McKinsey&Company

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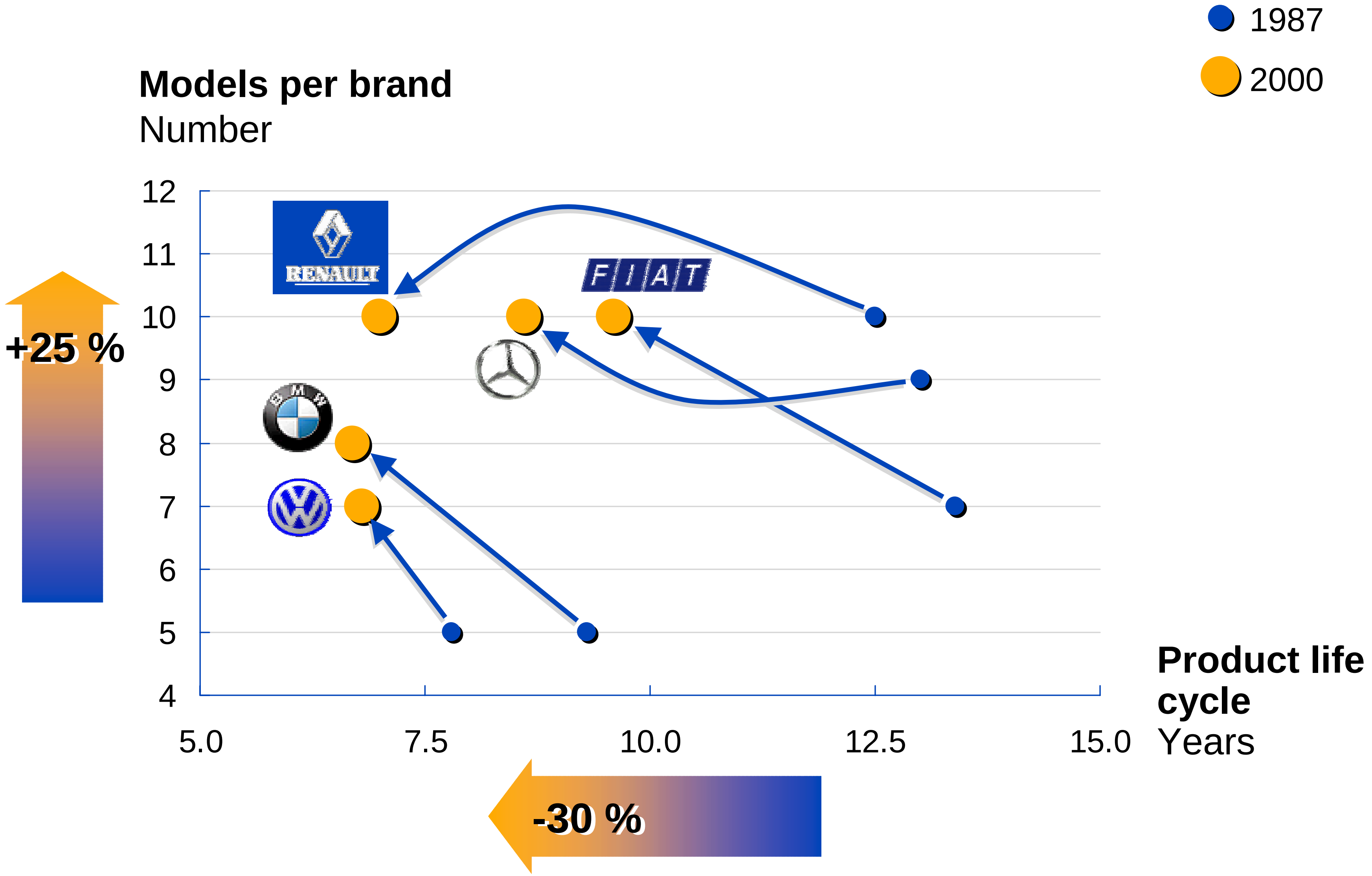
Product Development in the Automotive Industry: Strategies to Circumvent the Complexity Challenge

January 31, 2002

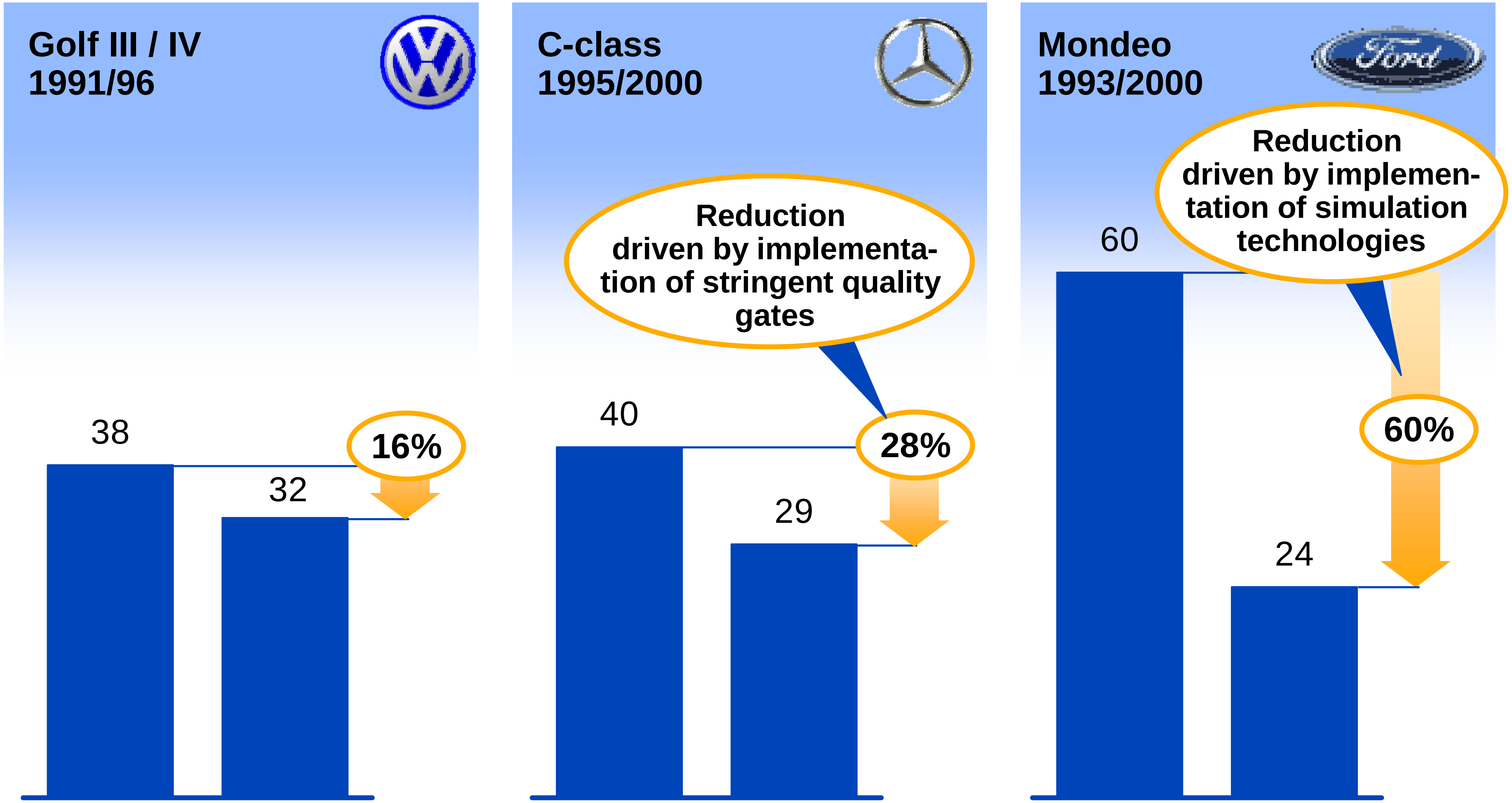
Number of models is increasing and product life cycles are decreasing



Source: Press clippings

Time-to-market is reduced dramatically

MONTH FROM DESIGN FREEZE TO SOP*

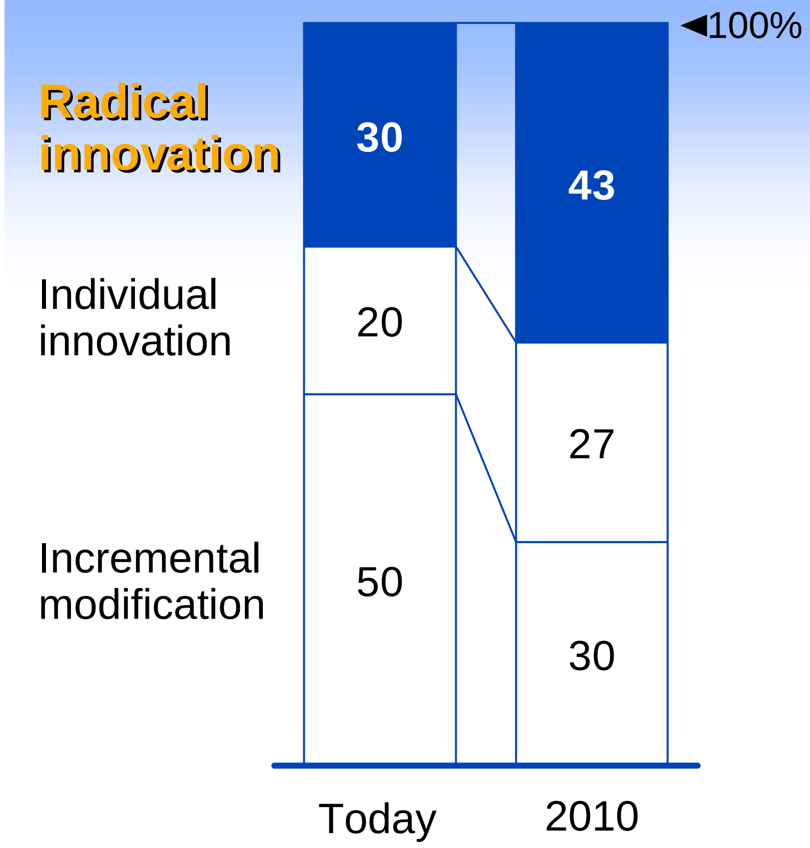


* Start of production

Source: Automobile production, AN, MID

In addition, urgency towards innovation drives vehicle complexity

Type of innovation in electronics
Percent



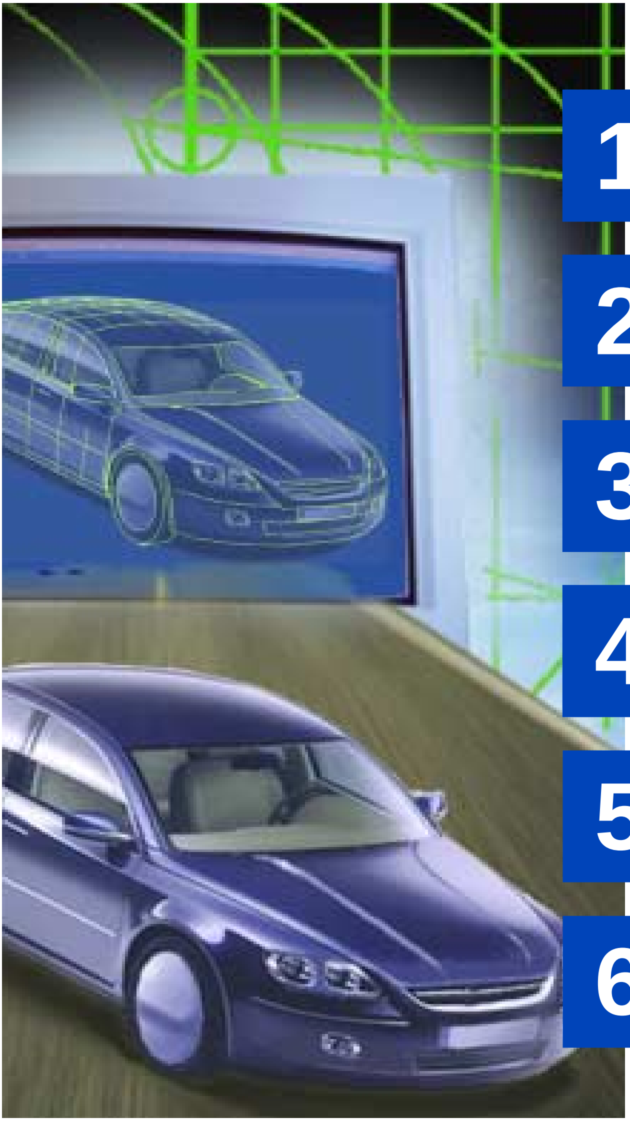
Vehicle complexity – example BMW Z22

- BMW Z22 carries 70 major innovations and 61 patents
- Objective is to ensure new technology concepts for 2005 and beyond
- Approx. 70 - 80% of innovations are in the field of electronics:
  - X-by-wire
  - Car PC
  - Center monitor
  - Fingerprint recognition
  - Head-up display
  - Integrated starter/ alternator
  - Curvelight
  - Speech control
  - Cameras for rear view
  - Telematics

Integration challenge

Source: Automobil Entwicklung, survey results, McKinsey/ika

Key levers to address complexity challenge



1 **Clear and precise customer knowledge and orientation**

2 Efficient product architecture – from identity to similarity

3 Value chain adaptation towards competence based structures

4 Improved development processes leveraging IT opportunities

5 Stringent quality processes along entire development process

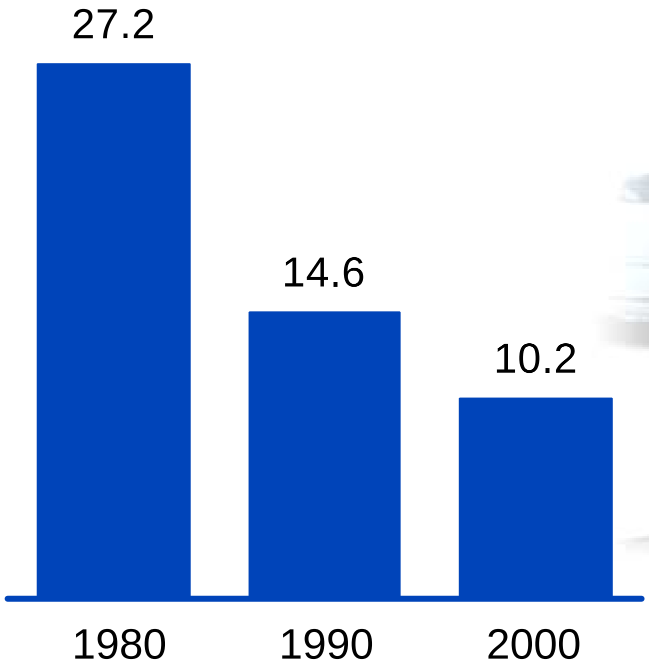
6 Project organization combining high functional and integration capabilities

Source: McKinsey

Increase in product variety and model change rate is driving passenger car market fragmentation

SHARE OF TOP-10 SELLING MODELS WESTERN EUROPE, 1980 - 2000

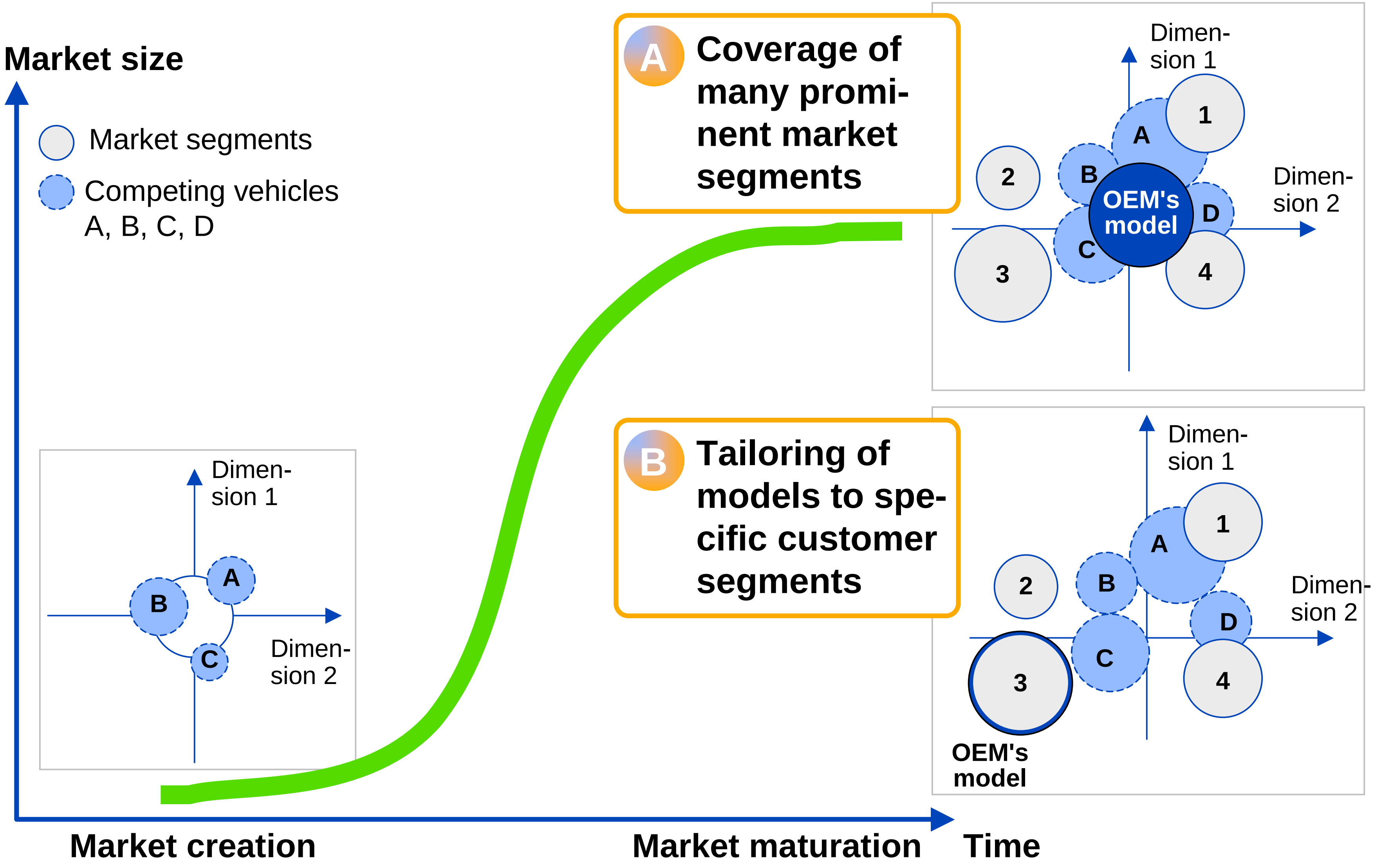
Percentage of total sales units



Source: Schwacke 1998, Marketing Systems, EIU, Automobil revue, press clippings, McKinsey

CONCEPTUAL

In mature and highly fragmented markets two strategies are possible: Targeting average vs. tailored market segment

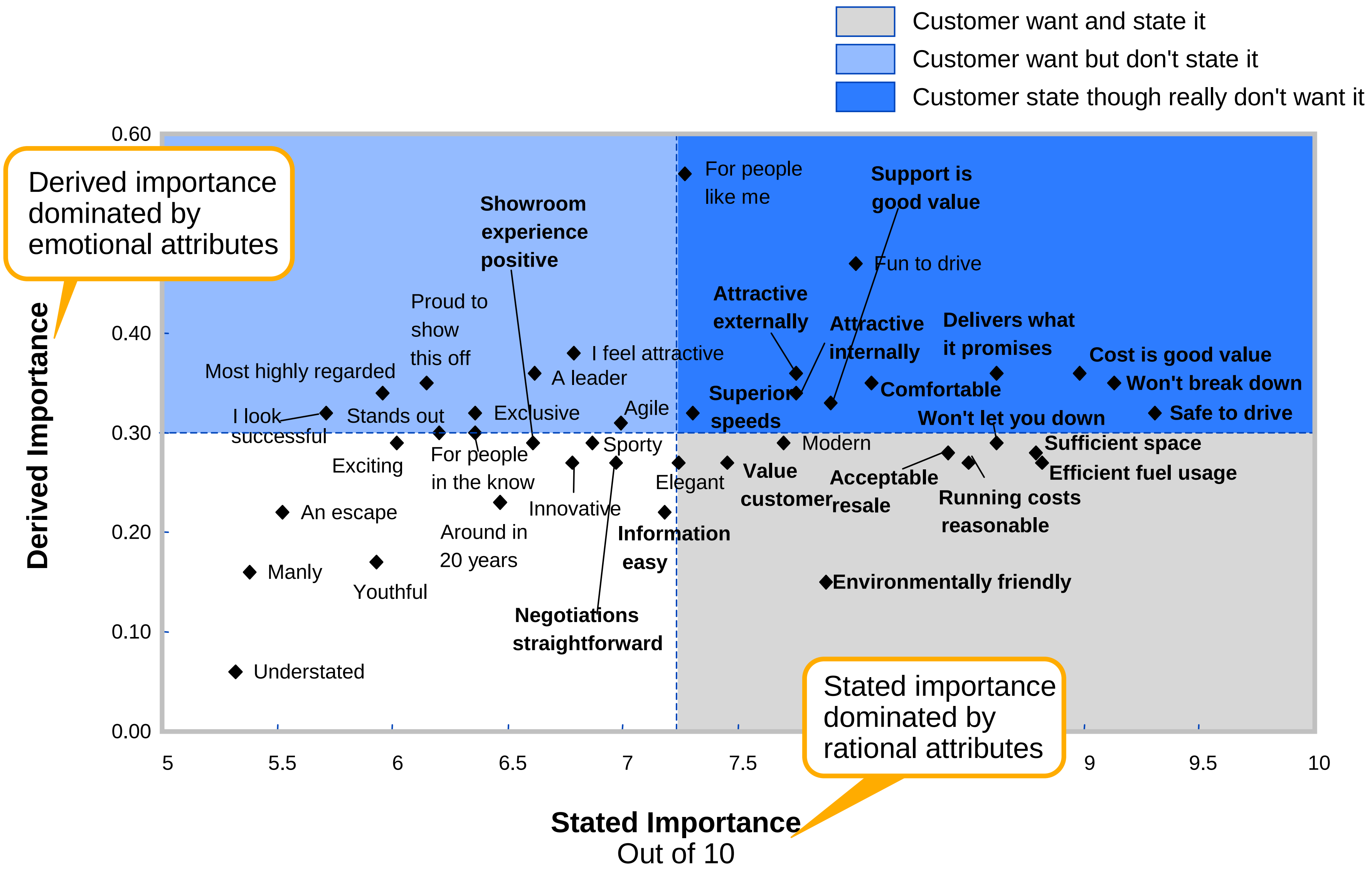


A Coverage of many prominent market segments

B Tailoring of models to specific customer segments

Source: McKinsey

To understand what customers really want is key

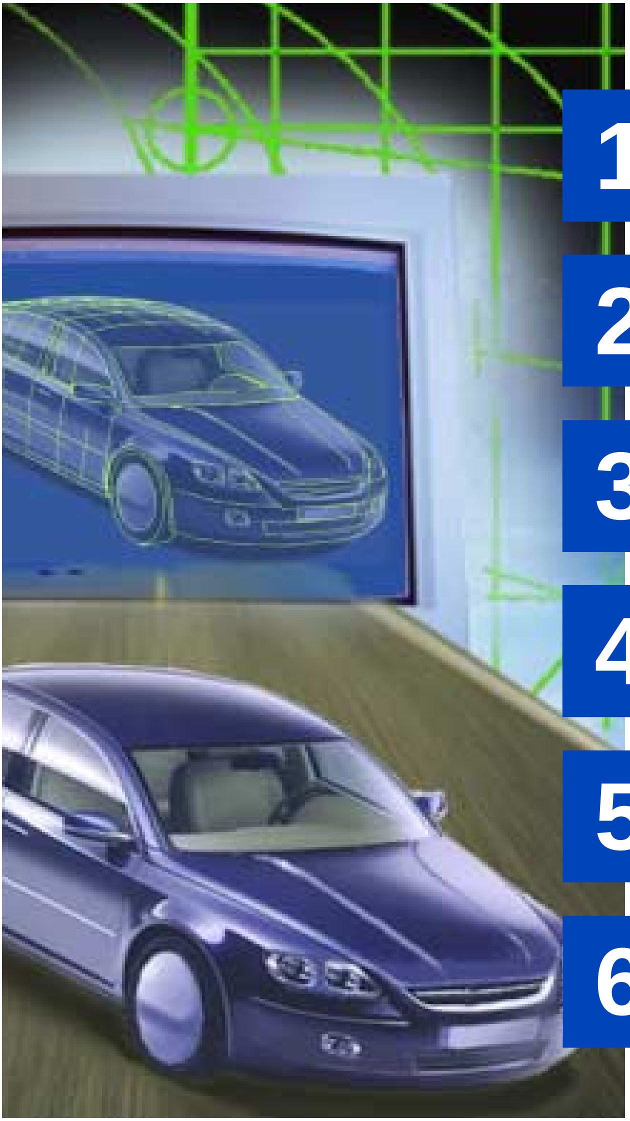


Derived importance dominated by emotional attributes

Stated importance dominated by rational attributes

Source: Automotive branding survey, May 2001

Key levers to address complexity challenge



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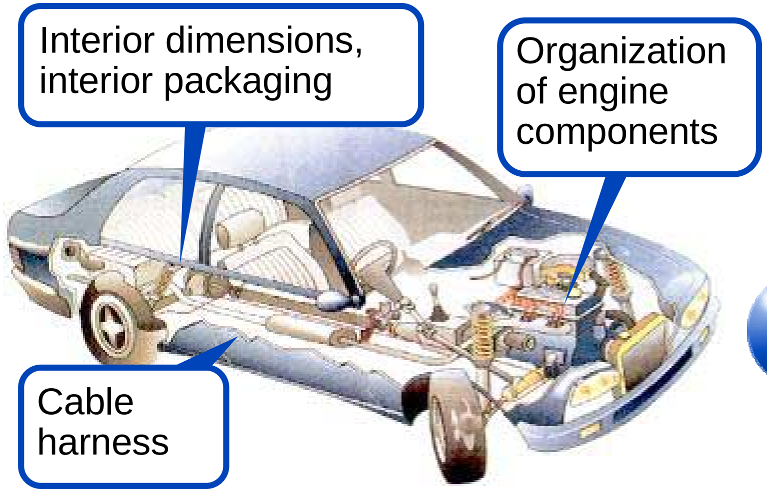
Source: McKinsey

Efficient architectures have to be optimized on vehicle and component level

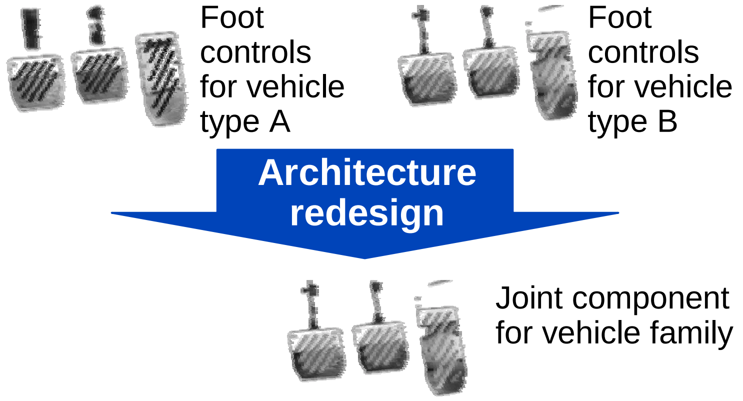
Vehicle design
(macroarchitecture)



- Define packaging zones
- Determine organization of components
- Define levels of freedom for microarchitecture

Component design
(microarchitecture)

Foot controls example



- Design components
- Systematically optimize number of variants

Focus of a standardized parts strategy

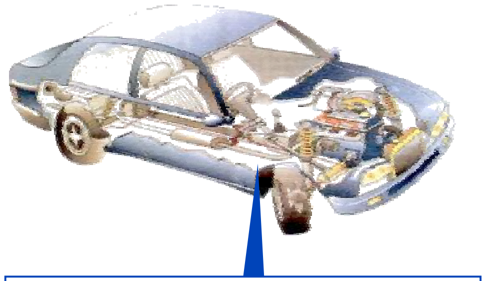
Ensure compatibility of macroarchitecture in family concepts (e.g., electronics architecture)

Increase share of standardized parts in vehicle family

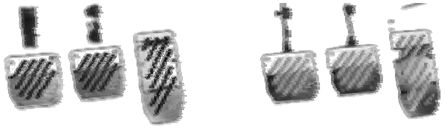
Source: McKinsey

Existing product architectures are redesigned with highest share of identical parts possible while maintaining sufficient differentiation

Product architecture



Foot controls example

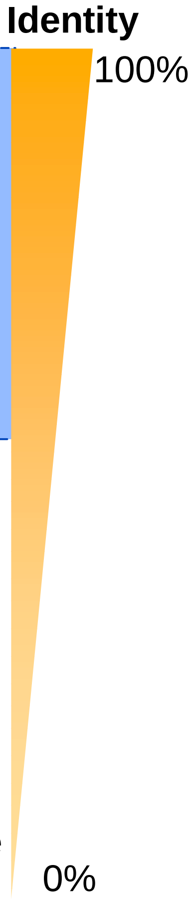


Foot controls for vehicle type A	Foot controls for vehicle type B

- **Function separation**
- **Function integration**
- **Function elimination**
- **Variant combination**
- **Restructuring**
- **Combination reduction**

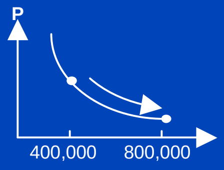
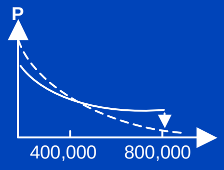
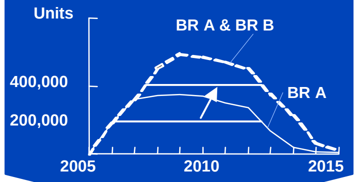
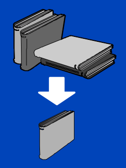
Parts/module architecture

Identical parts/modules	• 100% identical parts • Same variants across vehicle types • Building block modules
Adapted parts/modules	• Existing parts/ modules with adjustments
Principle or concept parts/modules	• Related functions or geometries ("pantograph")
Solitary parts/modules	• Parts/modules specific to vehicle types



Source: McKinsey

For deriving communality potentials four cost levers have to be understood

Potential levers	**Fixed-cost dilution** 	**Technology leaps** 	**Flexibility reserves reduction** 	**Complexity cost reduction** 
Descrip-tion	• Payback on investments across large numbers of units	• Reduction of variable costs by changing production concept	• Lower flexibility requirements due to higher share of ongoing core operations	• Reduction of variety costs
Examples	• Much lower development costs for vehicle type B • Higher utilization of machinery	• Increase in level of automation • Optimization of production site concept	• Increased production on highly specialized, constantly running lines (fewer variants on one line)	• Reduction of process costs at supplier: Purchasing, sales, production planning, administration, logistics, etc.

Increase in potential dependent on
- Blocking type
- Blocking level

Source: McKinsey

EXAMPLE

Cost types are impacted differently by cost levers

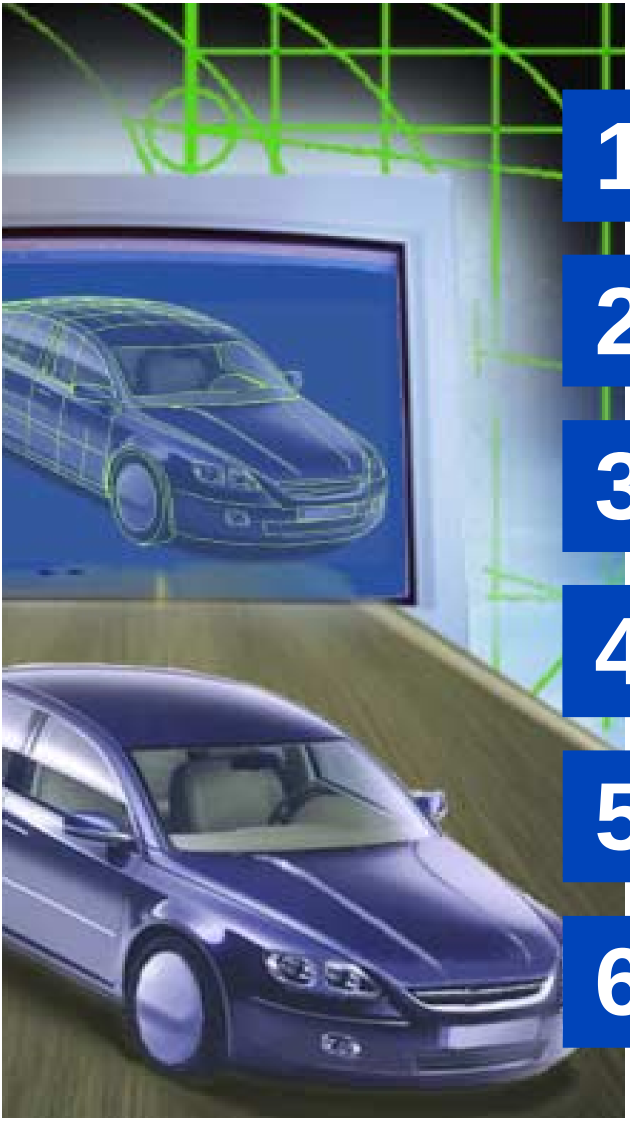
● High impact
◐ Partial impact
○ Low impact

Cost type	**Fixed-cost dilution**	**Technology leaps**	**Flexibility reserves reduction**	**Complexity reduction**	**Impact at 100% communality** Percent
Bought-in materials	●	◐	●	●	7 - 9
Manufacturing costs	●	◐	●	●	9 - 10
Research and development	●	○	○	◐	10
Warranty and goodwill	◐	○	○	◐	10
Administration and sales costs	◐	○	○	◐	5

Impact depends upon level of similarity/identity

Source: McKinsey

Key levers to address complexity challenge



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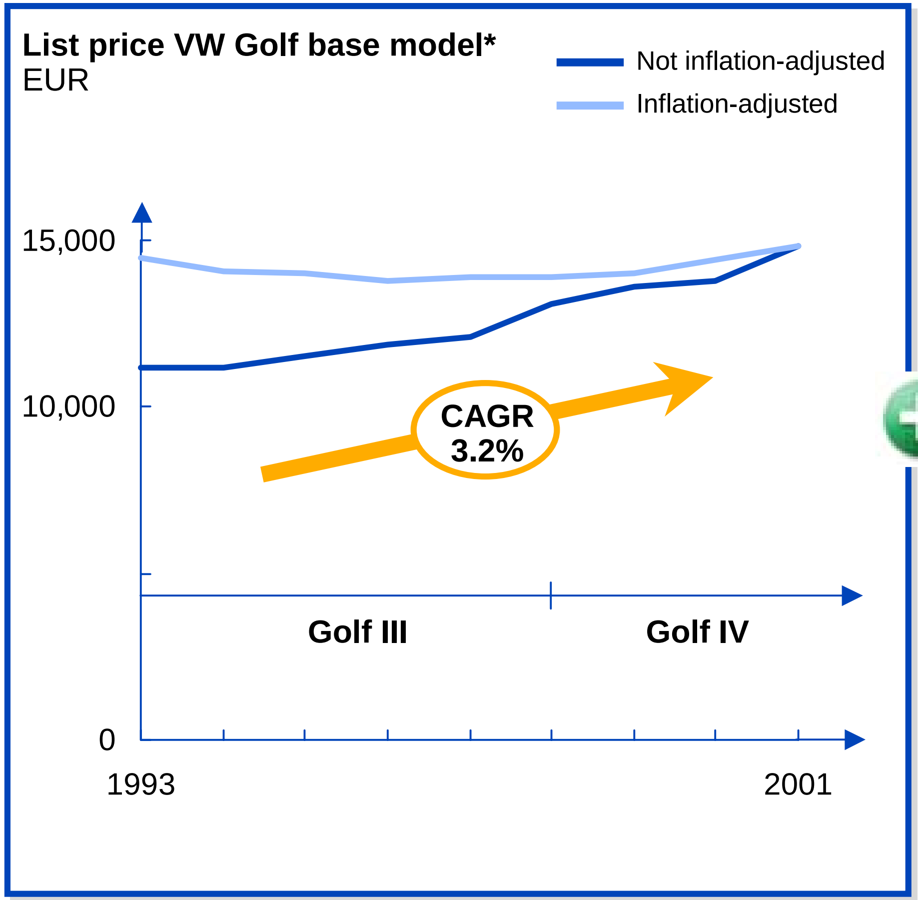
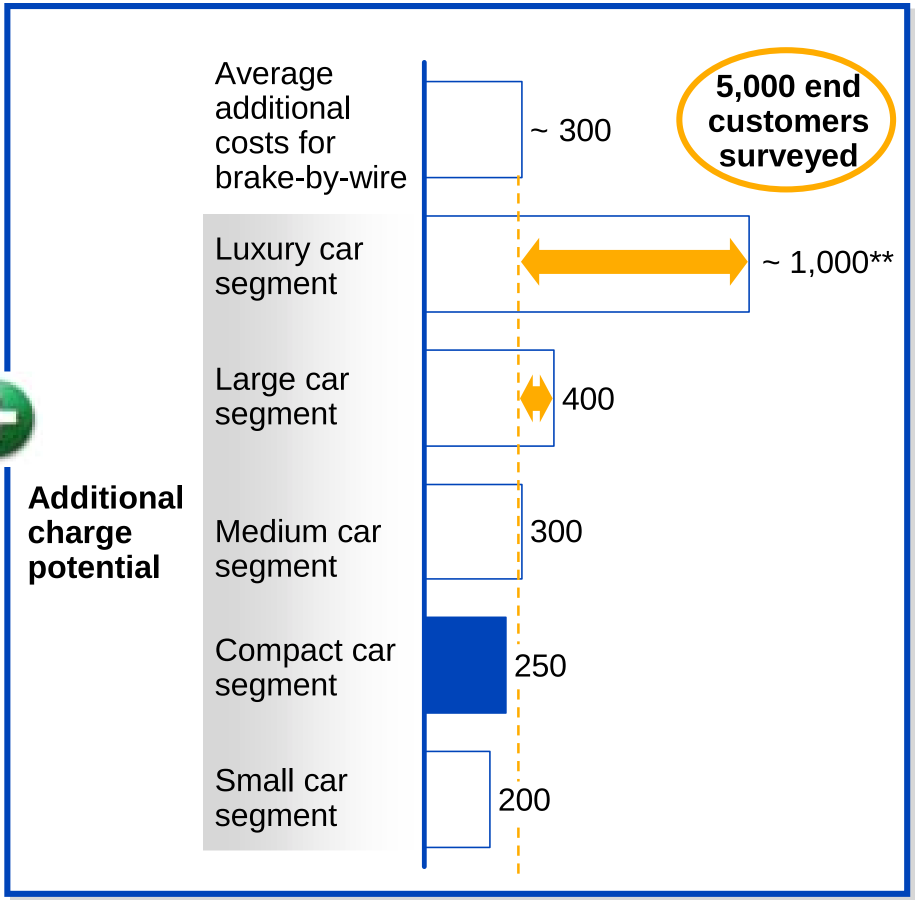
Source: McKinsey

Price increases above the inflation rate cannot be enforced despite new technologies

Historical price development



Additional charge potential for new technologies – example brake-by-wire



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* Incl. value added tax

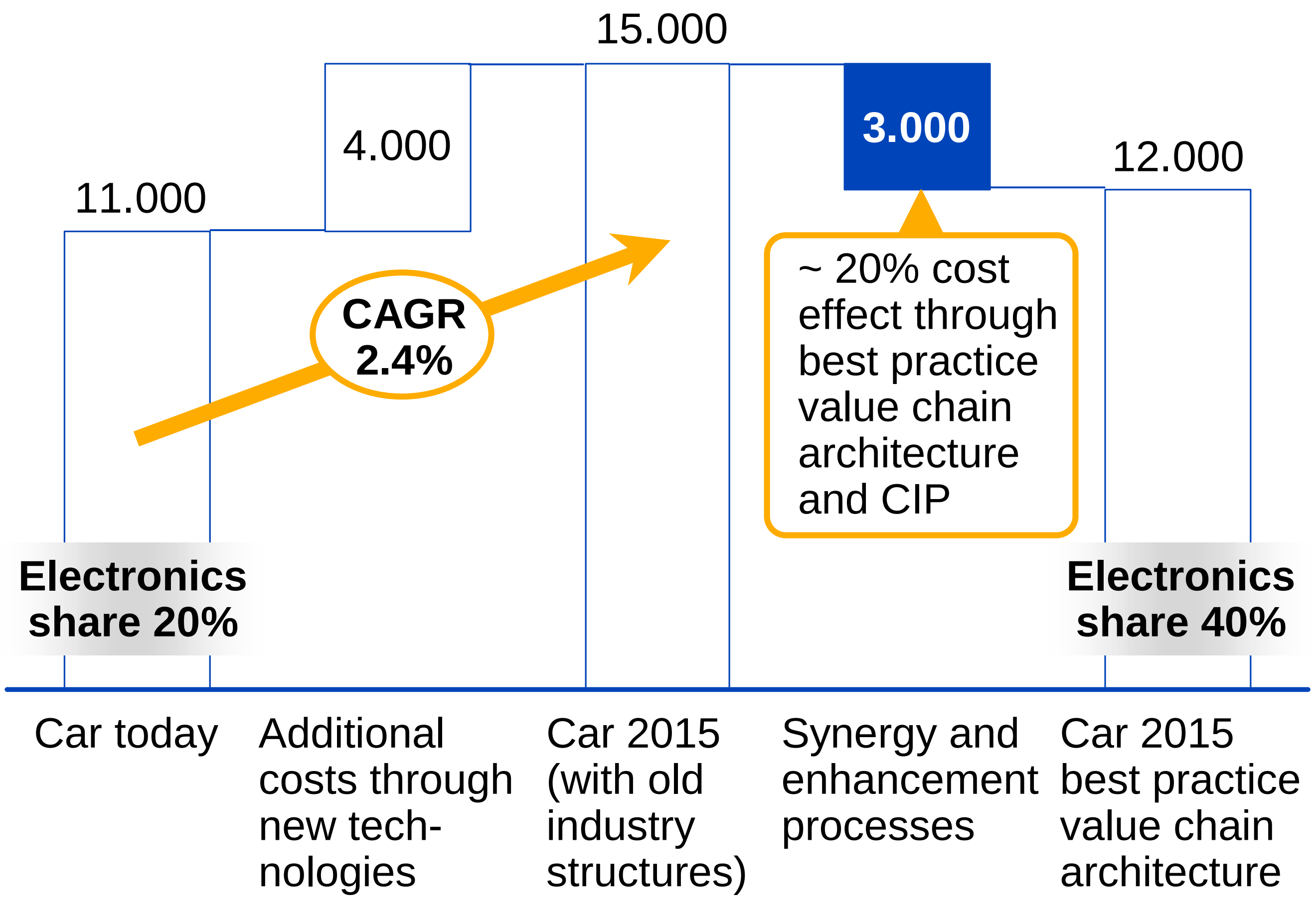
** Statistically not significant

Source: HAWK project team

Cost due to additional features have to be compensated by optimizing the value chain

PRODUCTION COSTS COMPACT CAR, NOT INFLATION-ADJUSTED

EUR/unit



Source: HAWK project team

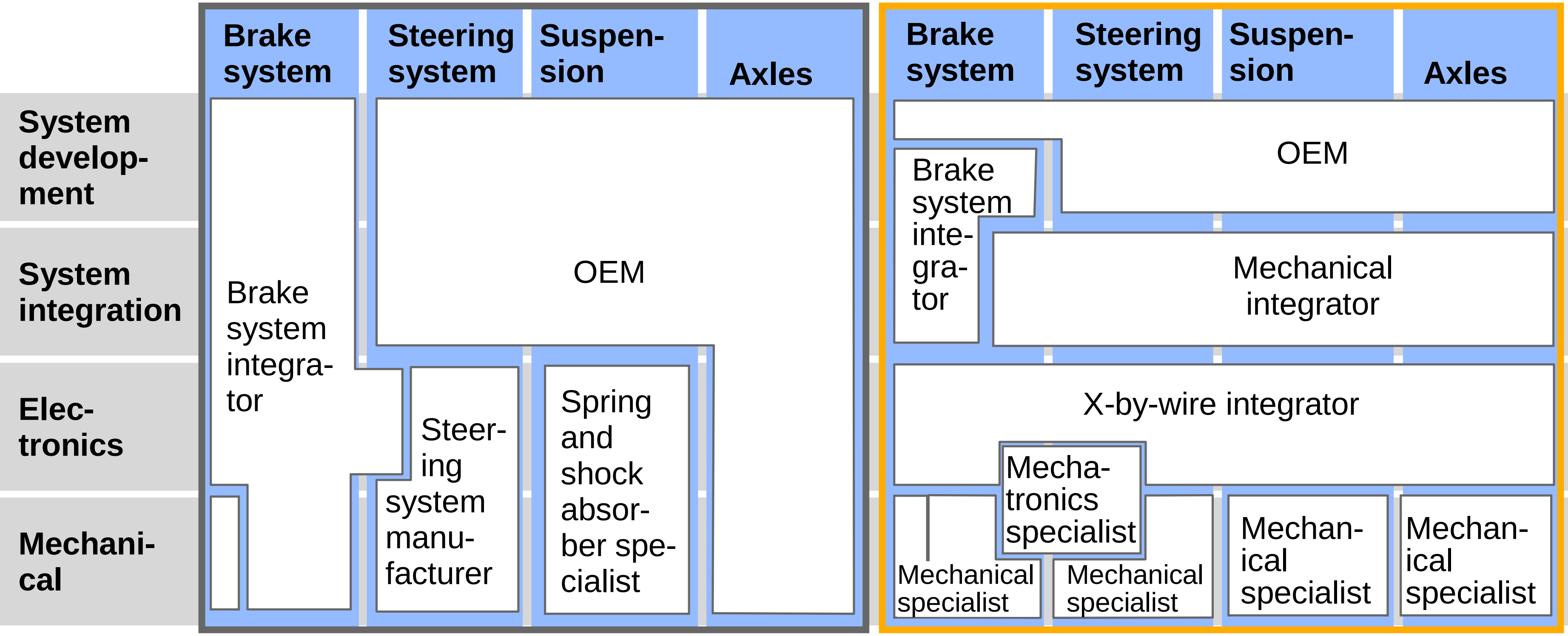
EXAMPLE: CHASSIS

Functional value chain architecture will give way to one that is know-how-driven

INDUSTRY STRUCTURE

Today

In the future



Division mainly by function (system) or spatial placement (module)

Division mainly by know-how because of
- Economies of scale
- Development synergies
- Complexity

Functionality-/position-driven

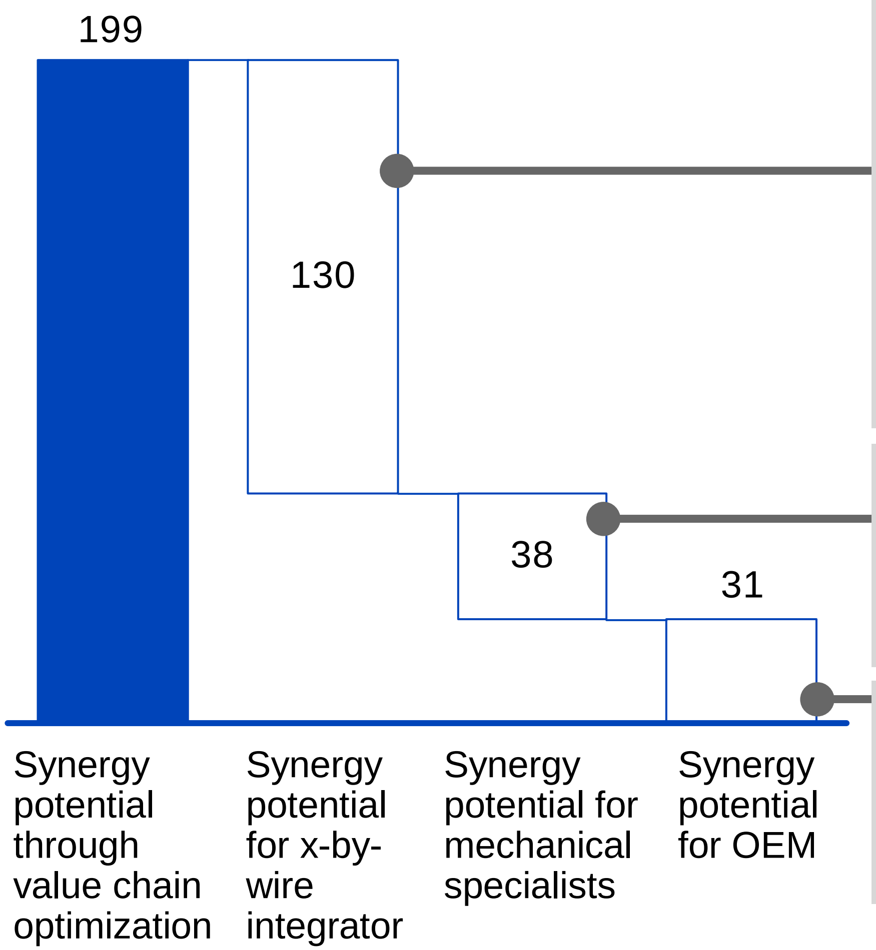
Know-how-driven

Source: Expert interviews, HAWK project team

Specific competencies are required to capture new synergies

NEW SYNERGY POTENTIAL IN CHASSIS SEGMENT

USD per vehicle



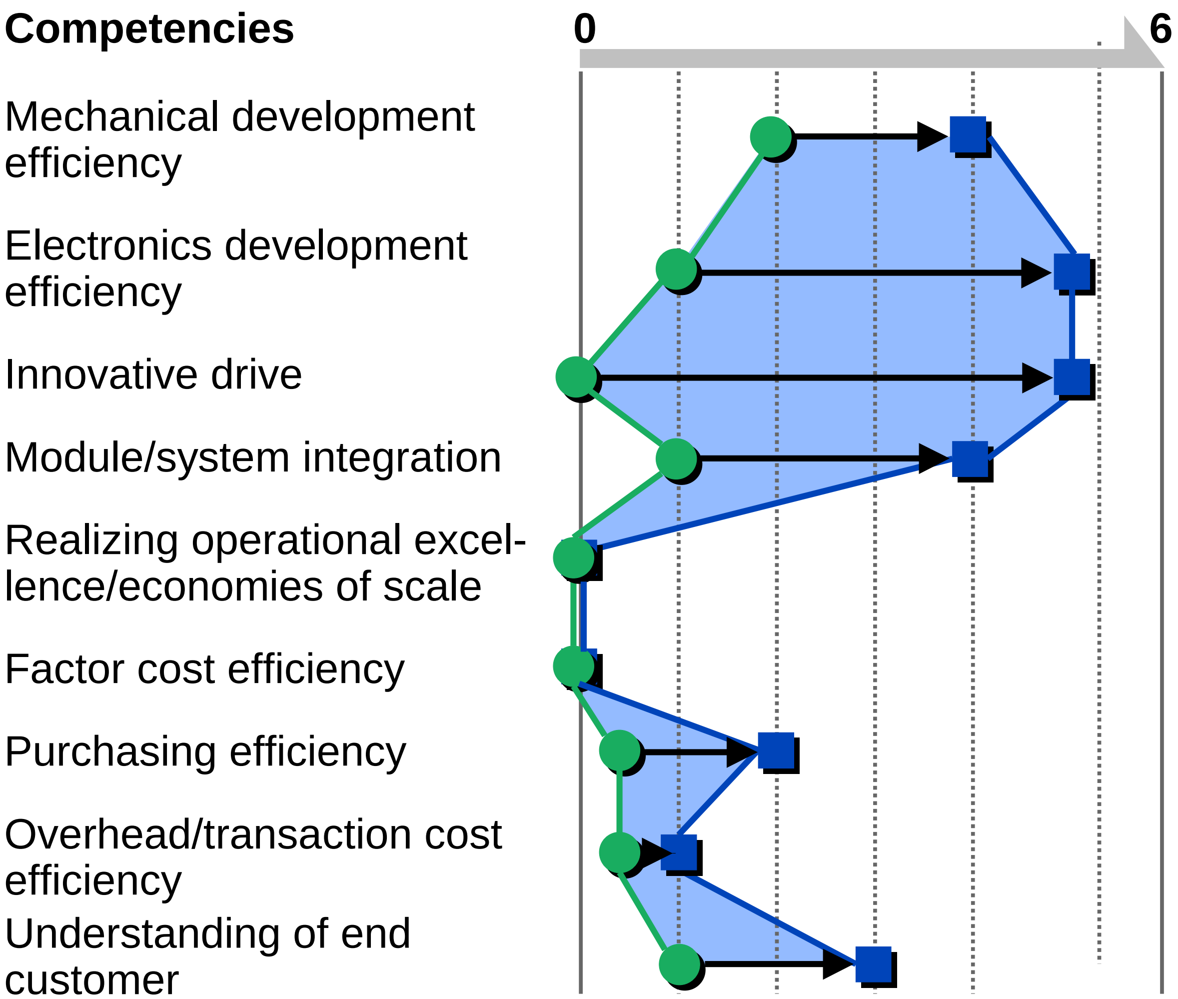
Synergies	Required competencies
X-by-wire-integrator • Centralization of ECUs and basis software • Scale effects and optimization of interfaces between new electronic components • Economics of scope in production of sensors and actuators	• System integration (e.g., ECU centralization) • Innovative creativity (e.g., ECU and Software design) • Development efficiency in electronics (e.g., sensors) • Operational excellence (e.g., actuators, sensors)
Mechanical specialists • Economics of specialization for mechanical components	• Operational excellence • Ability to capture scale effects • Factor cost efficiency
OEM • Avoidance of interfaces through centralized chassis control via software	• Transaction cost efficiency • Understanding of customer needs

Source: Team HAWK

Detailed analysis of competency gaps helps to derive specific activities

COST REDUCTION POTENTIAL FOR FUTURE STEERING SYSTEM INTEGRATOR

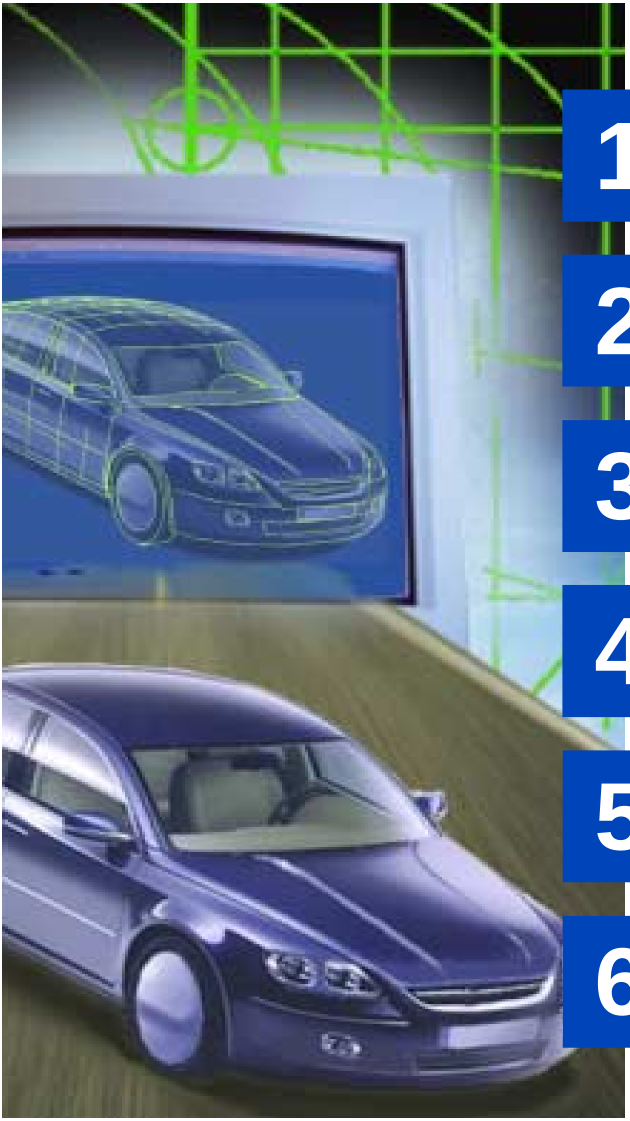
Percent



- **Competency building is needed, particularly in the areas of development efficiency for electronics and innovative drive**
- **Competency gap could be closed by means of cooperating with an innovative electronics specialist**

Source: HAWK project team

Key levers to address complexity challenge



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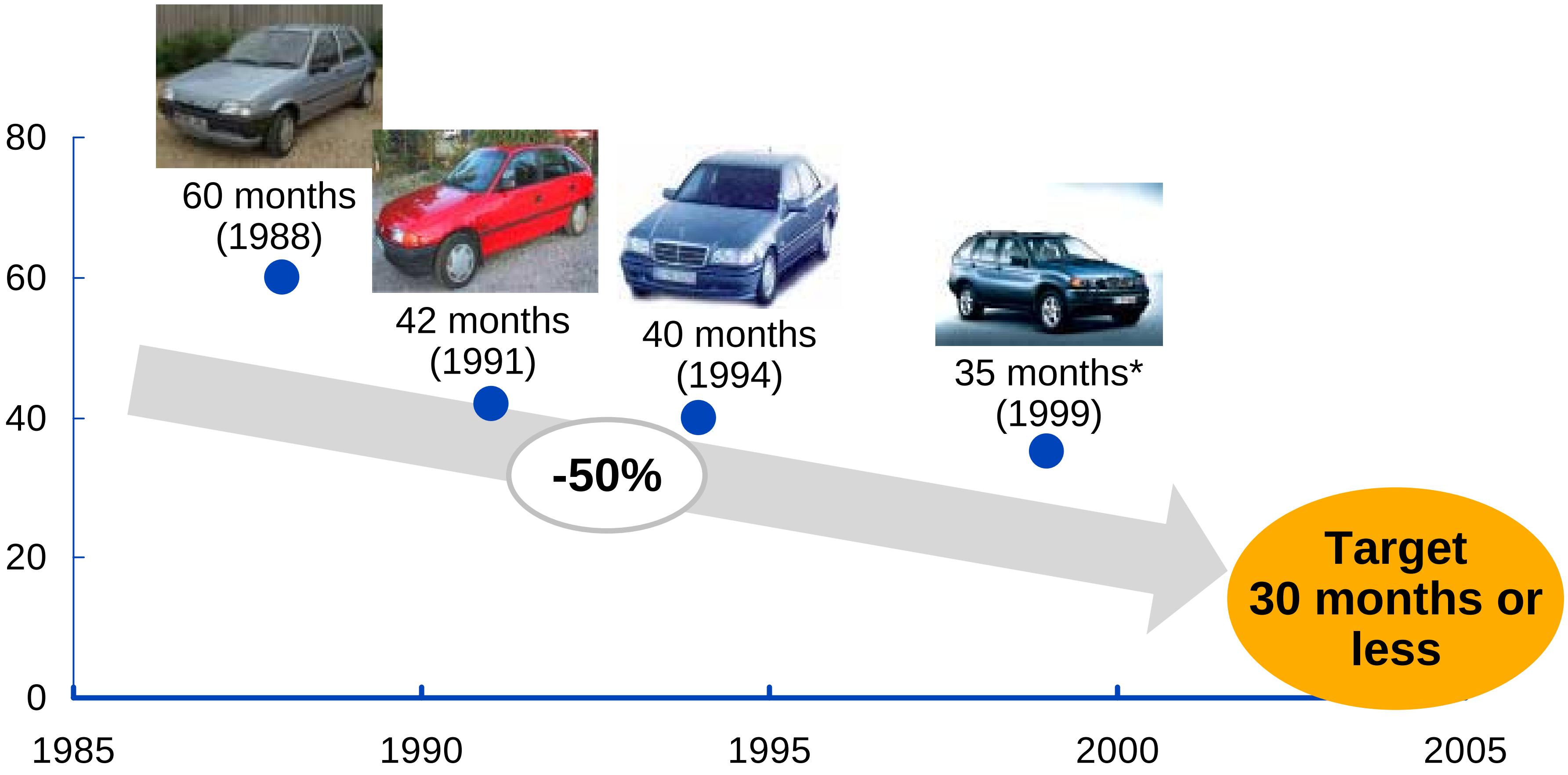
Source: McKinsey

The 2005 target requires a reduction of development times by 50%

AVERAGE DEVELOPMENT TIMES, PROJECT DECISION TO SOP

Month

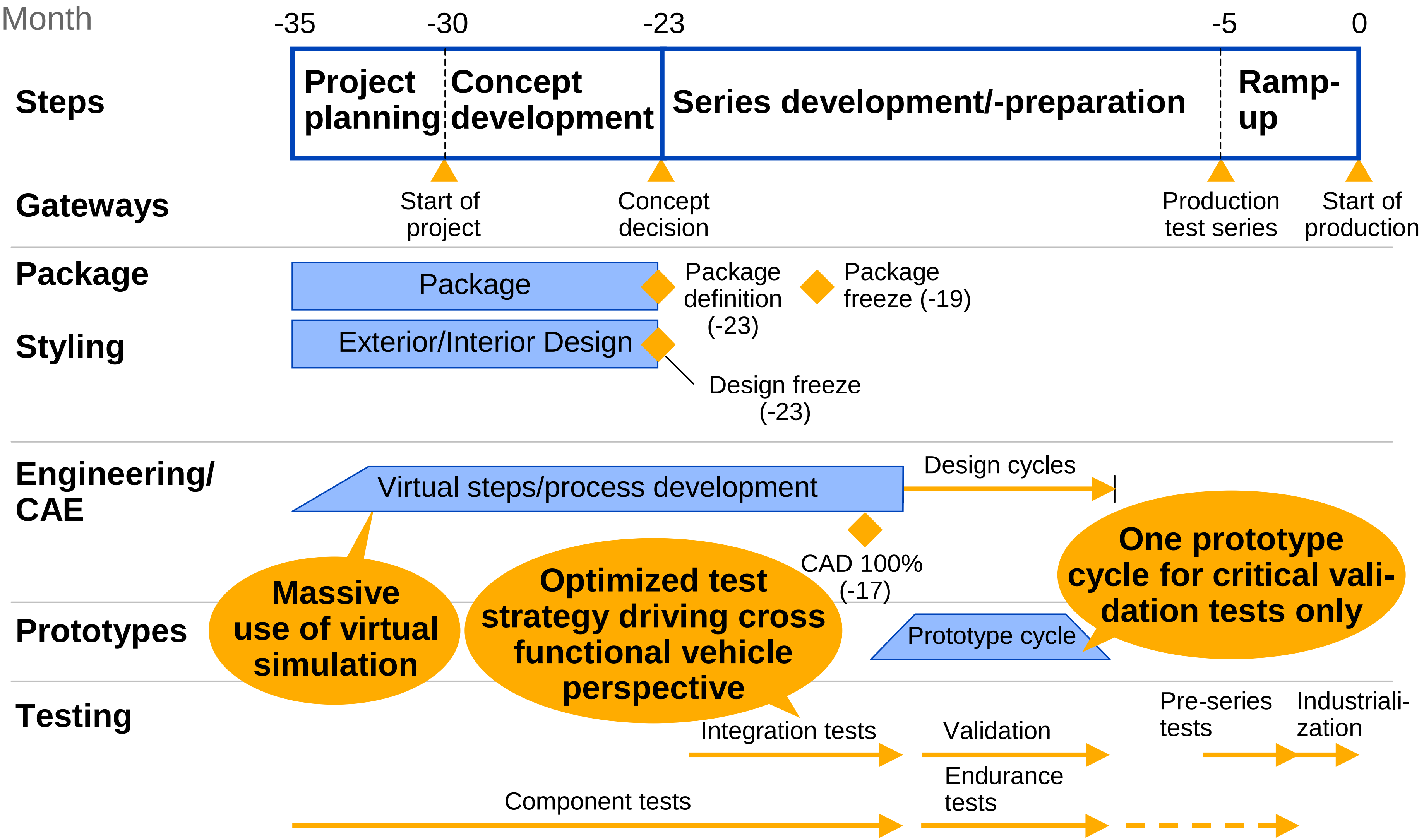


* Concept-freeze to SOP

Source: Publications on vehicle development times (70 vehicles worldwide) between 1988 and 2000, McKinsey-Research

A near future development process is characterized by virtual techniques and only 1 prototype cycle

30 MONTH DEVELOPMENT PROCESS

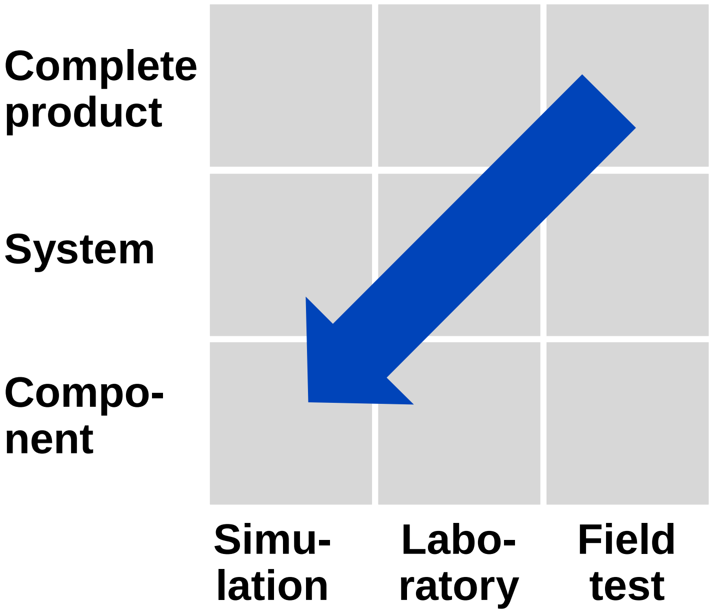


Source: Harvard Business Review

AUTOMOTIVE EXAMPLE

Product testing must be optimized along different dimensions

① Effective concept



Complete product

System

Compo-nent

Simu-lation **Labo-ratory** **Field test**

② Efficient execution

- **Test planning**
  - – Risk prioritization
  - – Optimization of utilization
  - – Cross-functional use of prototypes
- **Execution of tests**
  - – Automation
  - – Up-Speeding

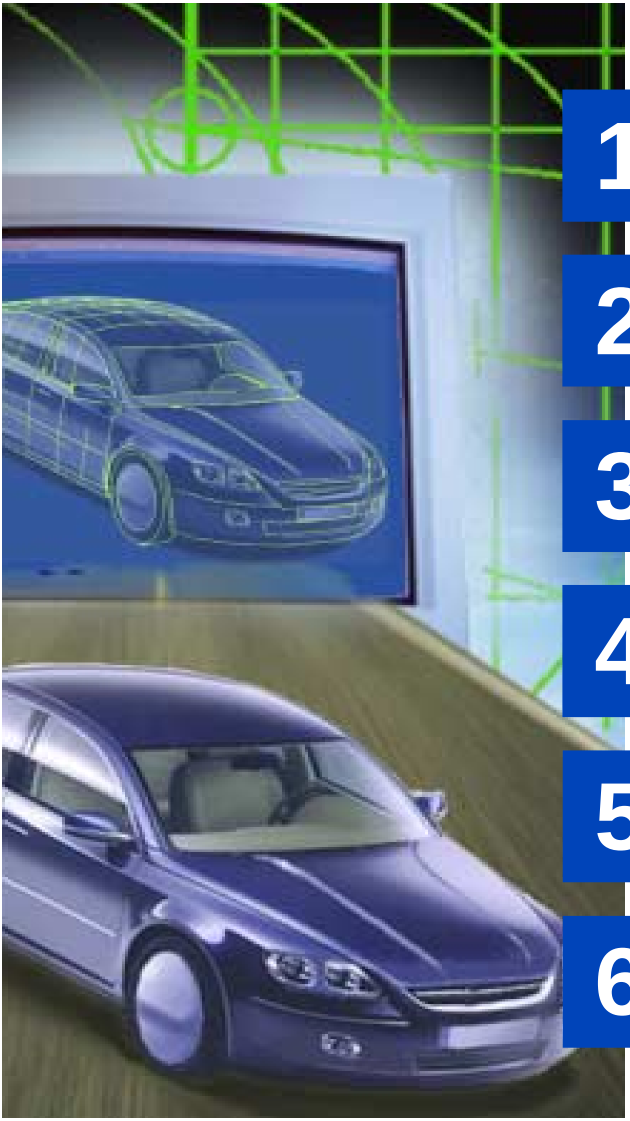
Impact

- Specific parameters can be tested very early
- Test of more variants/options due to faster test cycles
- Significant reduction of effort

- Early test of highly critical criteria/properties
- Cost reduction

Source: McKinsey

Key levers to address complexity challenge



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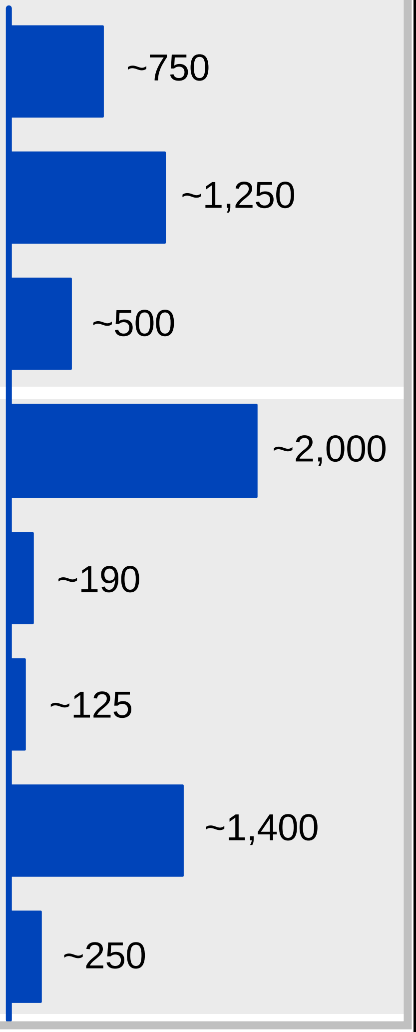
Source: McKinsey

Maturity problems at ramp-up/SOP have significant impact on profitability

- **Reduced profitability through potential problems at ramp-up/ SOP**
  - **Forgone sales**
    - Late market launch
    - Customer migration
    - Reduced production capacity
  - **Increased cost**
    - Target production cost exceeded
    - Target development cost exceeded
    - Resources used for ramp-up/SOP
    - Warranty and goodwill cost
    - Cost of changes

	Possible SOP problems (assumptions)	**Opportunity potential*** USD millions**
Late market launch	Market launch 6 months late	~750
Customer migration	15 percent migration of former customers	~1,250
Reduced production capacity	Full production reached 6 months late	~500
Target production cost exceeded	10 percent over target production cost	~2,000
Target development cost exceeded	15 percent over target development cost	~190
Resources used for ramp-up/SOP	50 percent over target SOP cost	~125
Warranty and goodwill cost	Long-term quality problems Ø USD 400/vehicle	~1,400
Cost of changes	Changes to body pressing tools 6 months before SOP	~250



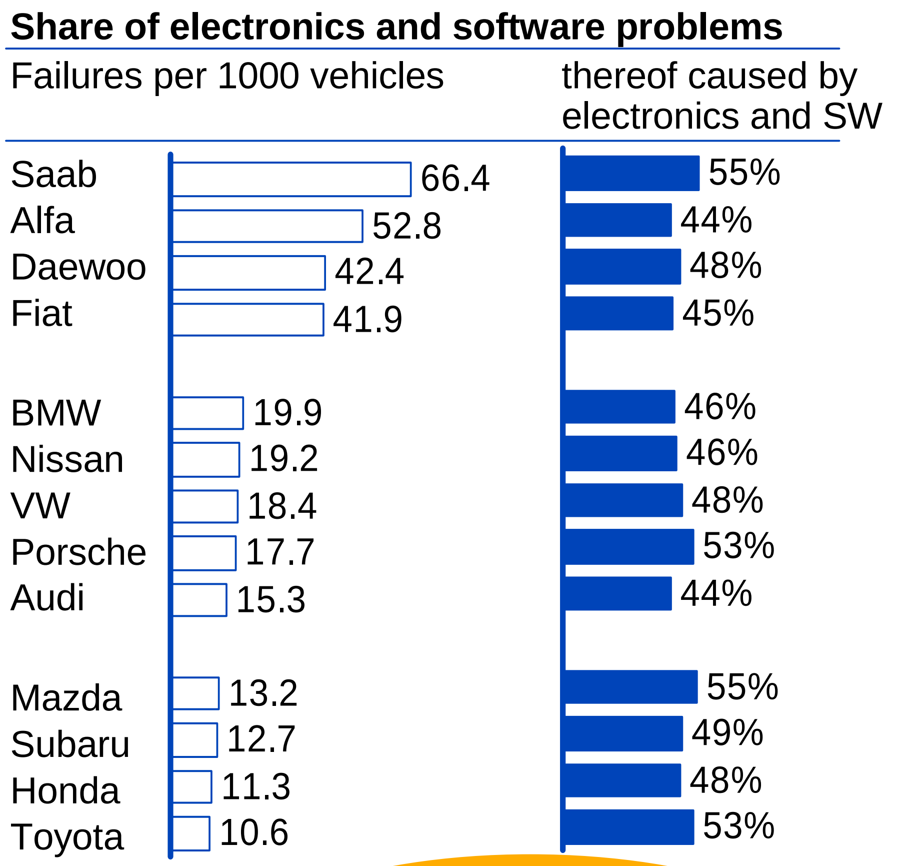
* Profit contribution from profits or cost differences over life cycle, assuming: 500,000 units p.a., USD 5,000 profit contribution/vehicle, production time 7 years

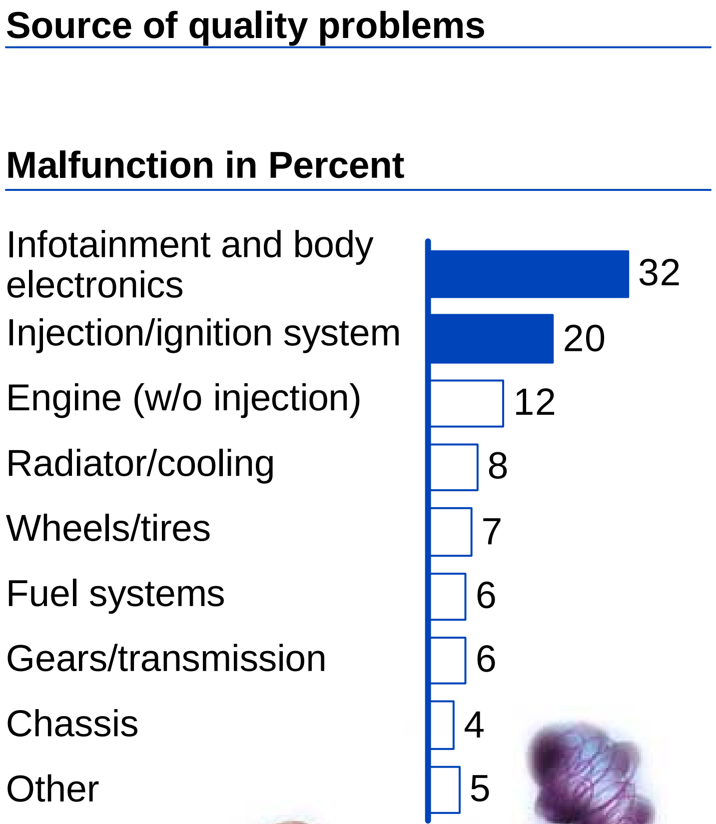
** Over total production time

Source:McKinsey

Software maturity is becoming a critical factor in automotive product development

■ Software-related





SW problems are reasons for recall of more than 700.000 vehicles in 2002

Source: McKinsey, Business Week, ADAC-AutoMarxX (3-5 year old car failures 1998-2001), cars in Germany only

Automotive software development adds a new layer of complexity compared to hardware

More complexity	• High number of tacit requirements • Heavy software and hardware interaction for embedded systems • Project complexity growing steeply with product size
Less trans-parency	• Intangible product, hard visualization and performance tracking • General mismatch between scope and available resources - projects always seem to be "nearly" complete

! Fundamental differences:

Find specific solution

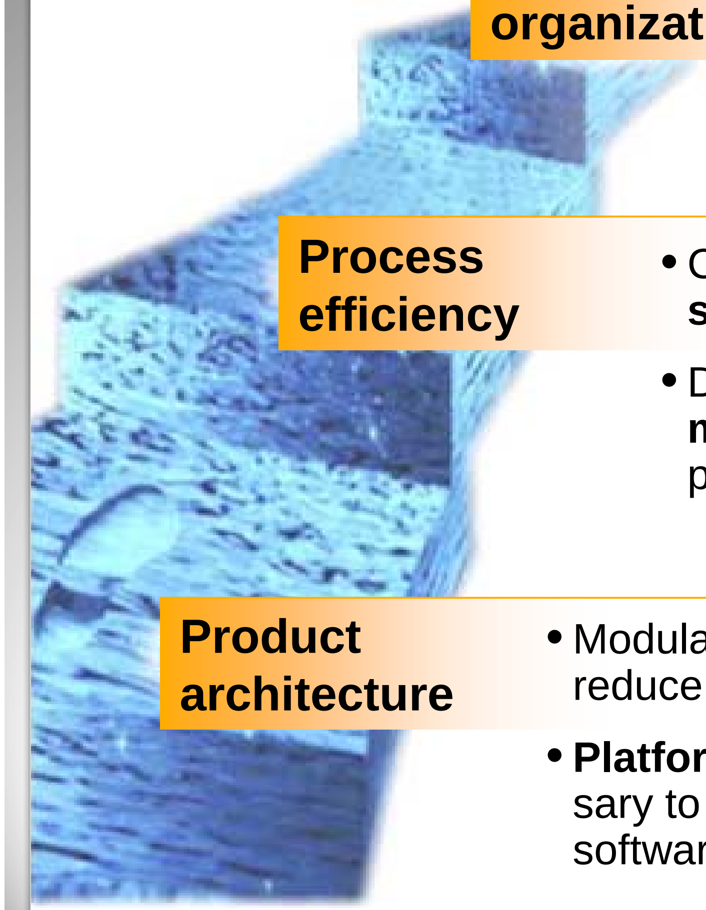
Less discipline	• Inherent tendency to over-engineering • Seemingly low cost of changes • Invariant resource under-estimation • Irrational developer preferences
More technolo-gical risk	• High degree of change in underlying complex technologies • No widely accepted platform standards • Immature tool landscape
More business risk	• Fast-moving (and in many cases immature) markets • Customer value hard to assess • Lack of experience translating customer requirements into functionality

! Will disappear as industry matures:

Learn from hardware

Source: Brooks: The Mythical Man-Month, McKinsey

Operational improvement can be achieved in a three step approach



Development organization

- Restructuring of development organization for **specific needs of SW projects** is necessary
- Building of specific skills in SW development and **SW project management** is needed

Process efficiency

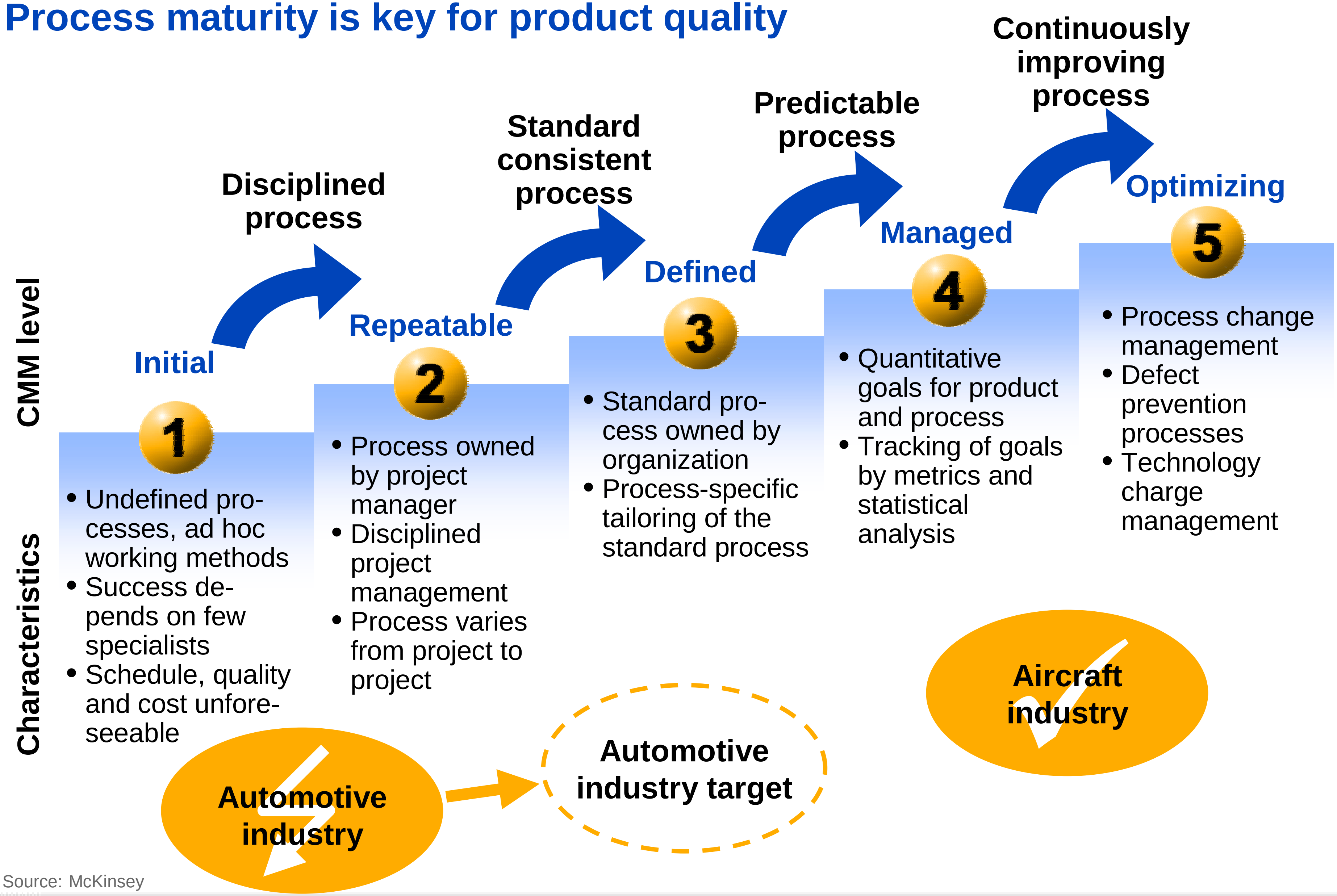
- Complex software projects are only feasible with **standardized, repeatable processes**
- Development effort depends heavily on **process maturity** - efficiency potentials of up to 90% are possible

Product architecture

- Modular, **feature specific product** design is key to reduce complexity and enable concurrent engineering
- **Platforming** and maximal degree of reuse is necessary to overcome complexity challenge and ensure software quality

Source: McKinsey

Process maturity is key for product quality



CMM level

Characteristics

1 Initial
- Undefined processes, ad hoc working methods
- Success depends on few specialists
- Schedule, quality and cost unforeseeable

Disciplined process

2 Repeatable
- Process owned by project manager
- Disciplined project management
- Process varies from project to project

Standard consistent process

3 Defined
- Standard process owned by organization
- Process-specific tailoring of the standard process

Predictable process

4 Managed
- Quantitative goals for product and process
- Tracking of goals by metrics and statistical analysis

Continuously improving process

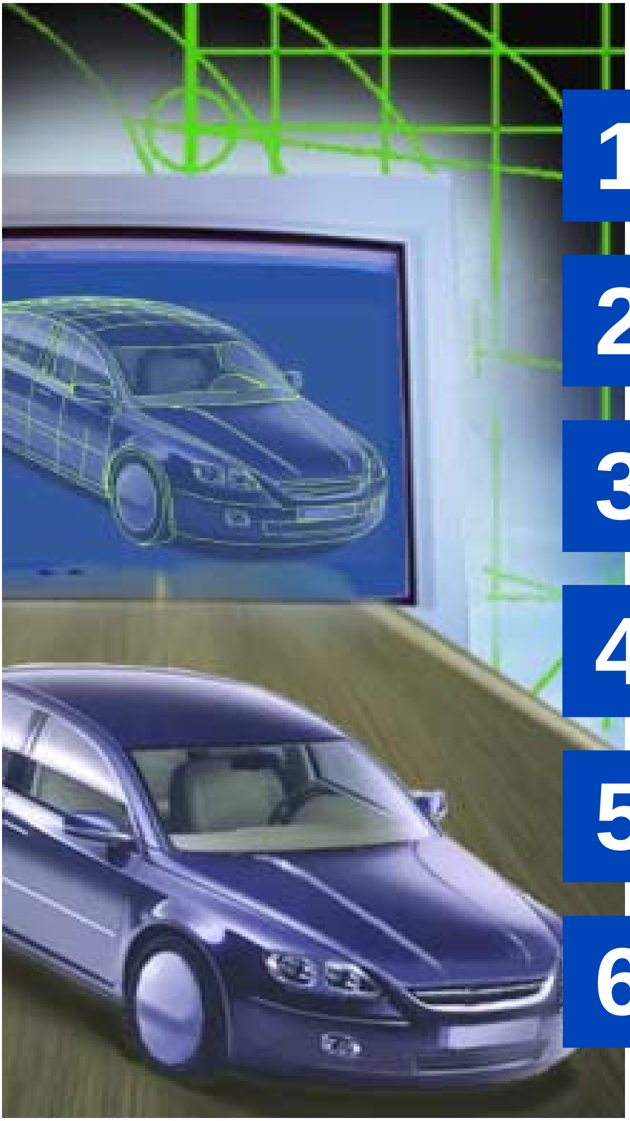
5 Optimizing
- Process change management
- Defect prevention processes
- Technology charge management

Automotive industry → **Automotive industry target**

Aircraft industry ✓

Source: McKinsey

Key levers to address complexity challenge



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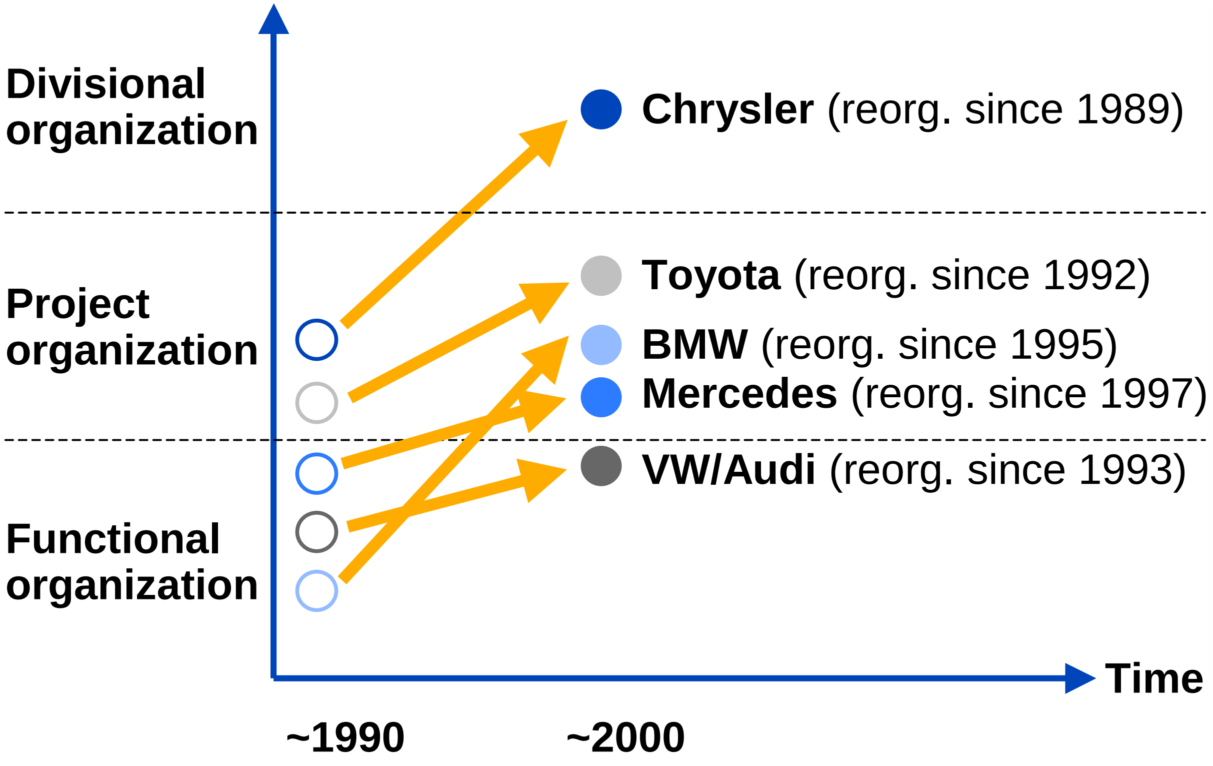
Source: McKinsey

Significant issues after reorganizations

CHANGES IN ORGANISATIONAL ORIENTATION



Chrysler (reorg. since 1989)

Toyota (reorg. since 1992)

BMW (reorg. since 1995)

Mercedes (reorg. since 1997)

VW/Audi (reorg. since 1993)

Critical issues

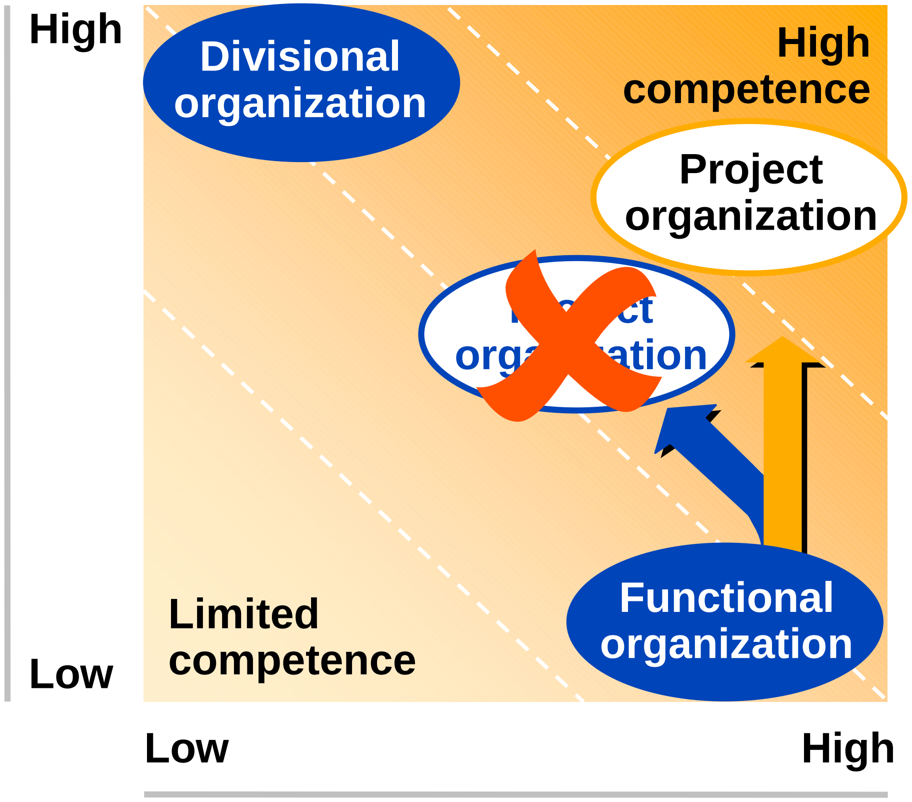
- **"Empire strikes back" – change not sustainable**
  - **Project management without real power**
  - **Support from top management and organization too weak**
- **Organization unable to accept shared responsibilities**

Source: Interviews, press clippings

CONCEPTUAL

Project organizations must combine high integration and functional development capabilities

EVALUATION OF DEVELOPMENT CAPABILITIES



Integration capabilities

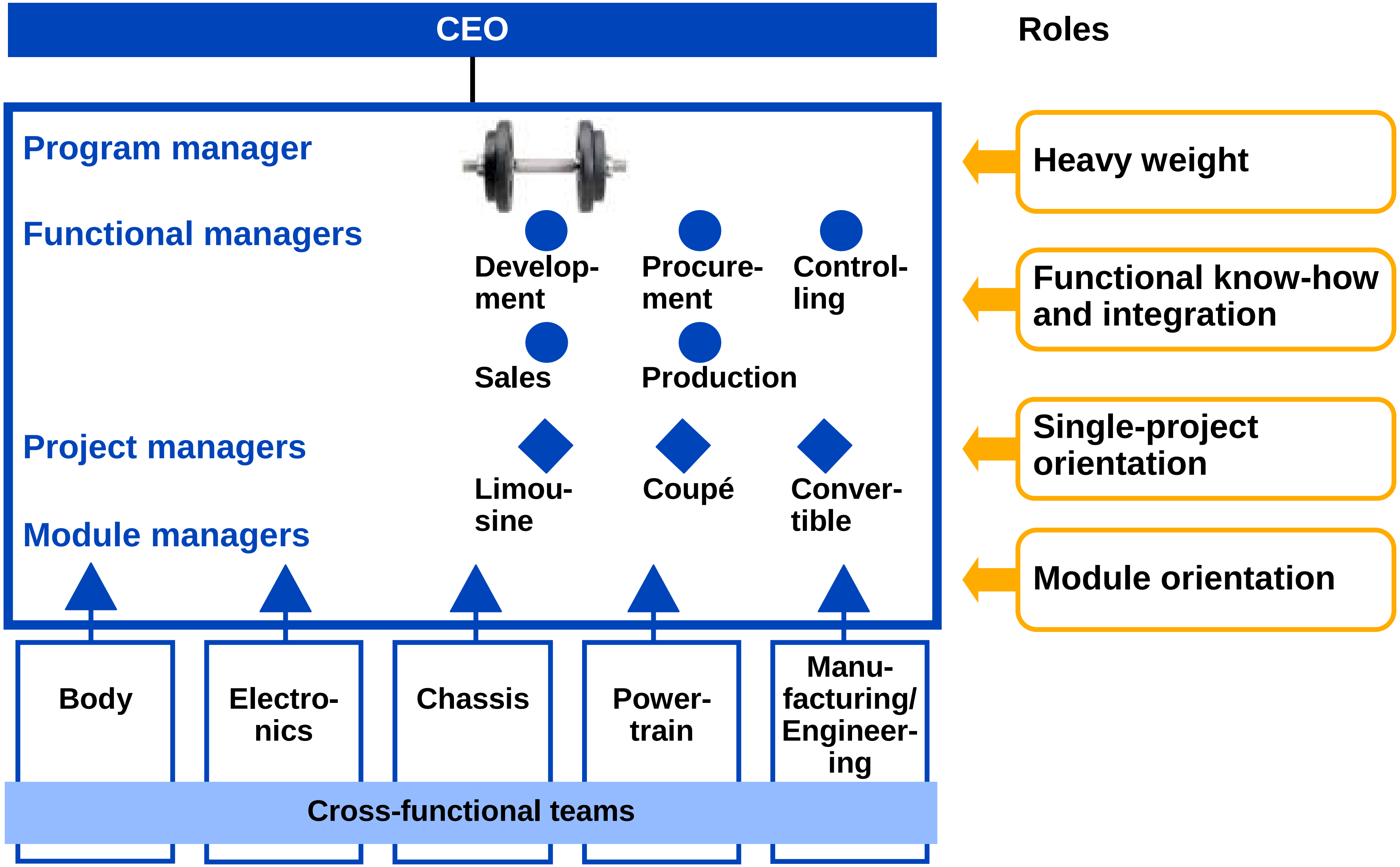
- Development time
- Target costs
- Known customer requirements
- Platform concepts

Functional capabilities

- Commercialized innovations
- Quality of vehicle features
- Efficiency of function

Source: McKinsey

Structure and roles within project organization defined to ensure high competency



CEO

Roles

Program manager

Functional managers

- Development
- Procurement
- Controlling
- Sales
- Production

Project managers

- Limousine
- Coupé
- Convertible

Module managers

- Body
- Electronics
- Chassis
- Powertrain
- Manufacturing/Engineering

Cross-functional teams

Heavy weight

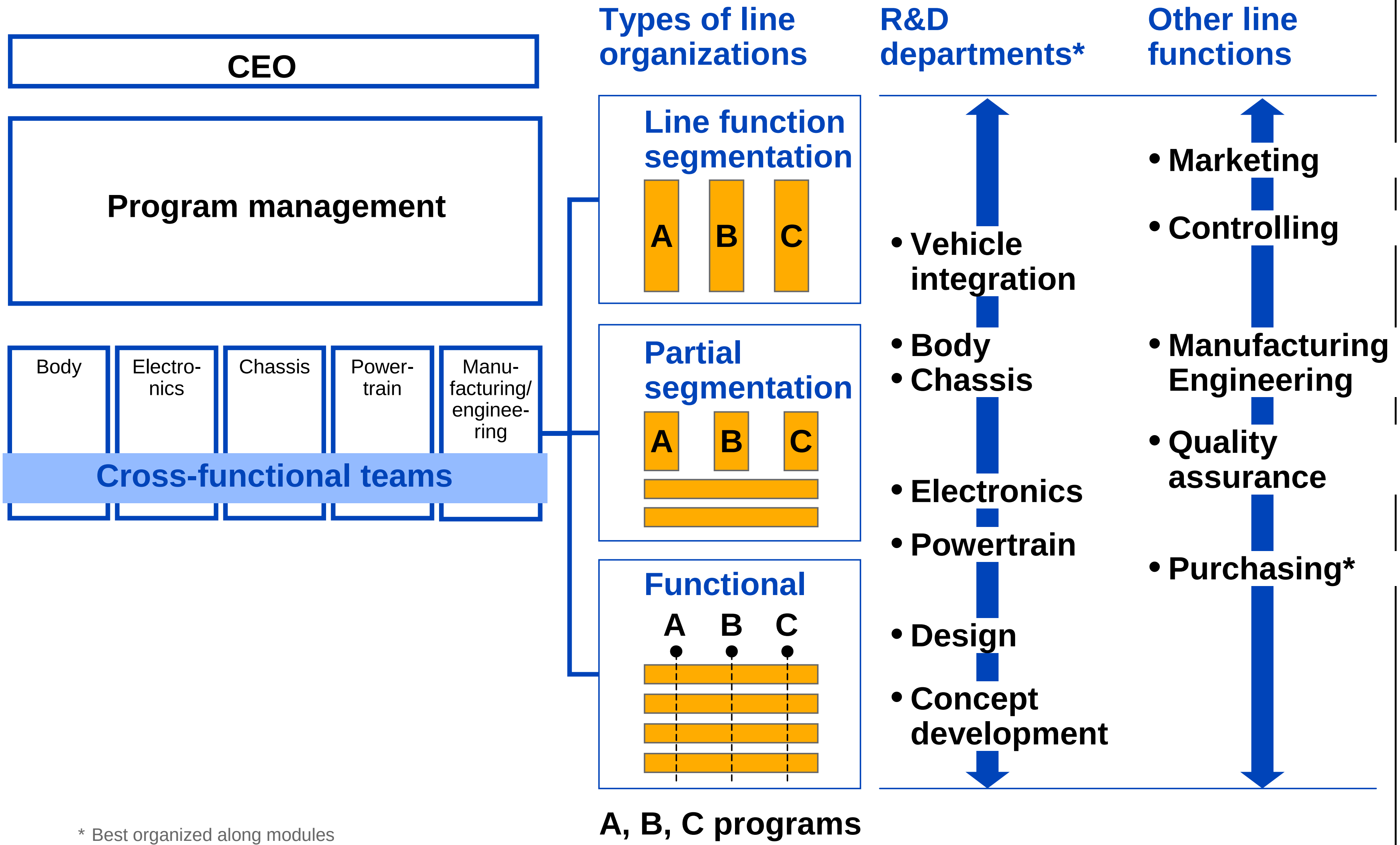
Functional know-how and integration

Single-project orientation

Module orientation

Source: McKinsey

Organizational setup of line functions based on individual function



R&D departments*

- Vehicle integration
- Body
- Chassis
- Electronics
- Powertrain
- Design
- Concept development

Other line functions

- Marketing
- Controlling
- Manufacturing Engineering
- Quality assurance
- Purchasing*

* Best organized along modules

Source: McKinsey

The necessary change process must be driven by top management and requires a long term change in people's mindsets

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Characteristics of change process

- Top management topic
- Change management approach required
- Long term process

Act now forward instead of reacting afterwards

Source: McKinsey