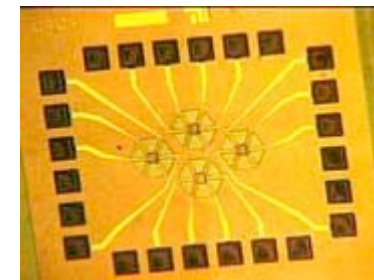
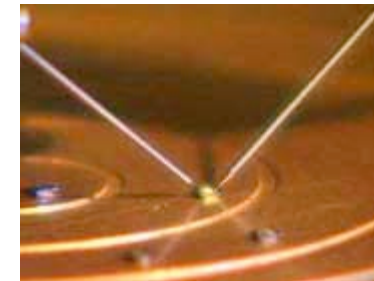
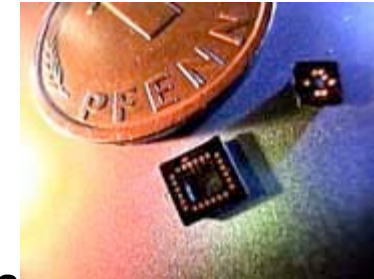


The international market for automotive microsystems: regional characteristics and challenges

Advanced Microsystems for Automotive Applications

03/16/05 - 03/16/05

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March 2005



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Summary and outlook

Introduction

- Automotive supply chain is undergoing tremendous changes
- Suppliers are turning more and more into development and risk sharing partners
- High RnD and production investments are necessary
- Decrease of current number of suppliers from 5500 to 3500 (2010) (800 to 34 1st tier suppliers (2010))
- Product development cycles decrease from 23.6 to 18.3 months (2010)
- The vertical integration of the manufacturing level is expected to decrease (OEM 39.5 % 2002 to 27.8 % 2010; supplier: from 46.1 % 2002 to 40 % 2010)
- The percentage of cars using common platforms will continue to rise from 65 % (2000) to about 82 % (2010) allowing larger production volumes of identical or only slightly modified parts for suppliers and OEMs

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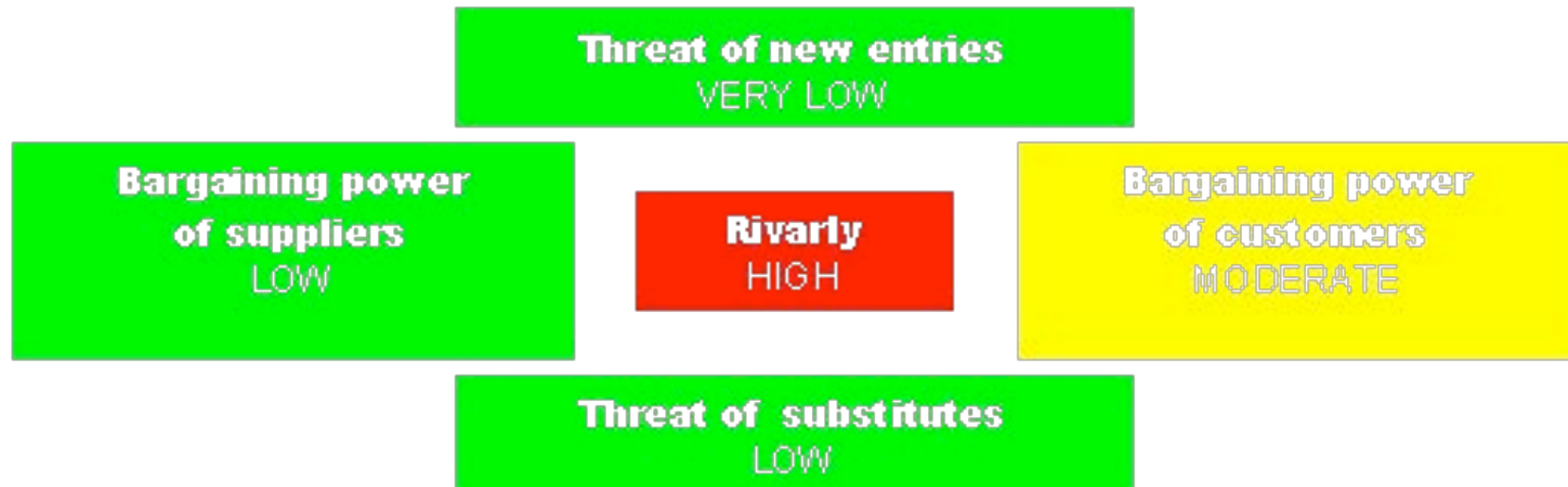
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Porter's five forces model of the automotive industry



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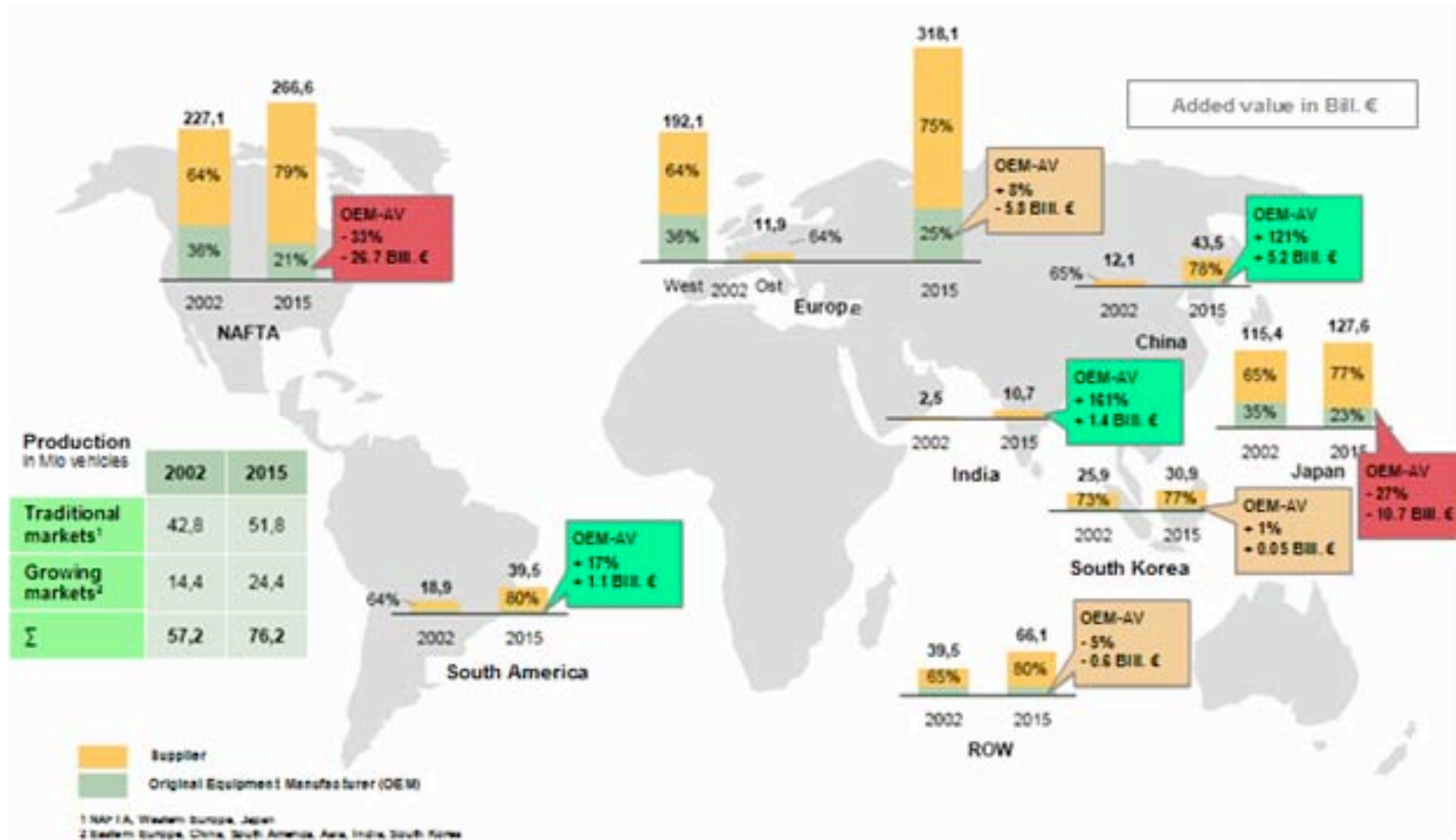
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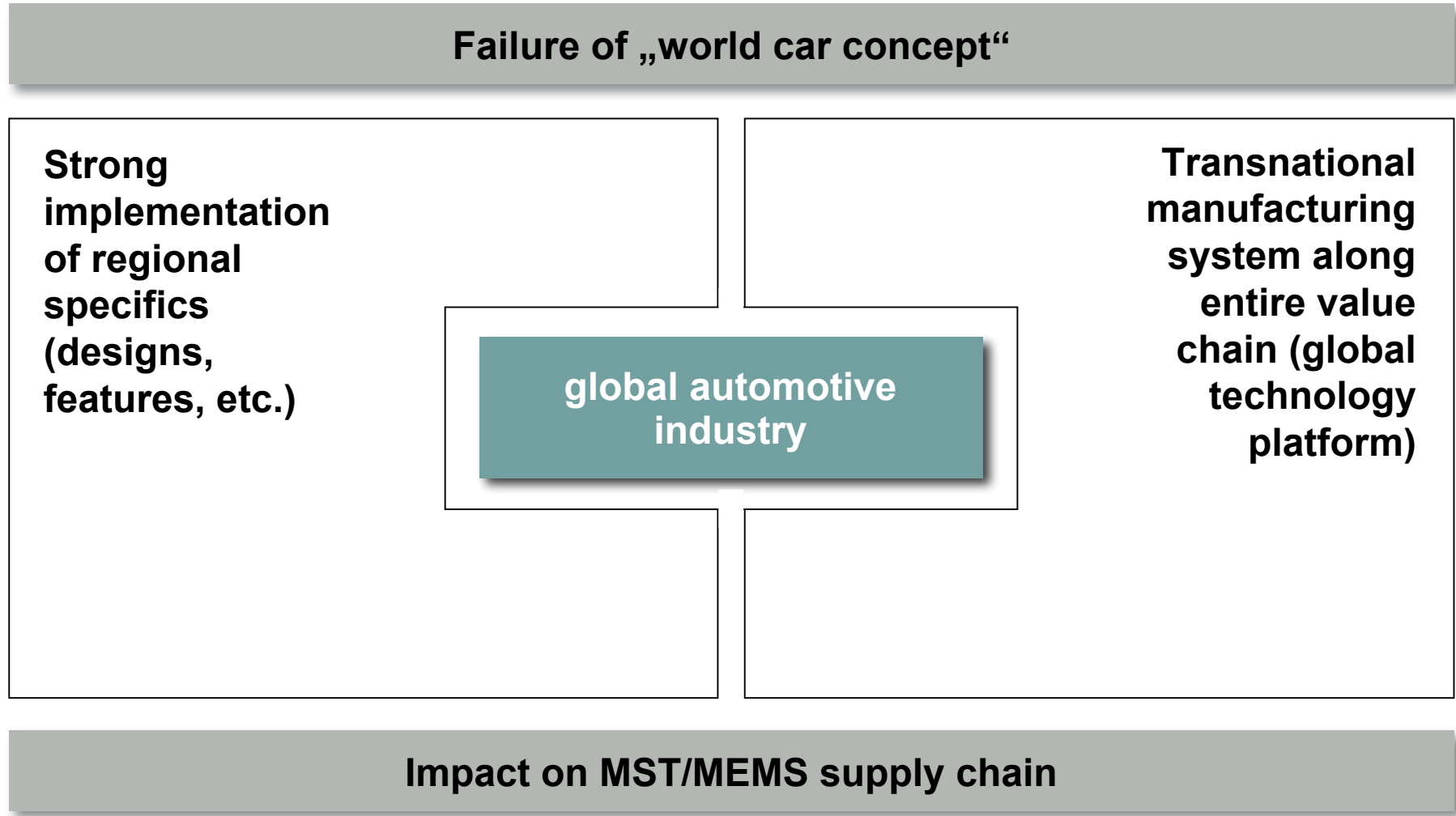
The global automotive market – production forecast (1 of 5)

Global automotive market development 2015



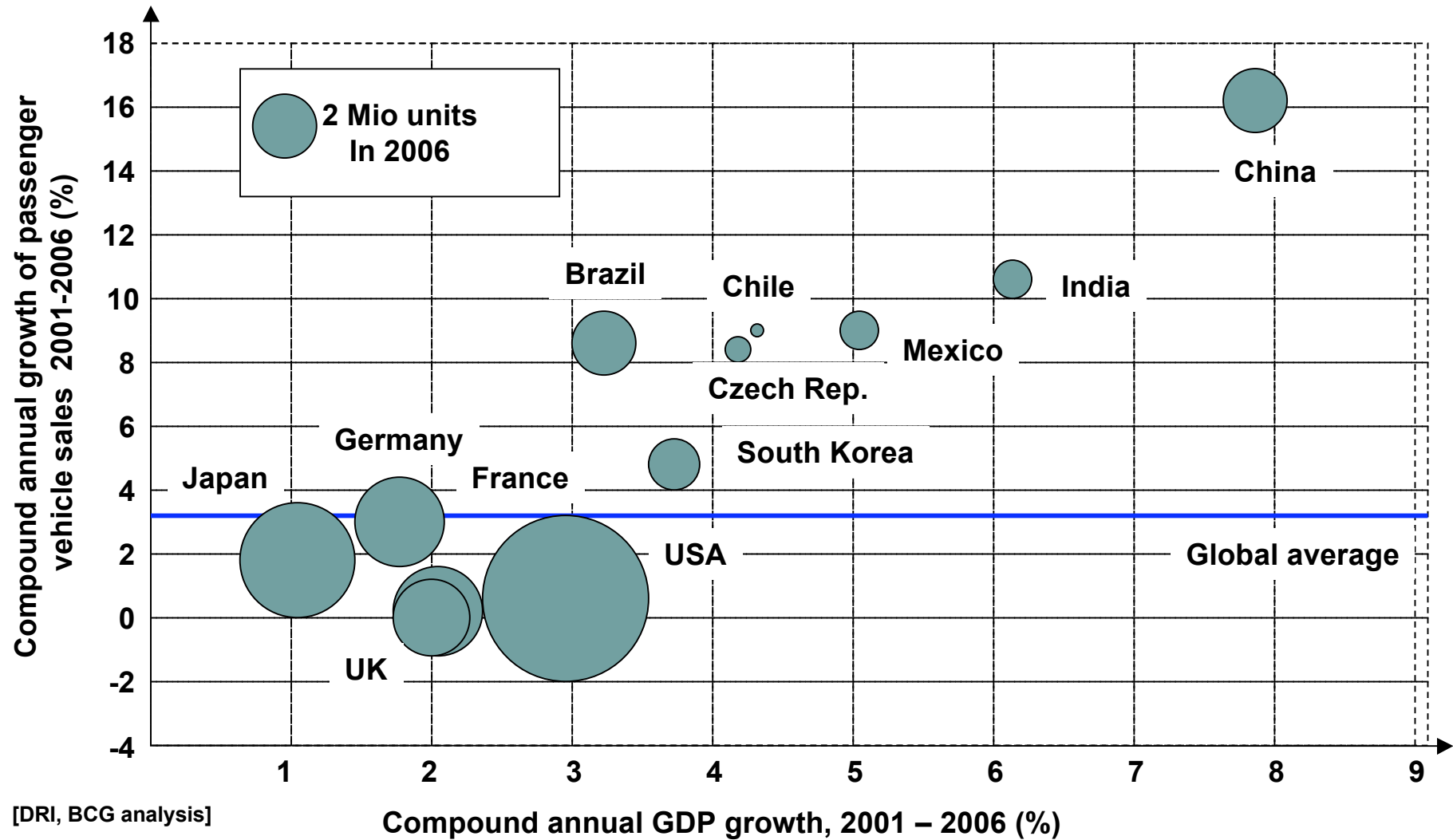
The global automotive market – production forecast (2 of 5)

Regional specifics - general



The global automotive market – production forecast (3 of 5)

Regional specifics – general



[DRI, BCG analysis]

The global automotive market – production forecast (4 of 5)

Regional specifics - overview

	Value chain	MST RnD	MST production	Lead market	Volume market
North America	competetive	2 ~	3 -	3 legislation	3 ~ low margins
Western Europe	competetive	3 ~	3 ~	2 tech. persistance	3 ~ fragmented
Eastern Europe	-	1 ~	1 ~	1 price and status	1 + long term
Asia	-	1 ~	1 +	1 price and status	1 + mid term
Japan	complete	2 ~	2 +	3 innovation	2 ~ saturation
China	growing	1 +	1 +	1 quality and status	2 + mid term
1	below average	-	decreasing		
2	average	~	stagnating		
3	above average	+	increasing		

Table 1: comparison of the international markets

The global automotive market – production forecast (5 of 5)

Regional specifics – China

Joint Venture	Local partner	Foreign partner	Year	Market share in 2000 / %	Market share in 2004 / %	Projected
Shanghai - Volkswagen	Shanghai Automotive Industry Group (SAIC)	Volkswagen	1985	35.6	15 % (2002: 19.1 % 396,000)	20 % (2008) 462,000 (2004)
FAW-VW	First Automotive Works	Volkswagen	1985	17.8	11 % (2002: 300,000)	1 Mio. (2008)
TAIC	Tianjin Automotive Industry Group	Daihatsu, Toyota	1987	14.9	5 %	
Dongfeng - Citroën	Dongfeng Motor	Citroën	1992	8.9	4 %	300,000 (2007)
Shang'an – Suzuki	Chang'an Automobile	Suzuki	1993	8.9	5 %	
Shanghai GM	SAIC	General Motors	1998	5.0	11 % (2002: 9.8 %)	20 % (2008) 10 % 285,000 (2003)
Guangzhou – Honda	Guangzhou Auto Group	Honda	1998	4.9	5 %	300,000 (2007)
Beijing – Jeep	Beijing Automotive Industry Group	Daimler - Chrysler	1984	1.0		
			Total	97.0	56 %	
				0.6 Mio.	2.2 Mio	

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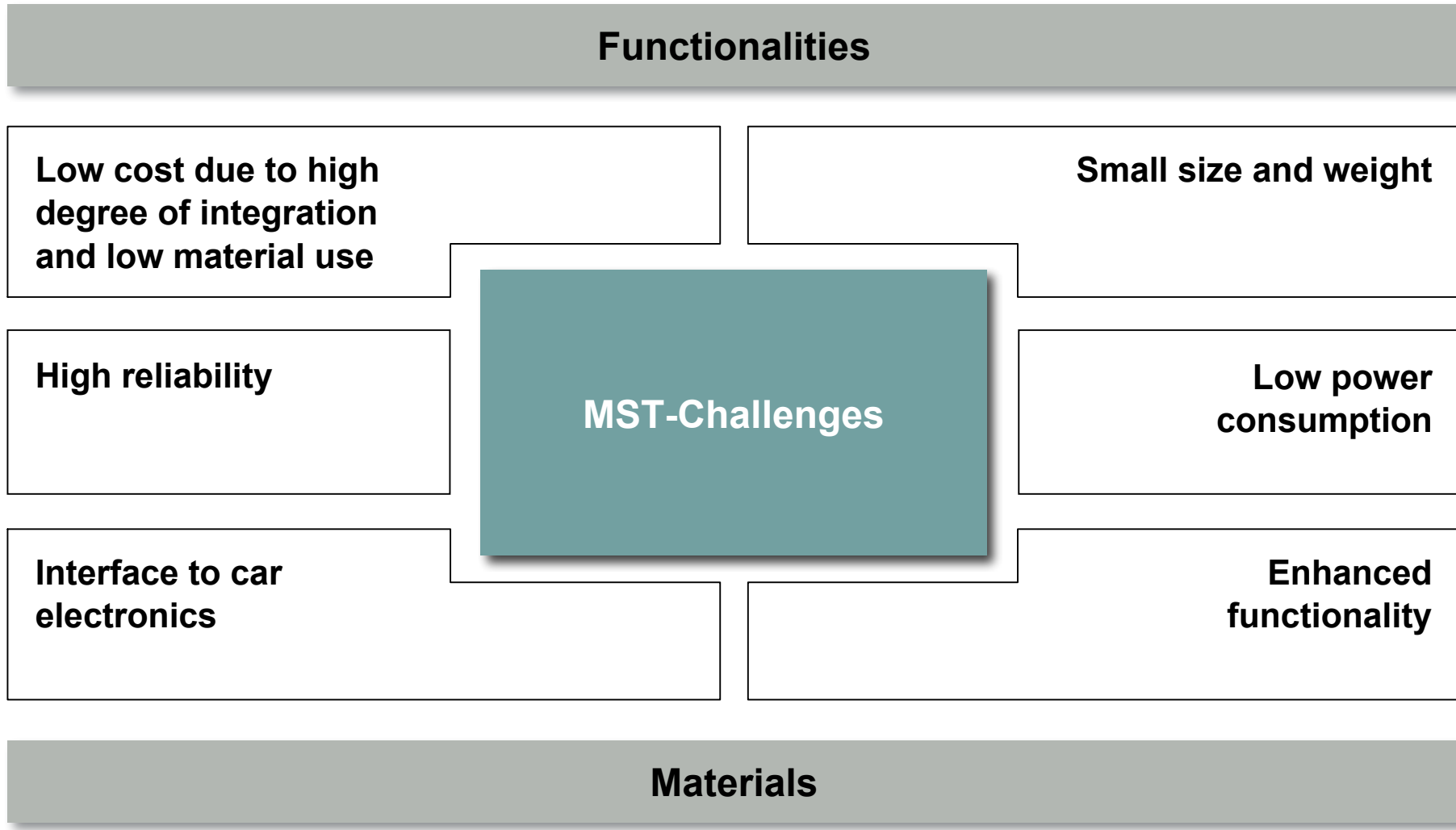
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Summary and outlook

Automotive microsystems – challenges (1 of 2)

Key factors



Automotive microsystems – challenges (2 of 2)

Technical requirements

Criterion	Values and description
Temperature	-65°C / -40°C / 85°C / 125°C / 150°C / 600°C / 1100°C Emissions regulations / engine compartment / engine / exhaust
Pressure	mbar (accuracy < 0,1 %) / 0-5 bar / 30 bar / 80 bar low pressure, 300 bar high pressure side / 100 bar / 200 bar / 1500 bar Level measurement / air intake / hydraulics, HVAC (old) / HVAC (CO ₂) / cylinder pressure / brakes / TDI injection
Acceleration	1 g / 6 g / 100 g / 250 g (engine up to 40 g) Gyroscopes / Airbag sensor / front satellite / side impact sensor
Media	Fuel and lubricants, hydraulic oils, reffridgerants, environment al gases, detergents For sensors and actuators operated in above stated media
Time	< 5 ms Initiation of side airbag (20 ms for driver side front airbag)
Life time	15 years (warranty) for airbag modules 6.000 h - 300.000 km operation (car) / 20.000 h - 1 Mio. km (trucks/commercial vehicles)
Reliability	Failure rates < 10 ⁻⁶ – 10 ⁻⁹ for safety relevant applications (brakes, airbag, etc.) ca. 50 ppm failure rate for electronic control units

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Summary and outlook

Automotive microsystems – applications (1 of 8)

Microsystems components in a car

Categories:

1. Established devices
2. Introduced systems
3. Research

About 30 electric/electronic systems and more than 100 sensors



System	Abb.	Sensors		
Distronic	DTR	3	Common-rail diesel injection	CDI 11
Electron. controlled transmission	ECT	9	Automatic air condition	AAC 13
Roof control unit	RCU	7	Active body control	ABC 12
Antilock braking system	ABS	4	Tire pressure monitoring	TPM 11
Central locking system	ZV	3	Elektron. stability program	ESP 14
Dyn. beam levelling	LWR	6	Parktronic system	PTS 12

[DaimlerChrysler]

Automotive microsystems – applications (2 of 8)

Drivetrain (1/1)

Application	Sensor	Status	Challenge	Potential
Intake	Pressure - MAP Flow Rpm meter turbo charger	Settled Saturation Introduction	- relyability, price price	- Regulations Diesel deployment
Injection	Pressure Sensor MST valve	Introduction Research	Price Size, energy	Regulations Full penetration
Engine	Cylinder Pressure / Ion current Knock Cam-, Crankshaft position Rpm sensors Torque sensor Oil quality	Research Settled Introduction Introduction Research Introduced	Temperature Quality Price Price Simplicity Quality	•Regulations Substitute Regulations Regulations Ideal control value intermediate
Exhaust treatment	Soot sensor Pressure sensor for soot filter Exhaust pressure sensor Lambda (O ₂) NOx, NH ₃ , CO, CO ₂)	Introduction Research Saturation Settled Research	Temperature, PM Differential pressure Price - reliability, price	Diesel deployment Diesel deployment Diesel deployment - Regulations
Transmission Control (automatic gearbox)	Rpm sensor Pressure Position Oil quality	Introduced Introduced Introduced Research	harsh environment harsh environment harsh environment quality	Regulations Regulations Regulations Heavy duty vehicles

Automotive microsystems – applications (3 of 8)

Safety (1/2)

Application	Sensor	Status	Challenge	Potential
ABS/ASR/ ESP (stability)	Angle sensor (steering wheel) Rpm sensors low-g Accelerometers Yaw rate sensors Gyroscope Pressure sensors Force sensors	Introduced Saturation Saturation Saturation Saturation Development Research	Reliability, price Price Inertial cluster Inertial cluster Inertial cluster Price Quality	Steer by wire Fusion with tyre Fusion Fusion Fusion Brake by wire Brake by wire
Roll over prevention	Gyroscope low-g Accelerometer	Introduced Introduced	Inertial cluster Inertial cluster	Fusion Fusion
Airbag	high-g Accelerometers Pressure sensors Bus igniter Remote sensor bus <i>Yaw rate sensors</i> Structure borne noise	Saturation Introduced Development Development Research Research	Inertial cluster Price Bus, price Bus, price Price Inertial cluster	Fusion Fusion Substitute Substitute Substitute Substitute
Seatbelt	See airbag system			
Occupancy classification	Weight of passenger Child seat detection (transponder) Occupant Classification Out of position sensor (static) Out of position sensor (dynamic)	Introduced Introduced Research Research Research	Reliability, Quality, price Reliability, price Reliability, price Reliability, price Reliability, price	Communication Fusion Fusion Fusion Fusion

Automotive microsystems – applications (4 of 8)

Safety (2/2)

Application	Sensor	Status	Challenge	Potential
Pedestrian Protection	Low-g accelerometers Force Sensors (optical, resistive) Bending Sensors (optical, resistive) Lidar Camera Hood position	Introduction Introduction Research Research Research Development	Price Price Reliability, price Reliability, price Reliability, price Price	Regulation Regulation Substitute Substitute Fusion Regulation
Longitudinal support	Radar or Lidar	•Introduced	Obstacles, integration, price, HMI	Fusion
Lateral support	Camera or Lidar	•Introduced	Quality, integration, price, HMI	Fusion
Obstacle detection	Radar, lidar, camera	Research	Quality, price	Frequency, Fusion, communication
Vision enhancement	Infrared systems	Introduced	HMI, price, integration	Fusion
Headlight control	Tilt sensor Yaw rate sensor Headlight beam actuators Adaptive light sources (DLP)	Introduced Development Introduced Research	Price Quality Price Price, reliability	Fusion Fusion Regulation Flexibility

Automotive microsystems – applications (5 of 8)

Diagnosis (1/3)

Application	Sensor	Status	Challenge	Potential
Road condition	Tire sensors Infrared systems Lidar Camera	Research Research Research Research	Quality Price Price Price	Fusion Fusion Fusion Fusion
Vehicle speed	Rpm sensors	Saturation	Direct measurement	Substitution
Tire pressure monitoring	Pressure sensors Wheel speed sensors (from ABS) Force sensors	Growth Introduced Research	Energy, price System integration Accuracy, price	Fusion Fusion Direct data
Fuel	Fuel tank pressure level sensors Igniters for fuel cut off	Introduction Development Research	Accuracy, price Accuracy, price Bus, price	- Substitute Regulation
Water systems	Level sensors	Introduced	Price	Comfort
Oil systems	Level sensors Oil quality (contamination)	Introduced Introduced	Accuracy, price Quality, price	Comfort Comfort

Automotive microsystems – applications (6 of 8)

Diagnosis (2/3)

Application	Sensor	Status	Challenge	Potential
Brake systems	Pressure / force sensors Wheel speed sensors (ABS)	Development Introduction	Accuracy, reliability Resolution	Brace by wire Fusion
Park distance control	Ultrasonic sensors 24 GHz Radar Rear view camera	Growth Introduction Introduced	Speed, distance Price, Frequency Price, HMI	Substitute Fusion, safety Fusion
Automatic parking	Ultrasonic sensors 24 GHz Radar Lidar Side view camera	Growth Introduction Development Development	Speed, distance Price, Frequency Price Price	Substitute Fusion, safety Fusion Fusion
Anti-theft / alarm	Remote control (IR/RF) motion sensors position and tilt sensors authorization sensors GPS sensor (location)	Growth Growth Growth Introduced Introduced	Price, energy, quality Price Price Price, reliability Price	Comfort Insurance companies Insurance companies Comfort Fusion

Automotive microsystems – applications (7 of 8)

Diagnosis (3/3)

Application	Sensor	Status	Challenge	Potential
HVAC	Air quality Temperature Humidity Pressure	Introduced Development Introduced Settled	Quality, price Dynamic user profile Accuracy, prediction Relative measurement	Comfort Comfort, fusion - CO2 systems
Chassis Control/ESS	Suspension height sensor Axis acceleration sensor Vertical acceleration sensor Pressure sensor (air suspension) Gyroscope (tilt)	Introduced Introduced Introduced Introduced Introduced	Price Inertial cluster Inertial cluster Price Inertial cluster	Comfort Fusion Fusion Fusion Fusion
Windshield	Rain sensor Fog sensor Darkness/light sensor	Growth Introduced Introduced	Accuracy, price, integrat. Quality, prediction Price	Comfort Comfort Comfort
Seat control	Child seat detection Sensors for power seat memory Passenger weight sensors Headrest position	Growth Growth Settled Development	Price, accuracy Price Price, out of position Price	Regulation, fusion Comfort Substitute (camera) Safety
Power window /door control	window / sunroof crush guard Automatic doors crush guard	Introduced Development	Quality, price Prediction	Regulation Regulation

Automotive microsystems – applications (8 of 8)

HMI (1/1)

Application	Sensor	Status	Challenge	Potential
Vision	Displays Projector/HUD	Growth Introduced	Price, integration Quality, price	Flexibility Primary viewing area
Audio	Speaker Microphone	Settled Introduced	Integration, price Quality	Noise cancellation Dynamic fields
Haptics	Force feedback pedal Driver seat vibration Steering wheel momentum	Introduced Introduced Introduced	Flexibility, reliability Price Price	X by wire, comfort X by wire, comfort X by wire, comfort

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Summary and outlook

Trends and global innovation networks (1 of 3)

Sensor and data fusion

Data fusion

the fusing of information originating from several physical sensors in order to compute new virtual sensors

Two different types of these virtual sensors:

High-precision and self-calibrating sensors

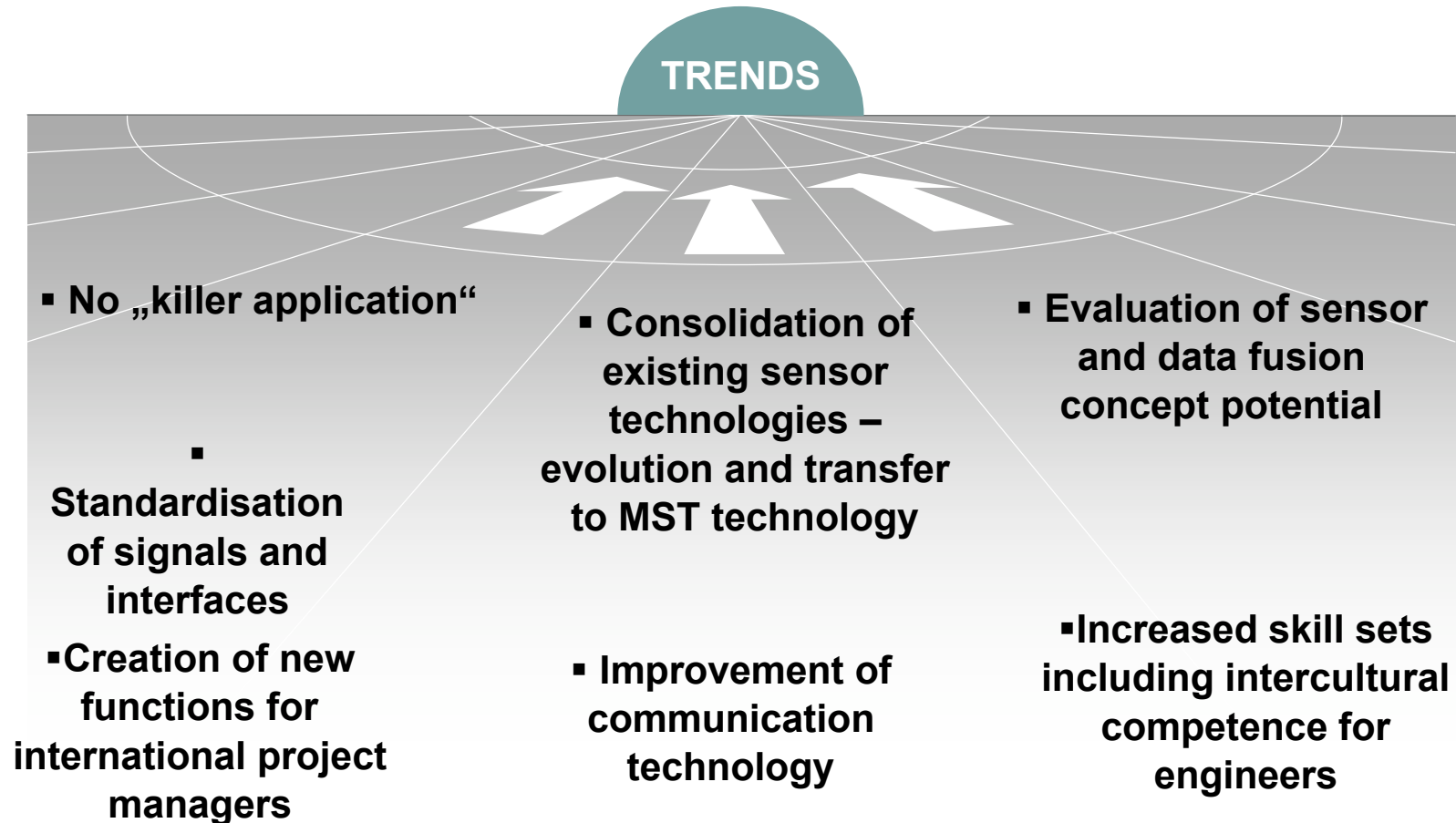
Improved versions of the physical sensors.

The goal is either to achieve higher performance using existing sensors or to reduce system cost by replacing expensive sensors by cheaper ones and by using sensor fusion to restore signal quality.

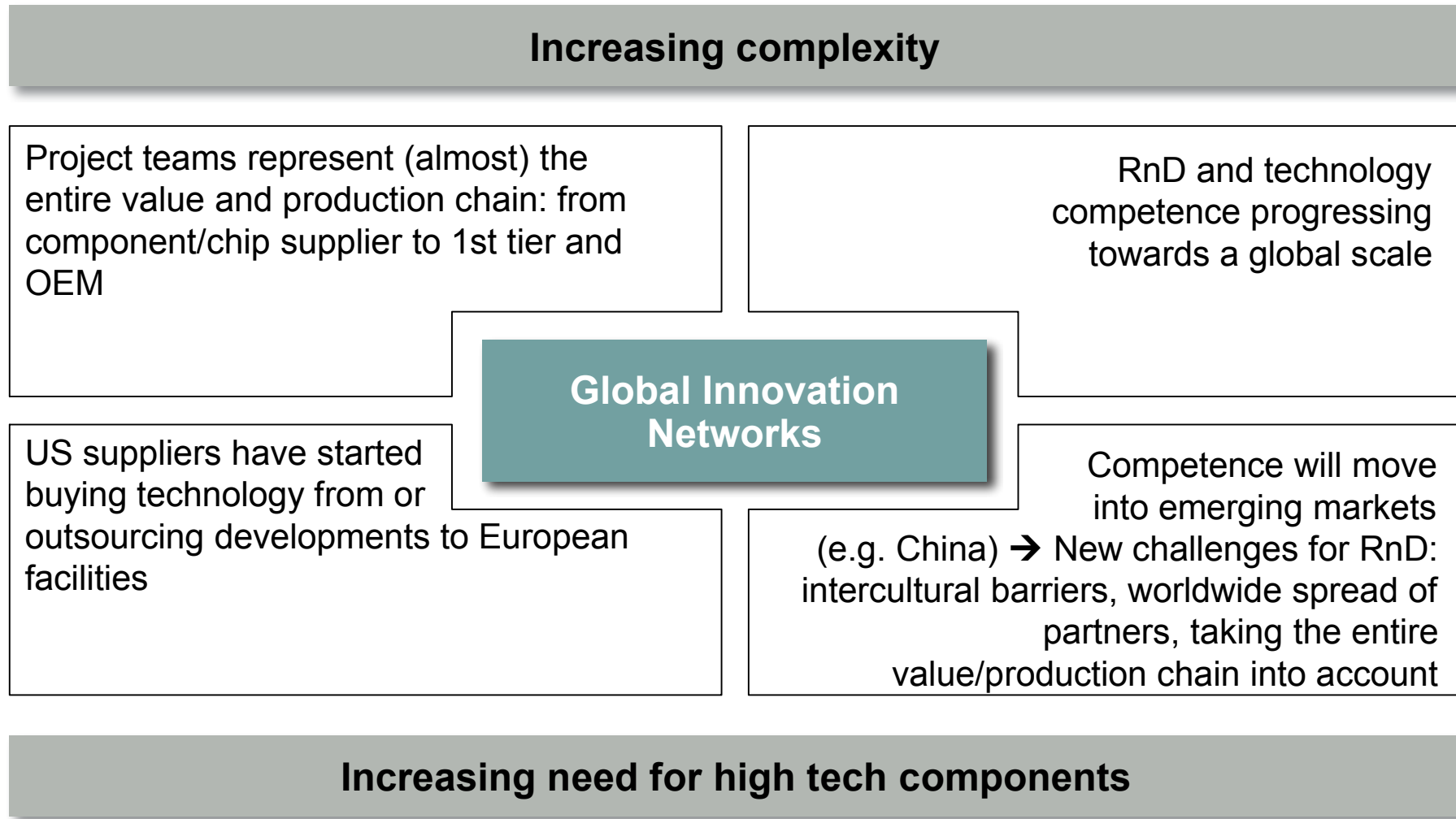
Soft sensors

Sensors that have no direct physical counterpart

Trends and global innovation networks (2 of 3)



Trends and global innovation networks (3 of 3)



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Summary and outlook

Summary and Outlook (1 of 3)

- MST for automotive markets and applications has certainly arrived at a watershed in its development
- automotive applications will remain an important cornerstone of MST development and products but will make up an ever smaller proportion of the market
- be expected that harsh environment compatible MST and high complexity MST or sensor systems will largely contribute to this remaining growth
- Biomedical and consumer market applications will however outclass automotive MST in market volume
- Germany as key driver market for automotive MST has returned a more conservative approach towards new technologies and new MST devices (only need to have devices)

Summary and Outlook (2 of 3)

- In line with this development, most major OEM's have to a large extent pulled out of earlier MST/MEMS commitments and RnD programs. Whereas until about 5 years ago the goal of many OEMs was to be technology leader when introducing new systems, today the primary objective appears to be “first-to-follow”, in order to be able to monitor the customer reaction as well as initial failure modes
- Legal requirements (e.g. new emissions regulations for diesel engines taking effect in 2007/2008) remain a powerful driver for continued innovation in this field
- Even though some of the regulations are stricter in the US, the European automotive OEMs still seem to be implementing a much larger number of new high tech systems than their US counterparts
- Likely reasons for this development: extreme price competition on US brand cars and reduced necessity for MST high tech devices due to lower traffic density, lower vehicle speeds, etc.

Summary and Outlook (3 of 3)

- Current trends point towards consolidation and data fusion – i.e. try to use systems in place first before adding additional new components which add to the overall car electronic system complexity and potential failure modes
- Car reliability?
- It can be assumed that until the reliability of the new systems has reached a level comparable to the one acquired in airplane control systems, cars that were built about 10 years ago will probably represent a peak in reliability
- Finally, the increasing globalisation of the automotive supply industry in unison with the need to cater for regional customer needs and desires calls for a new generation of automotive and MST RnD engineers. High intercultural competence will be a key to RnD project and product success
- Automotive MST has started to mature and will start to loose some of its original momentum. Just like car electrical systems, however it has established itself as essential component of individual transport systems and will replace basic electrical system continue to be the economic and innovation motor for the coming decades.

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