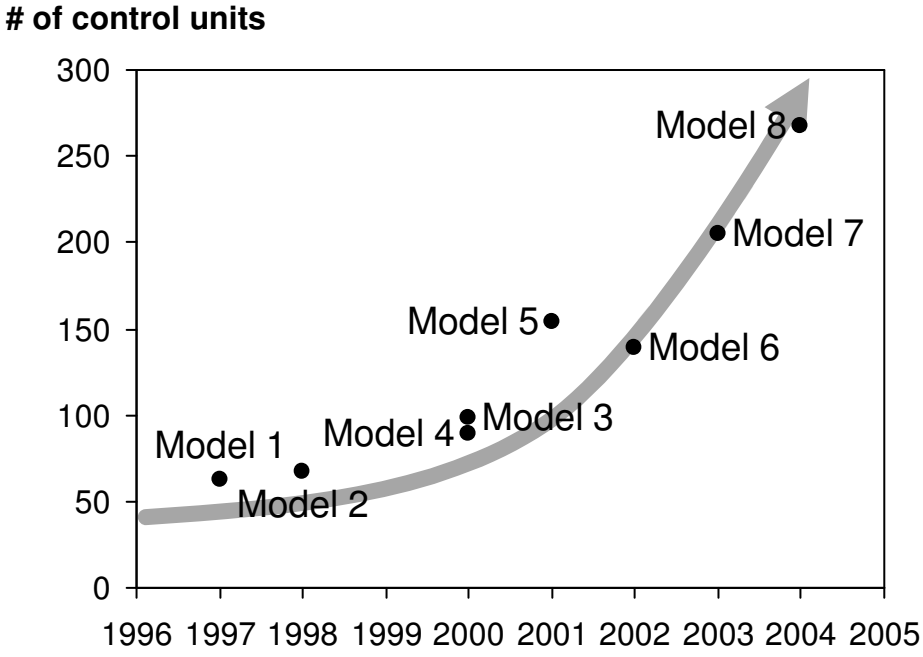
The continuously increasing number of ECU`s require expertise in system standardization and modularization

Example: ECU development

- Today, about 90% of all innovations in a vehicle are based on software and electronics
- The total number of ECU's is continuously increasing. Nowadays, more than 100 ECU's are build into an advanced car
- Nowadays, ECUs form a complex communication networking within a car
- The complex functions, integrated in the ECU's, require the usage of highly efficient development- and testing tools to ensure a zero bug quality

Example of increasing application of Embedded Electronic Systems (e.g. control units)



The increasing number of complex functions, integrated in the ECU's, are leading to an ES job growth for OEMs, suppliers and 3rd parties

Source: A.T. Kearney Embedded Systems Study 2010, car2car, Siemens

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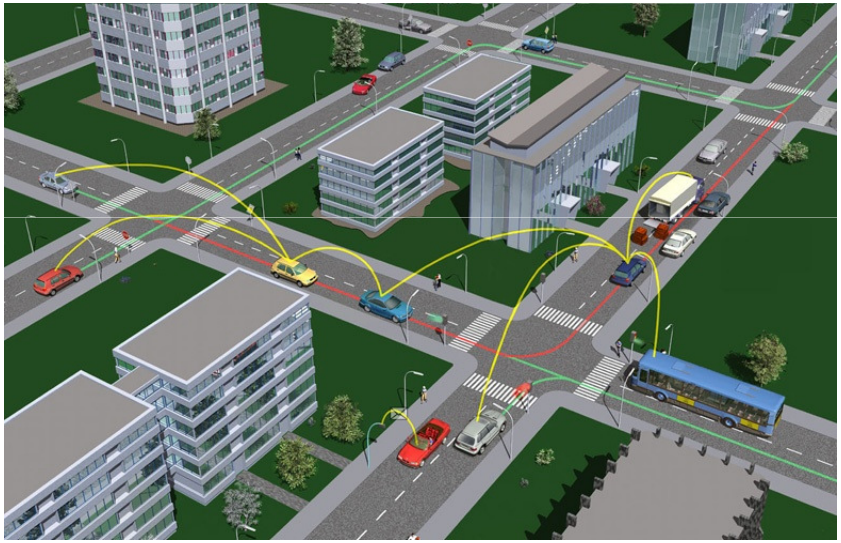
New innovative car services for more security, comfort and energy efficiency will generate additional demand

II

New Car Services

Example: Car2x communication

- In future car-to-car and car-to-infrastructure commincation is a leading trend that will lead to safer and more efficient road traffic
- 2025 is expected as the break-through year in which more than 50% of all new cars are able to communicate
- This ability is allows the traffic to flow more fluently it will be particularly interesting for optimal energy management in electric cars



New car services require a communication infrastructure and new standards , leading to an ES job growth for OEMs, suppliers and 3rd parties

Source: A.T. Kearney Embedded Systems Study 2010, car2car, Siemens

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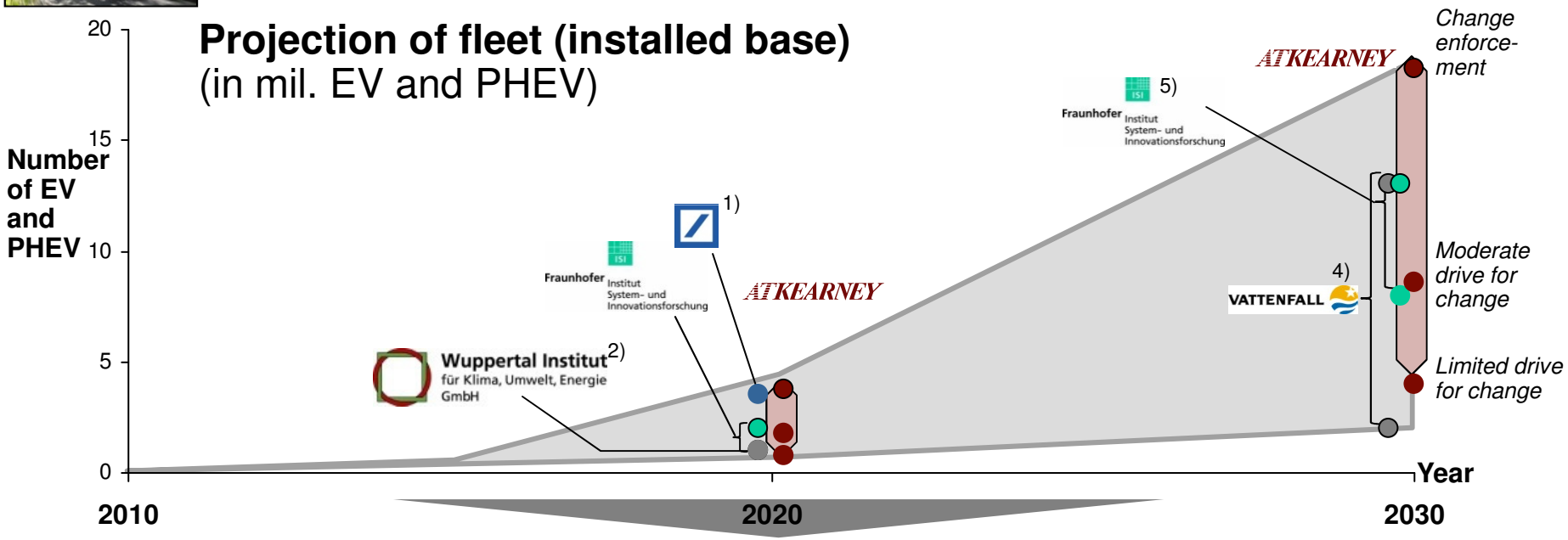
For automotive OEMs, the electric vehicle market will dramatically grow until 2030

III

Sustainab. & Mobility

A.T. Kearney study "Powertrain of the Future"

Projection of fleet (installed base)
(in mil. EV and PHEV)



- **Fleet of 1 to 3.7 mil. electric vehicles in 2020**
- **€ 20,000 per small electric vehicle[6)]**

→ **€ 20 to 74 bn. cumulated electric vehicle sales till 2020**

EV = electric vehicle; PHEV = plug-in hybrid electric vehicle
1) **Ca. 3.5 mil. EV and PHEV** in 2020, Deutsche Bank
2) **1 mil. EVs** not earlier than 2020, Wuppertaler Institut für Klima, Umwelt, Energie GmbH
3) **1 to 2 mil. EVs and PHEVs** in 2020, Fraunhofer ISI
4) **2 to 13 mil. EVs** in 2030 (**best guess: 10 mil.**), Vattenfall
5) **8 to 13 mil. EVs and PHEVs** in 2030, Fraunhofer ISI
6) Price for small car (Smart-class) today (Welt Online, article: march 11th 2008)

A.T. Kearney scenario

ATKEARNEY

In addition to existing services further growth can be generated by consumer oriented service offerings

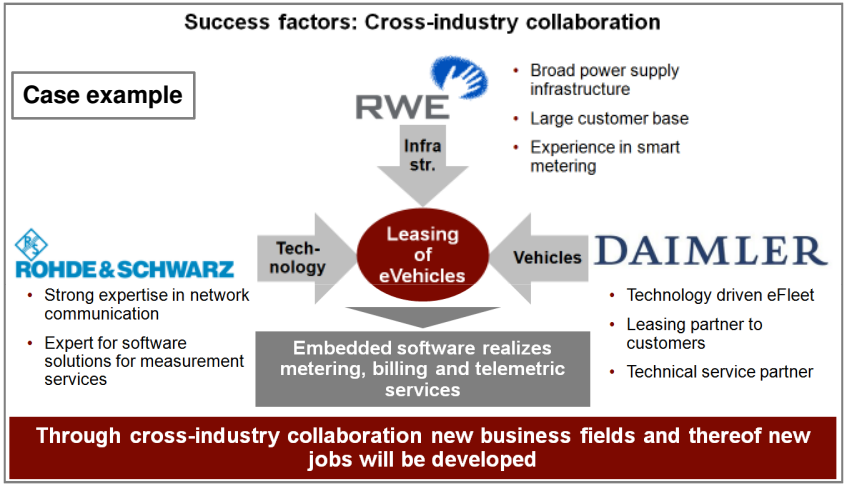
IV

New Consumer Services

Example: City Mobility Concepts

- Collaboration of companies of various industries enable new product offerings and innovative services
- Publicly available cars can be used by citizens
- Registration, car spotting, reservation and payment via mobile phone, internet, etc.
- Pay-per-minute/use model for providing mobility services

To offer new consumer oriented services systems integration for existing vehicles, devices and infrastructure is required



New consumer oriented services require an additional effort of collaboration leading to an ES job growth for OEMs, suppliers and 3rd parties

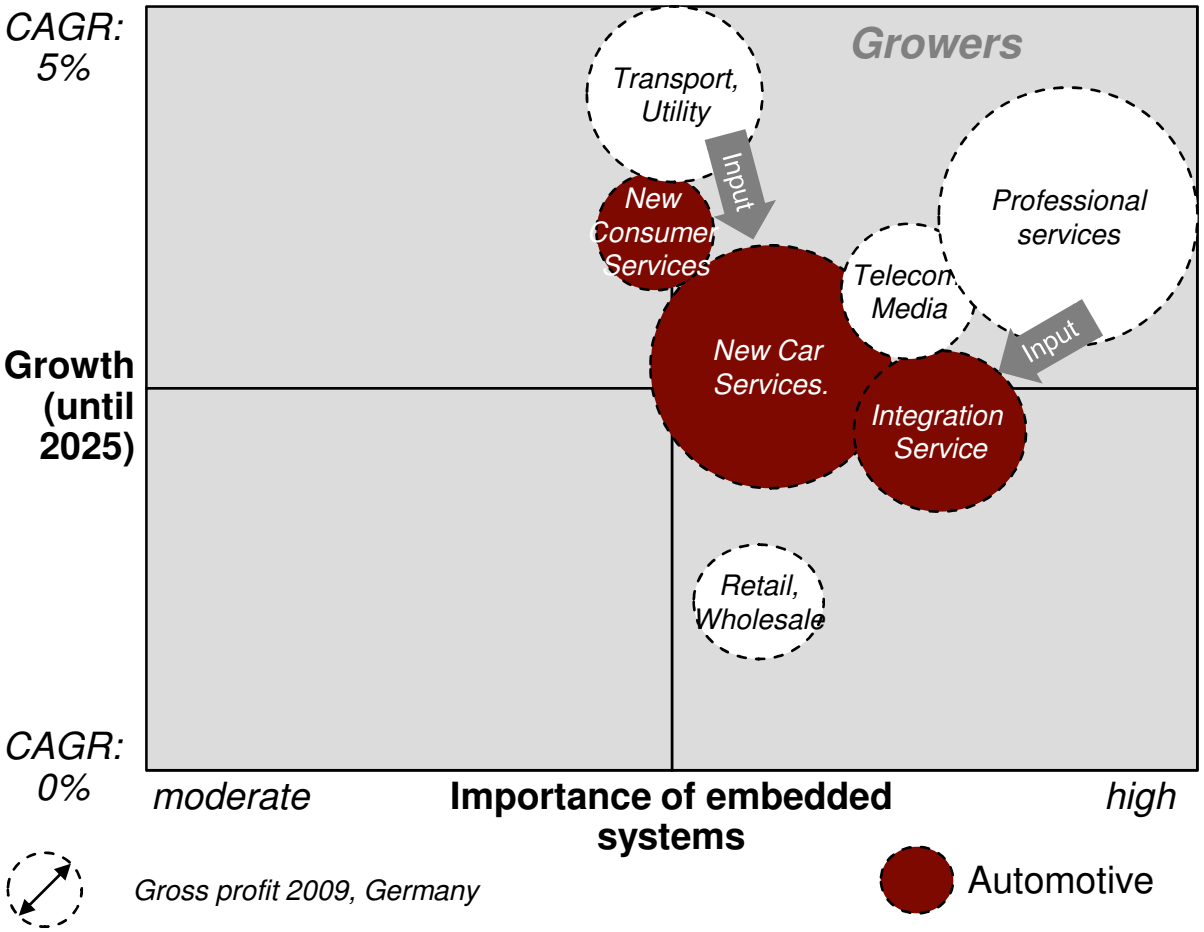
Source: A.T. Kearney Embedded Systems Study 2010, car2go, Daimler

ATKEARNEY

Embedded services may not only be driven by the automotive industry but inherited from other industries

Drivers of Embedded Electronic Systems

Selection



Comment

- As embedded systems also play a major role in various other industries such as Telco/ Media and Utilities those industries also have strong innovation potential for new customer services
- Services developed in other industries might also be applied in the automotive industry, e.g. smart metering
- The successful application of new services thereof requires innovative ideas across different industries

Source: A.T. Kearney Embedded Systems Study 2010, car2go, Daimler

ATKEARNEY

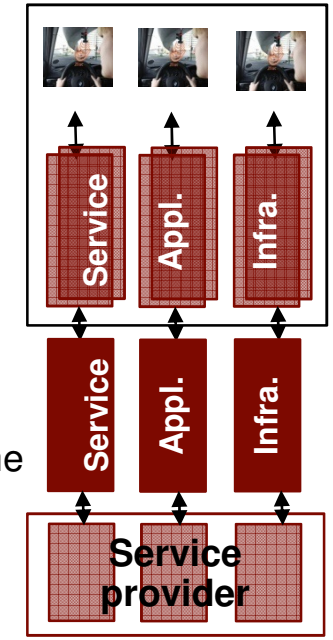
New services require strong cross-company collaboration, which will lead to more customer-centric business models

Success factors: Future business models

Actual: Single technical solutions

Current applications:

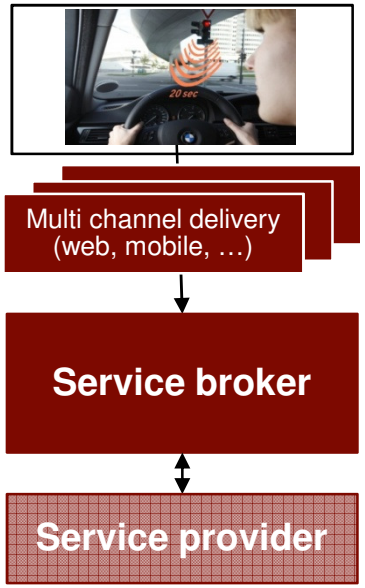
- Many stand-alone solutions
- Strong focus on technical solutions, less customer oriented
- No flexibility and possibility to increase functionality
- One application serves one function
- No/ few collaboration between suppliers



Single technical solutions integrated by OEMs

Future: Customer oriented solutions

Current applications:



- Modular architecture
- Distinction between technical and content provider
- Customer-oriented functions
- Upgradable services
- Joint development and partnership models
- Strong collaboration between suppliers

Customer-oriented services provided by collaborative suppliers

Source: A.T. Kearney Embedded Systems Study 2010

A.T. KEARNEY

German industry has a good starting position to play a major role in embedded systems

Value proposition for Germany

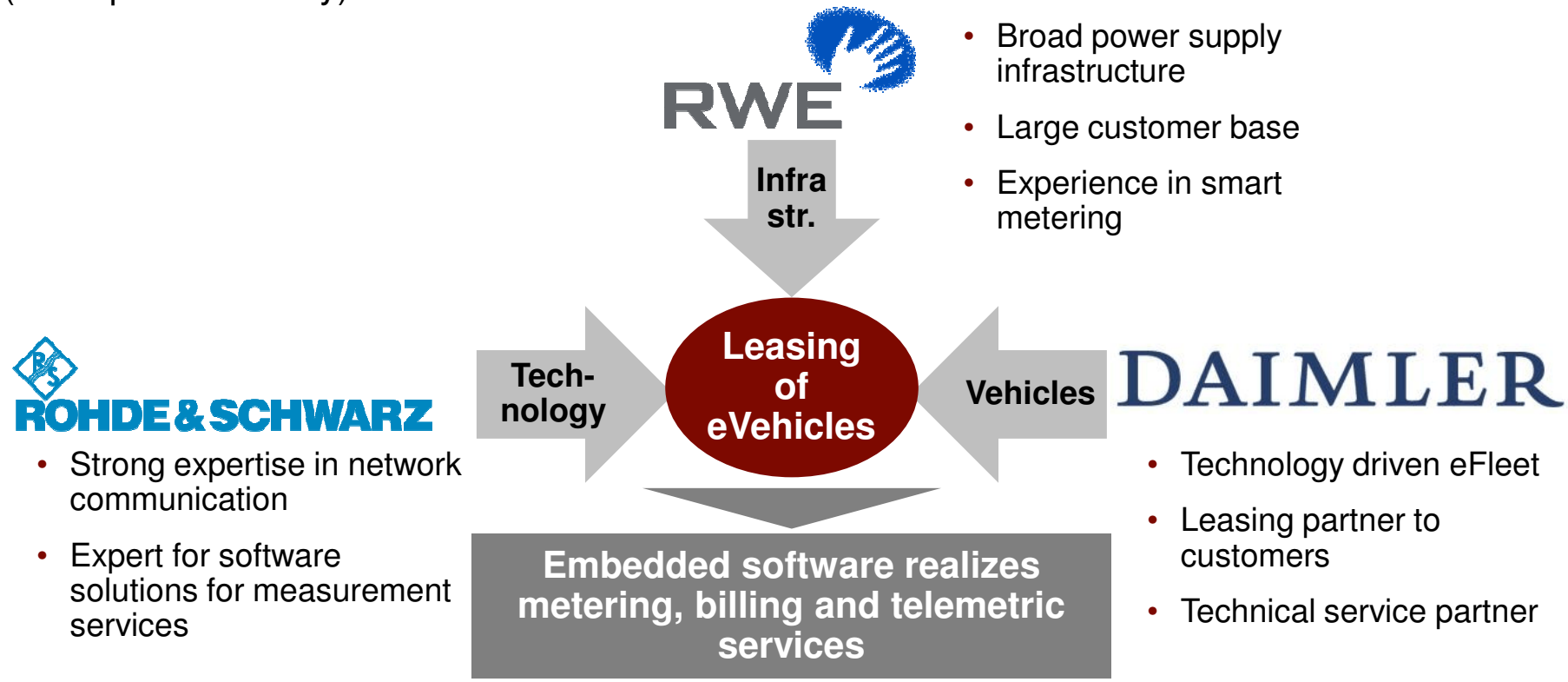
Strong economics	• Strong economic growth in almost all industries • Strong demand for automotive vehicles
Leading automotive OEMs	• Footprint of technology leading automotive OEMs (e.g. VW) with strong focus on innovation
Innovative supplier business	• Strong technology driven suppliers with strong R&D capabilities
Strong know-how in IT	• Large portfolio of innovative IT companies across Germany
Well trained resources	• Strong network of universities and well-trained IT and automotive professionals

Source: A.T. Kearney Embedded Systems Study 2010

ATKEARNEY

Cross-industry collaboration may tackle this issues and drive innovation to successfully place new services

Success factors: Cross-industry collaboration
(Example: e-Mobility)



Through cross-industry collaboration new business fields and thereof new jobs will be developed

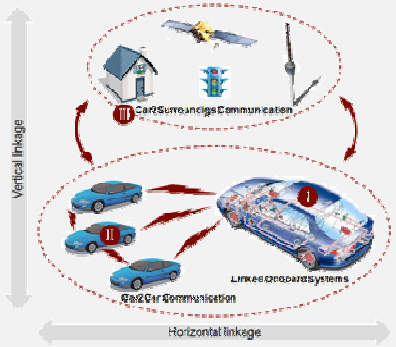
Source: A.T. Kearney Embedded Systems Study 2010

A.T. KEARNEY

To make the growth of embedded systems a German success story, key questions need to be addressed

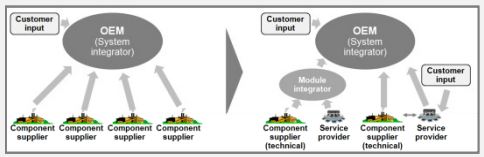
Key questions for success of embedded systems

1 Which future application and segments will drive growth?



- Where is the highest value add for ES?
- Which market segments can be tapped with ES?
- Which new developments in ES could facilitate a burst of growth?

2 How will future ES change business models??



- Which are new requirements to the market?
- Which roles will OEM play in future?
- How will growth of embedded systems change business models?

3 How can Germany become the major player for embedded systems?

- What are the prerequisites for growth in Germany?
- How can German industry leverage the good strating position?
- In which areas will new jobs be created?