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Towards Human-Robot Cooperation – Systematic Approach and Applications within the Volkswagen Group

02.10.2015 International Conference on Intelligent Robots and Systems, Hamburg
Dr. T. Krüger, Dr. H. Heyn – R & D Robotics - Volkswagen AG

Towards Human-Robot Cooperation – Systematic Approach and Applications within the Volkswagen Group

1.

Motivations

2.

**Applications within
the Group**

3.

**Systematic Approach
for Car Assembly**

4.

**Human-Robot
Cooperation in Smart
Factory Environments**

5.

Conclusion

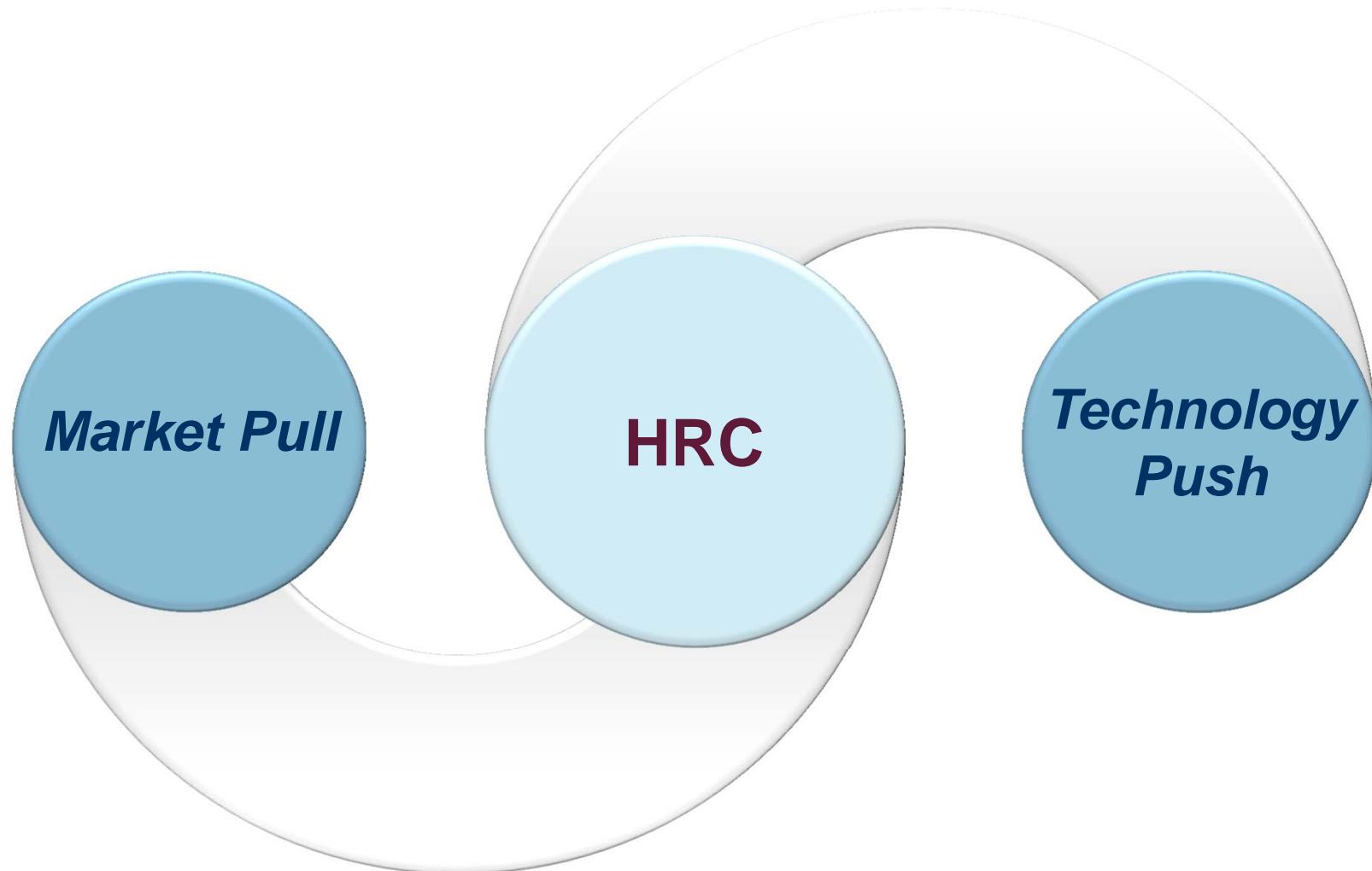
Towards Human-Robot Cooperation – Systematic Approach and Applications within the Volkswagen Group

1.

Motivations

Drivers of Innovation

Human-Robot Cooperation and New Robot Concepts (HRC)



Technology Push

Human-Robot Cooperation and New Robot Concepts (HRC)

Algorithms and Machine Learning

Sensors

Robots – Mobile Platforms – Handling Technology

Technology Push

Human-Robot Cooperation and New Robot Concepts (HRC)

Object Recognition for
Bin Picking Tasks

Intuitive
User Interfaces

Environment
Recognition and
Mapping

Robot-Integrated
Sensors
e.g. Force/Torque Sensors

Supplemental
Sensors
e.g. Capacitive Skins

Plant-Integrated
Sensors
e.g. Camera Systems

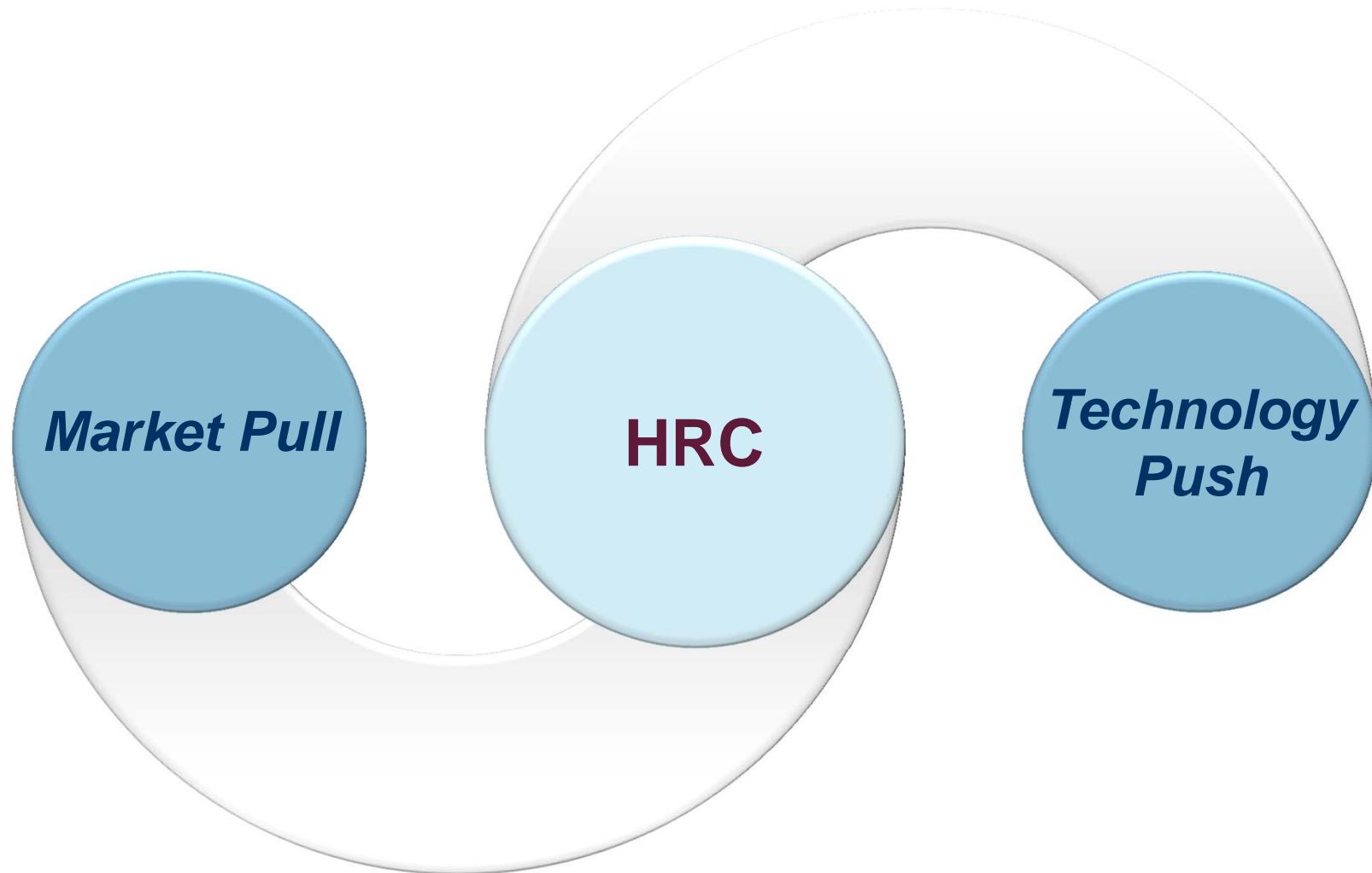
Safe Robots and
Control Systems

Lightweight Robots

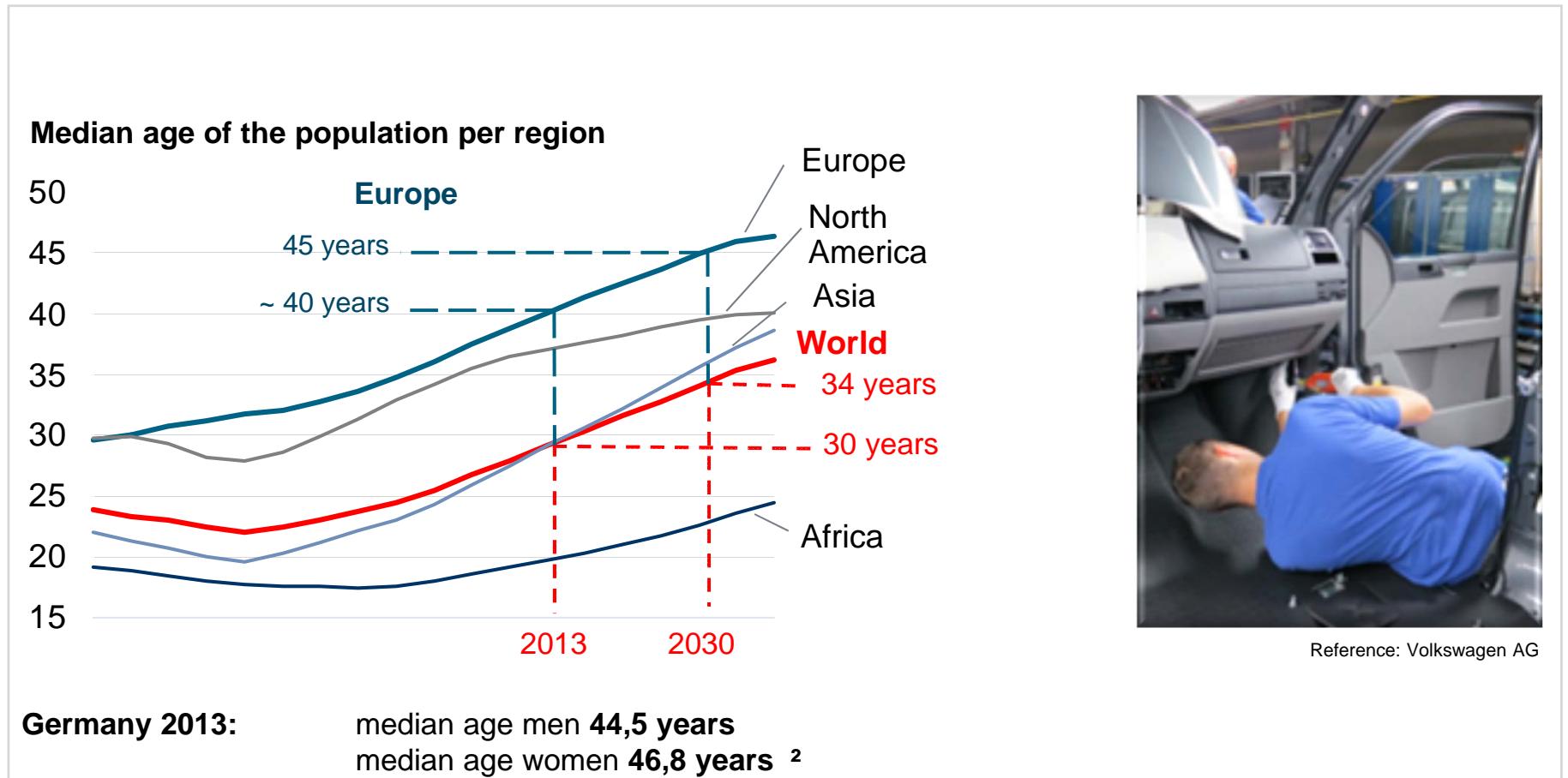
Safe and Flexible
Gripping Systems

Drivers of Innovation

Human-Robot Cooperation and New Robot Concepts (HRC)



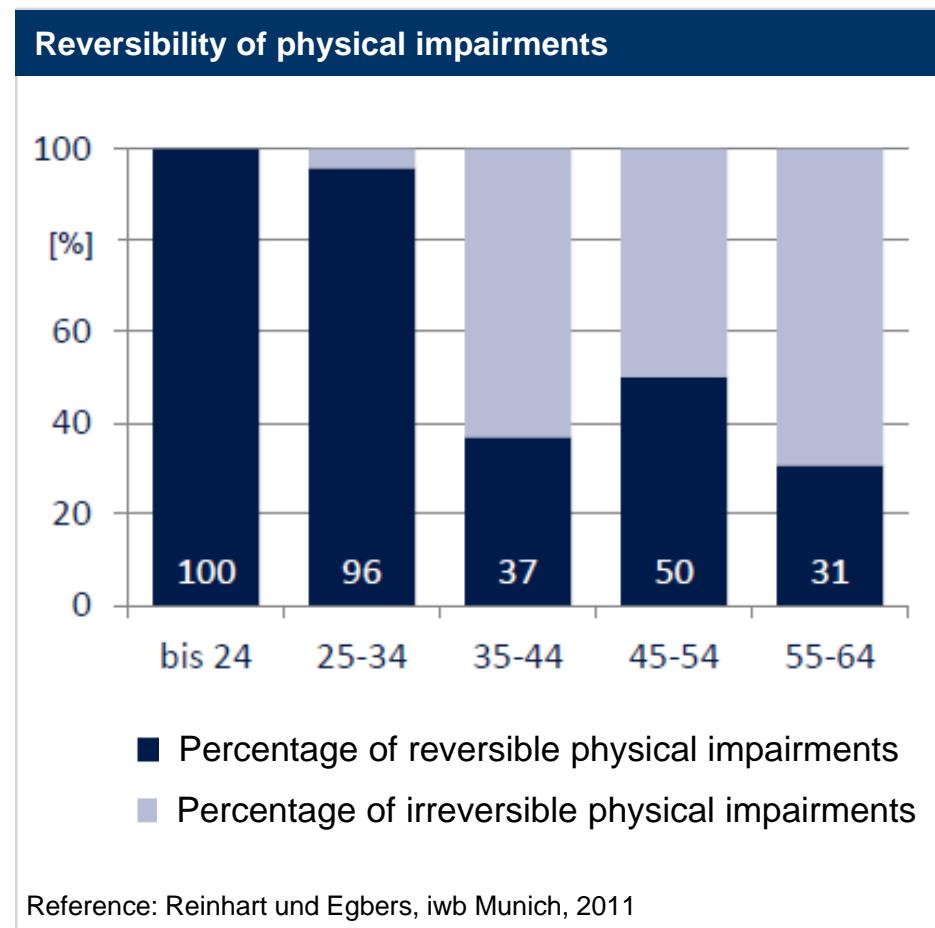
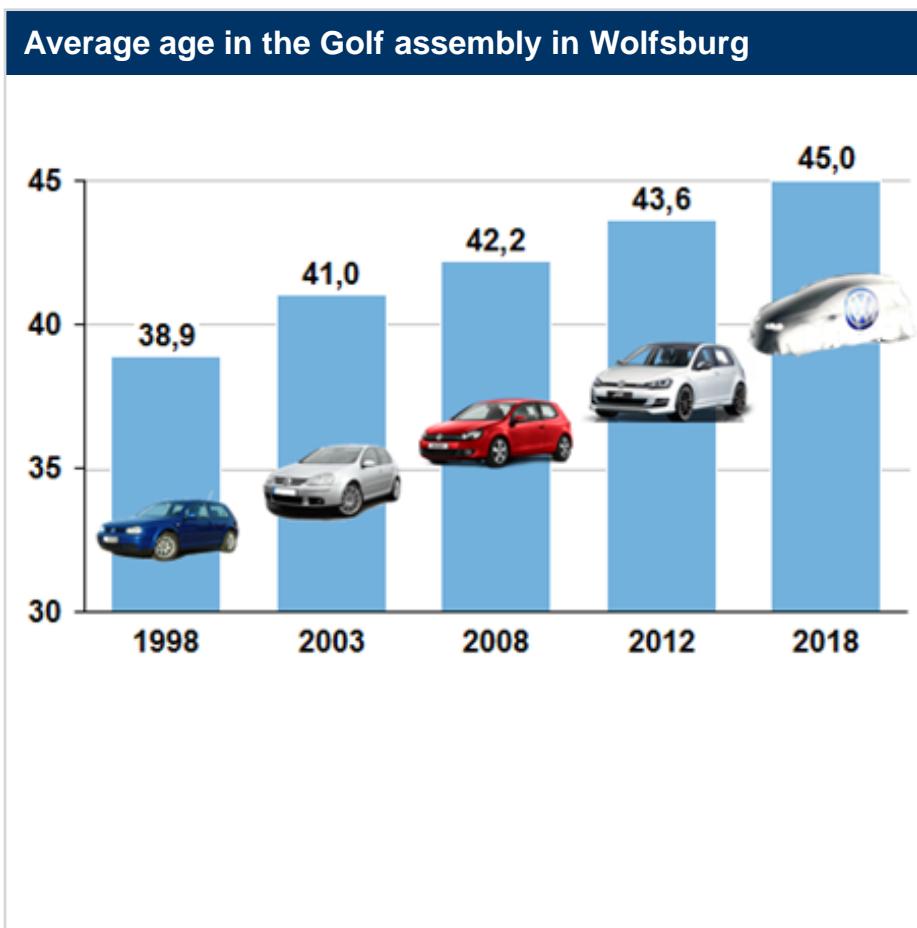
The Average Age of the Population is Increasing Worldwide



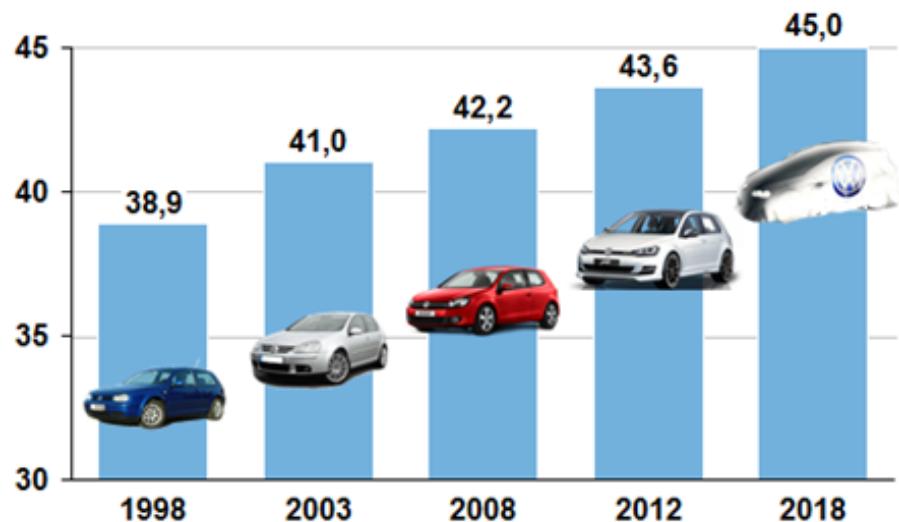
References: <http://esa.un.org/unpd/wpp/Excel-Data/population.htm>

² German Federal Institute for Population Research

Increasing Average Age of Employees and Physical Stress



Increasing Average Age of Employees in the Assembly and Consequences



Consequences:

- Increasing percentage of employees with physical impairments
- Differences in capabilities of employees
- Requirement for improved ergonomics and age-appropriate working environments
- Reduced flexibility in suitable work assignments for employees

Ergonomic Challenges are Being Answered with Multiple Measures



Reference:
Volkswagen AG



Reference:
Volkswagen AG

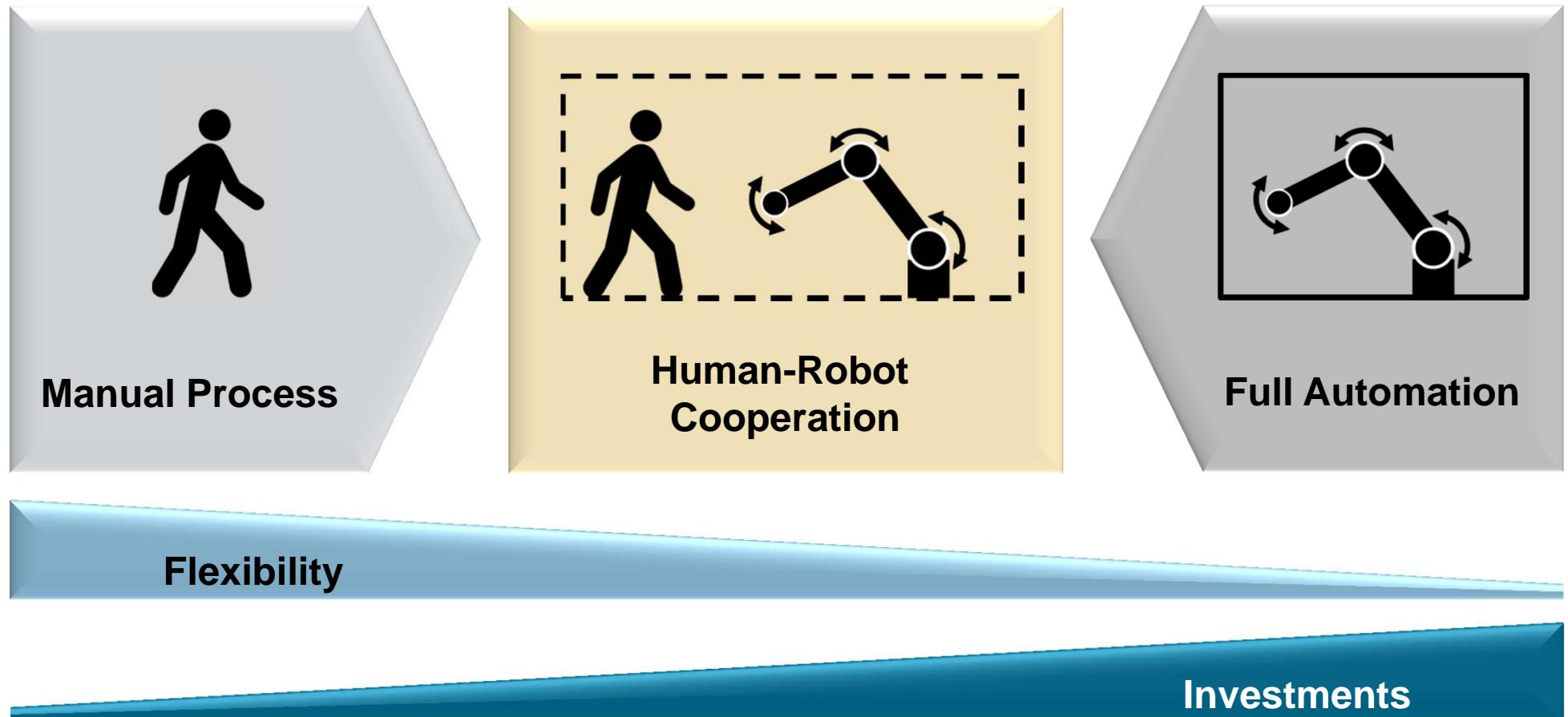


Reference:
VW Poznan



Reference:
Audi AG

Human-Robot Cooperation as New Approach between Manual Labour and Full Automation



Aspects Related to Personnel Management

„The lucky coincidence, that the baby boomer generation is entering retirement, makes it possible to reduce and automate ergonomically unfavourable workplaces without laying off employees.“



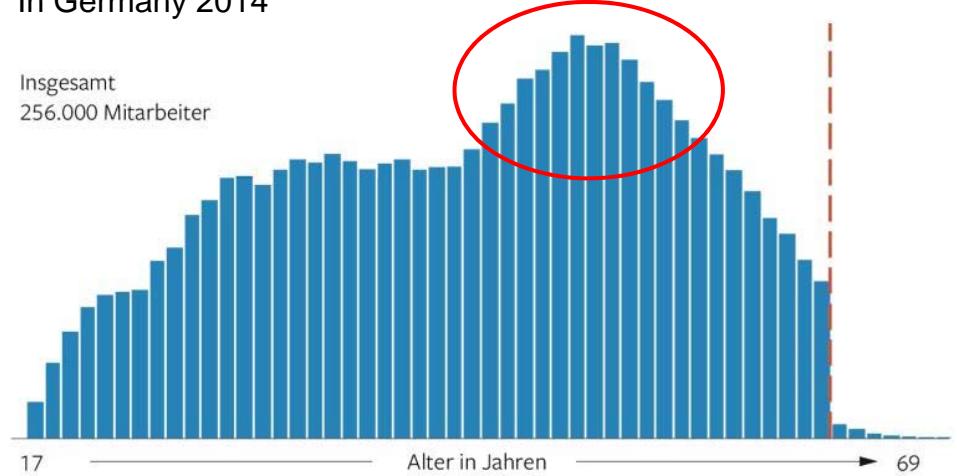
Dr. Horst Neumann,
Human Resources and Organization
Volkswagen Aktiengesellschaft

Reference: Die Welt, February 2015

Aspects Related to Personnel Management

- between 2015 and 2030 an extraordinarily high number of employees will enter retirement
- **Possibility to support or replace employees with intelligent robots**
- Still hire junior staff in today's scale

Age distribution of the Volkswagen workforce
In Germany 2014



Motivations to Utilize Human-Robot Cooperation

Ensuring
Ergonomics

Increasing
Productivity

Improving the Quality
of Work

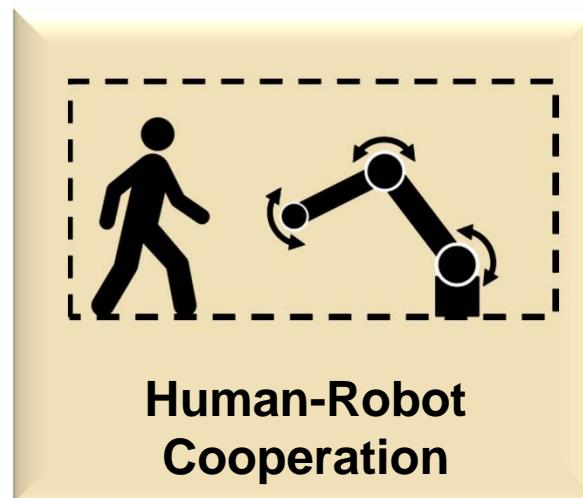
Improving
Precision

Relaxing Cycle
Time Adherence

Enhancing
Flexibility

Mastering
Complexity

Assuring
Process Quality



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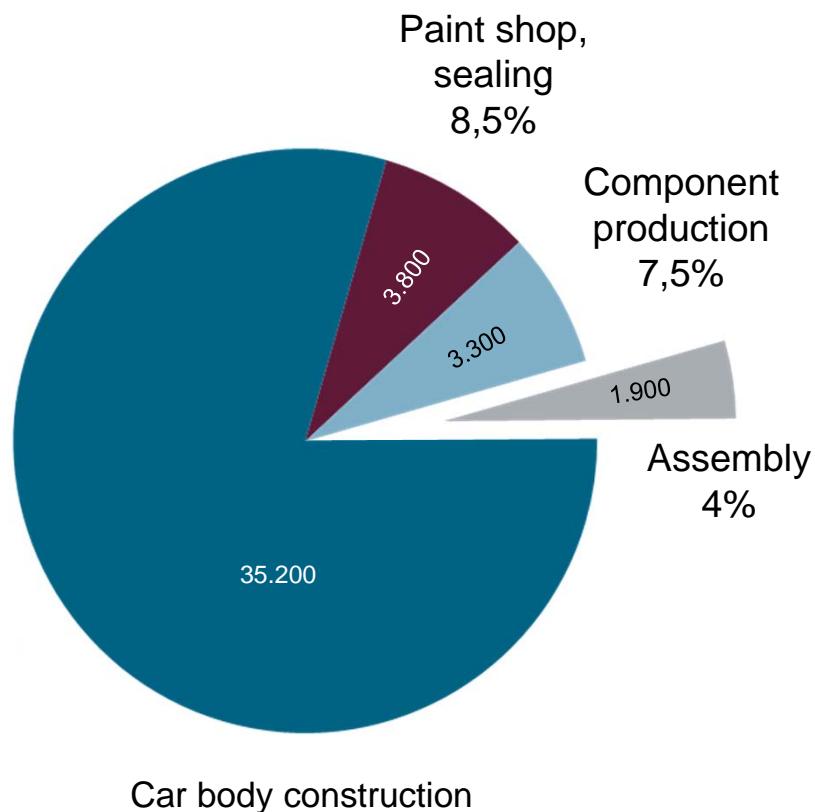
1.

Motivations

2.

**Applications within
the Group**

Potential for New Robot Technologies in Assembly and Logistics



- > 44.000 robots globally in use at Volkswagen
- High level of automation already in car body construction
- Highest potential for HRC in assembly and logistics processes

Applications within the Volkswagen Group



Volkswagen Salzgitter



Audi Ingolstadt



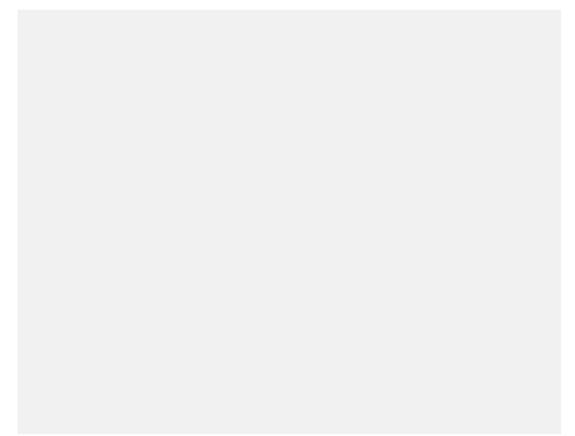
Audi Ingolstadt



Volkswagen Sachsen



Audi Neckarsulm



...

Applications within the Volkswagen Group

Volkswagen Sachsen

Handling of actuators and sensors with Bosch „APAS“

Goals:

- Ergonomical support of the employee
- Relaxing cycle time adherence
- Improving quality

Project timeline:

- 5 months till safety approval (Berufsgenossenschaft)
- 6 months till SOP



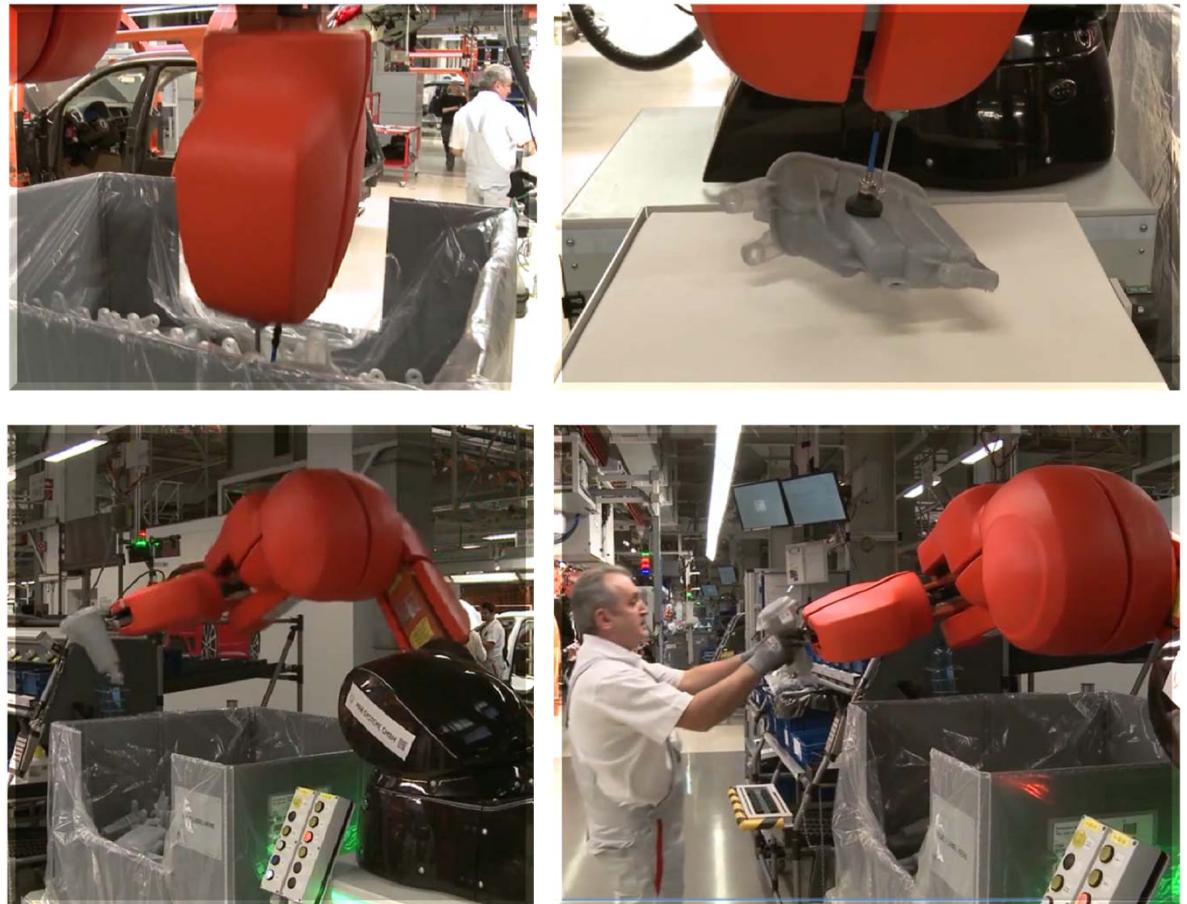
Applications within the Volkswagen Group

Audi Ingolstadt

Passing coolant expansion tank to employee with MRK-Systeme „KR5I“

Goals:

- Improved ergonomics and taking over tasks without added value
- Employee defines the cycle time, not the robot



Reference: Audi AG

Applications within the Volkswagen Group



Reference: Volkswagen AG

Volkswagen Salzgitter

Application of Universal Robots „UR 5“ in the motor assembly – different scenarios since 2013

Goal:

Ergonomical support of the employee, reducing monotony

Applications within the Volkswagen Group

Audi Neckarsulm

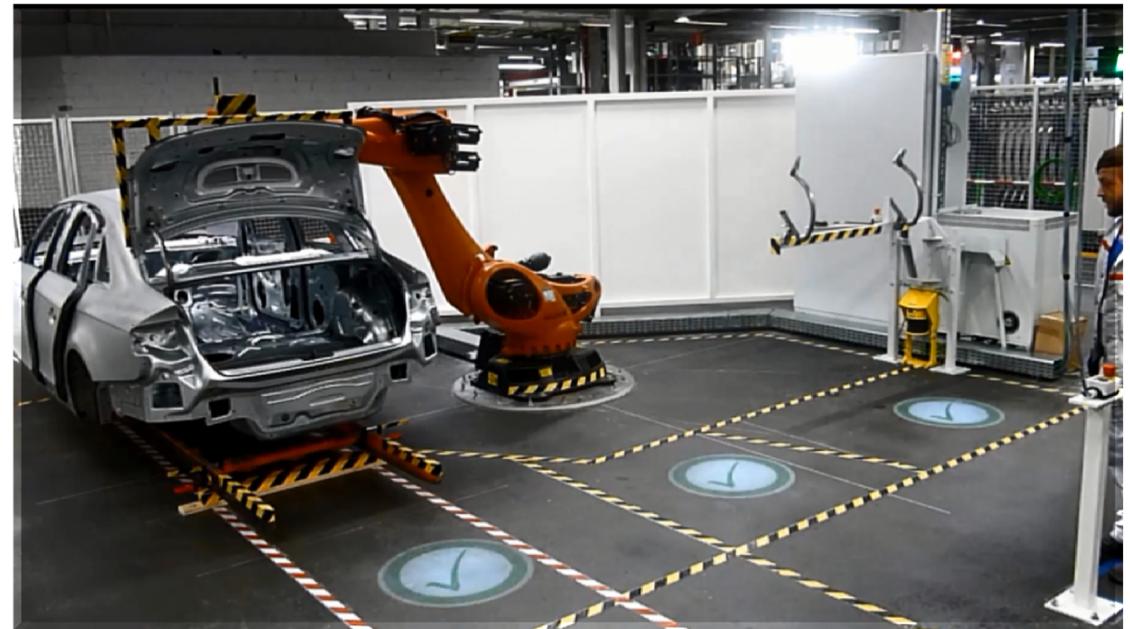
Automated tailgate assembly
using a safe industrial robot
(employee not in the
workspace at the same time)

Goal:

Acceptance testing for
industrial robots in HRC
settings

Project timeline:

~ 24 months until safety
approval of test area



Reference: Audi AG

HRC Applications – Lessons Learned

- Reliable operation of HRC systems
- Robots are perceived as a support measure
- Important:
The employee defines the cycle time, not the robot.



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**Systematic Approach
for Car Assembly**

Systematic Approach for the Field of Car Assembly

Work Content
Analysis

1. Operations:
 - Part separation
 - Gripping, handling
 - Positioning, mounting
2. Frequency of particular tasks

Systematic Approach for the Field of Car Assembly

Work Content
Analysis

Evaluating Potential
for Automation

Criteria for Classification

- Accessibility
- Type of movement
- Tolerances
- Positioning support measures, etc.



Reference: dpa,
Volkswagen AG

Systematic Approach for the Field of Car Assembly

Work Content
Analysis

Evaluating Potential
for Automation

Ergonomical
Classification

1. EAWS* method
- or
2. Criteria-based:
 - Overhead work
 - Car cabin
 - Body posture
 - Weights, etc.



Reference: Volkswagen AG

* Ergonomic Assessment Worksheet

Systematic Approach for the Field of Car Assembly

Work Content Analysis

Evaluating Potential for Automation

Ergonomical Classification

Evaluating the potential of work stations for the realization of HRC applications.

Selection and Detailed Analysis

Validation of Potentials and Efficiency

Pilot Projects

Development of Technical and Organizational Solutions

Implementation into Series Production / Multiplication of the Solution

Examples of Relevant Lightweight and HRC-Capable Robots

						
Manufacturer	MRK-Systeme	Universal Robots	gomTec	Bosch	KUKA	FANUC
Model	KR5 SI	UR 3 / UR5 / UR10	Roberta	APAS	LBR iiwa	CR35iA
Payload	5 kg	3 kg / 5 kg / 10 kg	4 kg / 8 kg / 12 kg	1,5 kg	7 kg / 14 kg	35 kg
Conformity to standards certified	by Berufsgenossenschaft	Certificate from TÜV Nord *	Certificate from TÜV Nord * envisaged	by Berufsgenossenschaft	Approval for entire application	Certificate from TÜV Süd
Advantages	<ul style="list-style-type: none"> Contact-free and tactile sensor skin Padding Proved industrial capability 	<ul style="list-style-type: none"> Easy operation Established in the market, proved industrial capability 	<ul style="list-style-type: none"> Integrated gripper and camera system Intuitive operation 	<ul style="list-style-type: none"> Integrated gripper Contact-free and tactile sensor skin 	<ul style="list-style-type: none"> Sensitivity through integrated sensors High flexibility (7-axis-kinematics) Platform FlexFellow 	<ul style="list-style-type: none"> High payload
Serial Application within the group	Audi Ingolstadt: Passing of coolant expansion tanks and bin picking.	VW Salzgitter: Lubrifying bearing points, placing screws, mounting actuators		VW Sachsen: Mounting of sensors and actuators		

* TÜV NORD is not accredited for EN ISO 10218-1: 2011

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Human-Robot Cooperation in Smart Factory Environments

Vision of a Mobile Assembly Assistant Requirements for the Automotive Production

- Learning, autonomous robots
- Agile through mobile platforms



Reference: Volkswagen AG

Vision of a Mobile Assembly Assistant Requirements for the Automotive Production

- Learning, autonomous robots
- Agile through mobile platforms
- Dynamic environment recognition



Reference:
Volkswagen AG

Vision of a Mobile Assembly Assistant Requirements for the Automotive Production

- Learning, autonomous robots
- Agile through mobile platforms
- Dynamic environment recognition
- Flexible and safe gripping systems



Reference:
Volkswagen AG

Vision of a Mobile Assembly Assistant Requirements for the Automotive Production

- Learning, autonomous robots
- Agile through mobile platforms
- Dynamic environment recognition
- Flexible and safe gripping systems
- Efficient vision systems



Reference:
Volkswagen AG

Vision of a Mobile Assembly Assistant Requirements for the Automotive Production

- Learning, autonomous robots
- Agile through mobile platforms
- Dynamic environment recognition
- Flexible and safe gripping systems
- Efficient vision systems
- Modular, platform independent functionalities
- Interaction through voice and gesture control
- Intention recognition / collision avoidance
- Complete integration into existing plant architectures (simulation, „plug and produce“, etc.)



Reference:
Volkswagen AG

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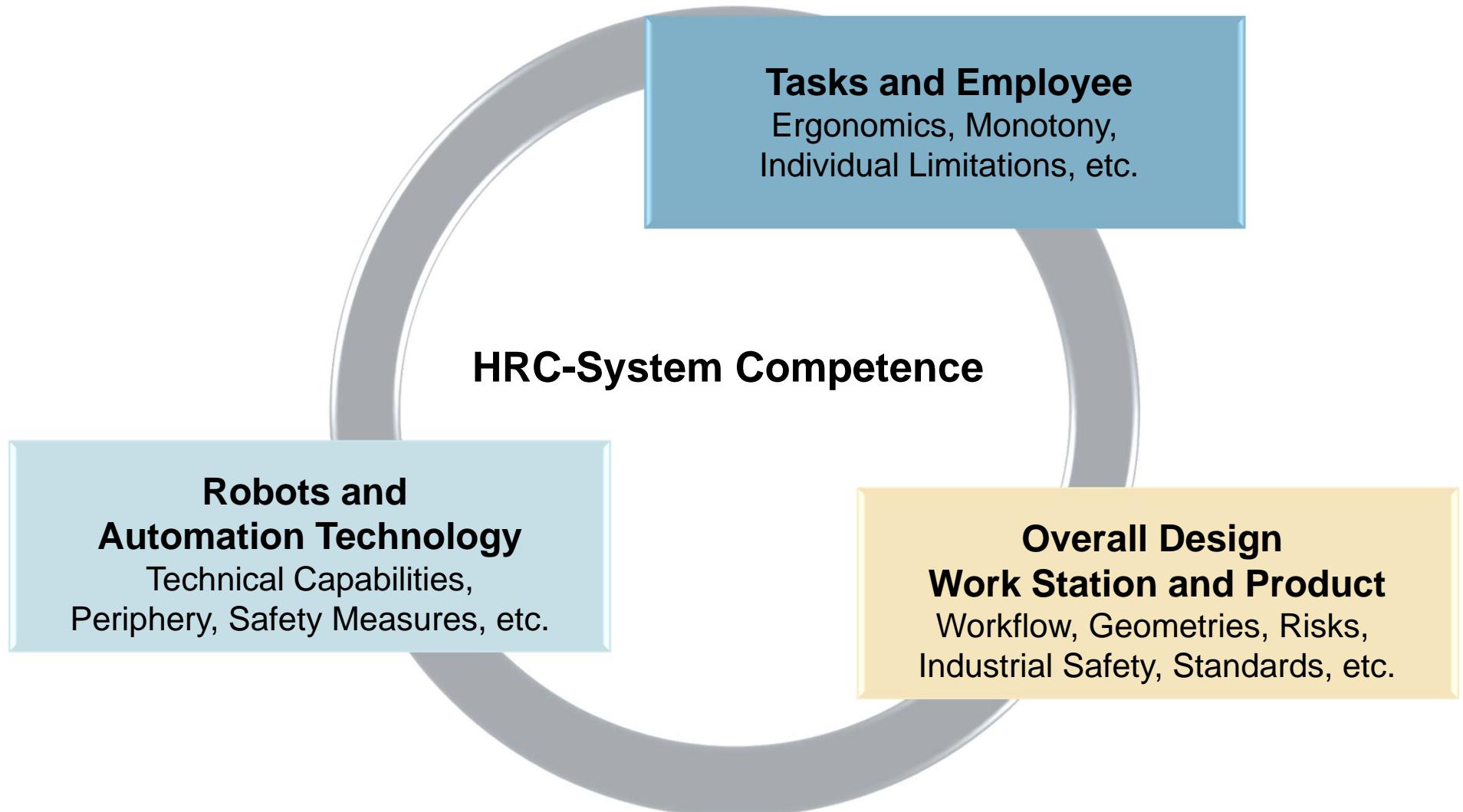
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Conclusion

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- **Enabling technologies have reached necessary maturity level**
- **Acceptance and availability can be observed**
- **Integration of multiple subsystems results in new, intelligent systems solutions**
- **Assembly and logistics offer high potentials for HRC and represent challenges as well**
- **New concepts and approaches for the planning of work stations necessary**

Holistic Consideration when Planning Work Stations





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