Factory of the Future
Intelligente Robotik in der digitalisierten Produktion

Korbinian Nottensteiner
Institut für Robotik und Mechatronik (RM), Oberpfaffenhofen

DLR

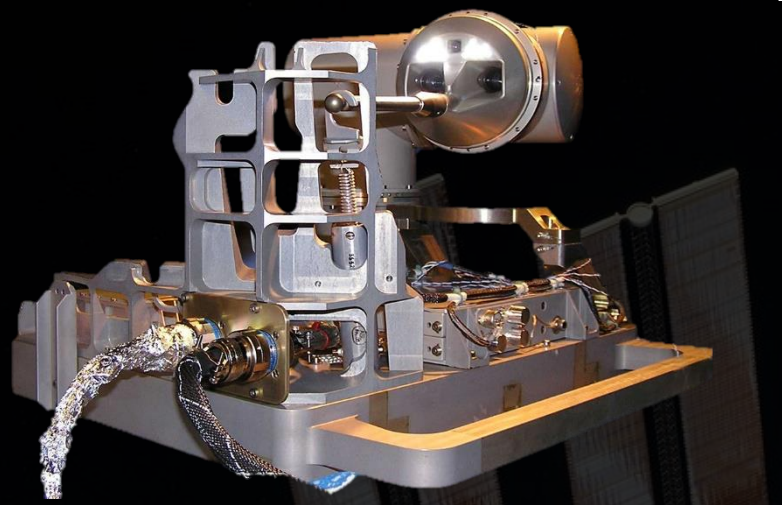
Institut für Robotik und Mechatronik

- **Deutsches Zentrum für Luft- und Raumfahrt (DLR)**
  ~ 9000 Mitarbeiter, 40 Institute und Einrichtungen, 30 Standorte

  - Raumfahrtmanagment
  - Projektträger
  - **Forschung:**
    Luftfahrt, **Raumfahrt**, Energie, Verkehr, Sicherheit, Digitalisierung *(seit 2018)*

- **Institut für Robotik und Mechatronik (RM)**
  ~ 200 Mitarbeiter in Oberpfaffenhofen (OP), 6 Abteilungen
  https://www.dlr.de/rm/

ROKVISS



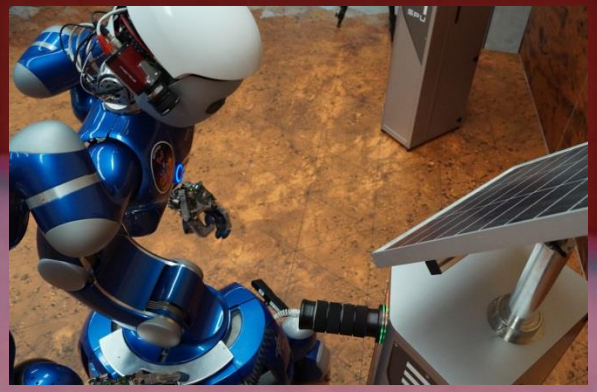
Kontur 2

Meteron SUPVIS Justin

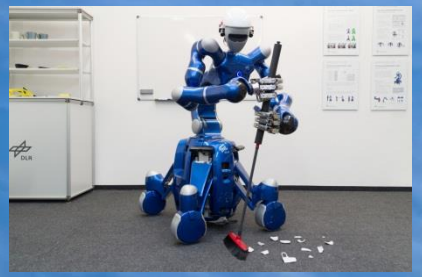
Anwendungsfelder

Orbitale Robotik

Raumfahrtassistenzrobotik



Planetare Explorationsrobotik



Intelligente Service Robotik

Medizin- und Pflegerobotik

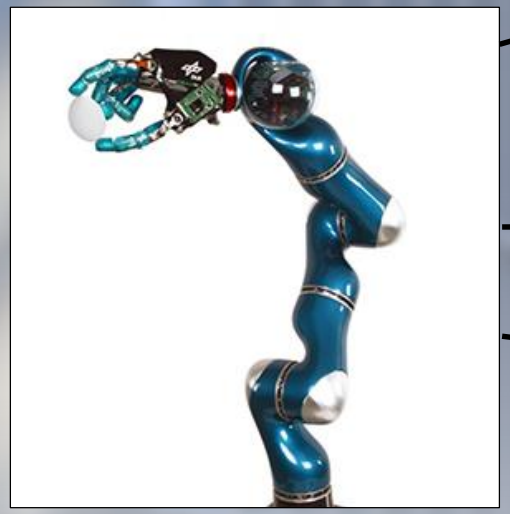
Geländerobotik

Produktion der Zukunft

Entwicklung der Leichtbaurobotertechnologie

LBR I
1991

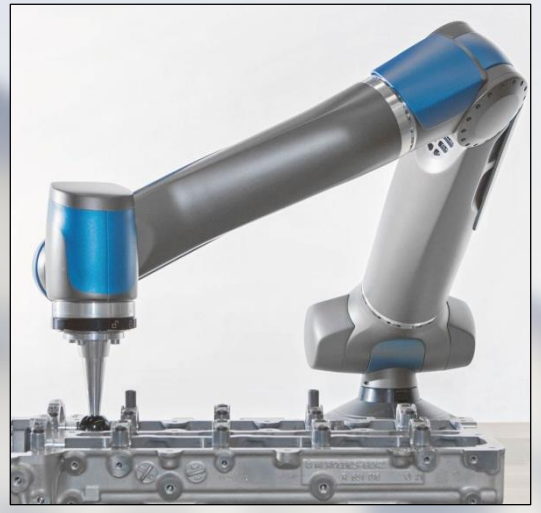
LBR II
2000



LBR III
2003

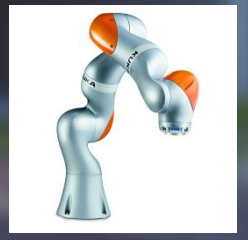
Justin
2008

MIRO
2008



SARA
2018

LBR 4/4+

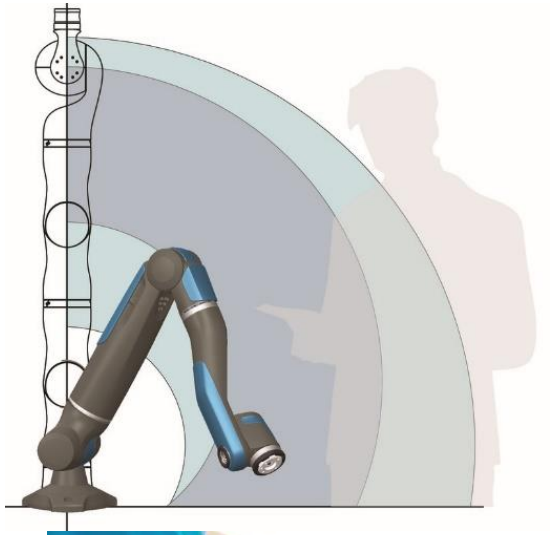


KUKA LBR iiwa

FRANKA EMIKA

Agile Robots

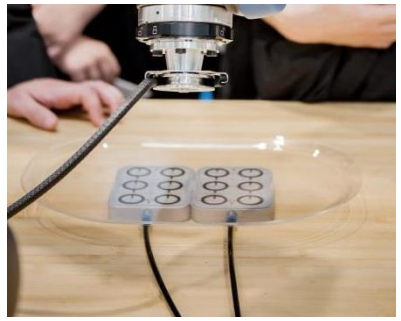
SARA – *Safe Autonomous Robotic Assistant*

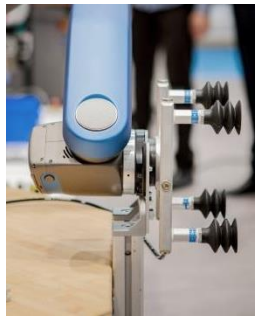


- 400 deg/s
- 12kg Traglast
- 22.6kg Eigengewicht
- 297 -1024 mm Arbeitsraum
- A7 ohne Limitierung
- **Force-Teaching** im Kontakt
- **Werkzeugwechseladapter** integriert
- Integrierte Schnittstelle für die **Sensorerweiterung**

https://www.dlr.de/rm/de/sara

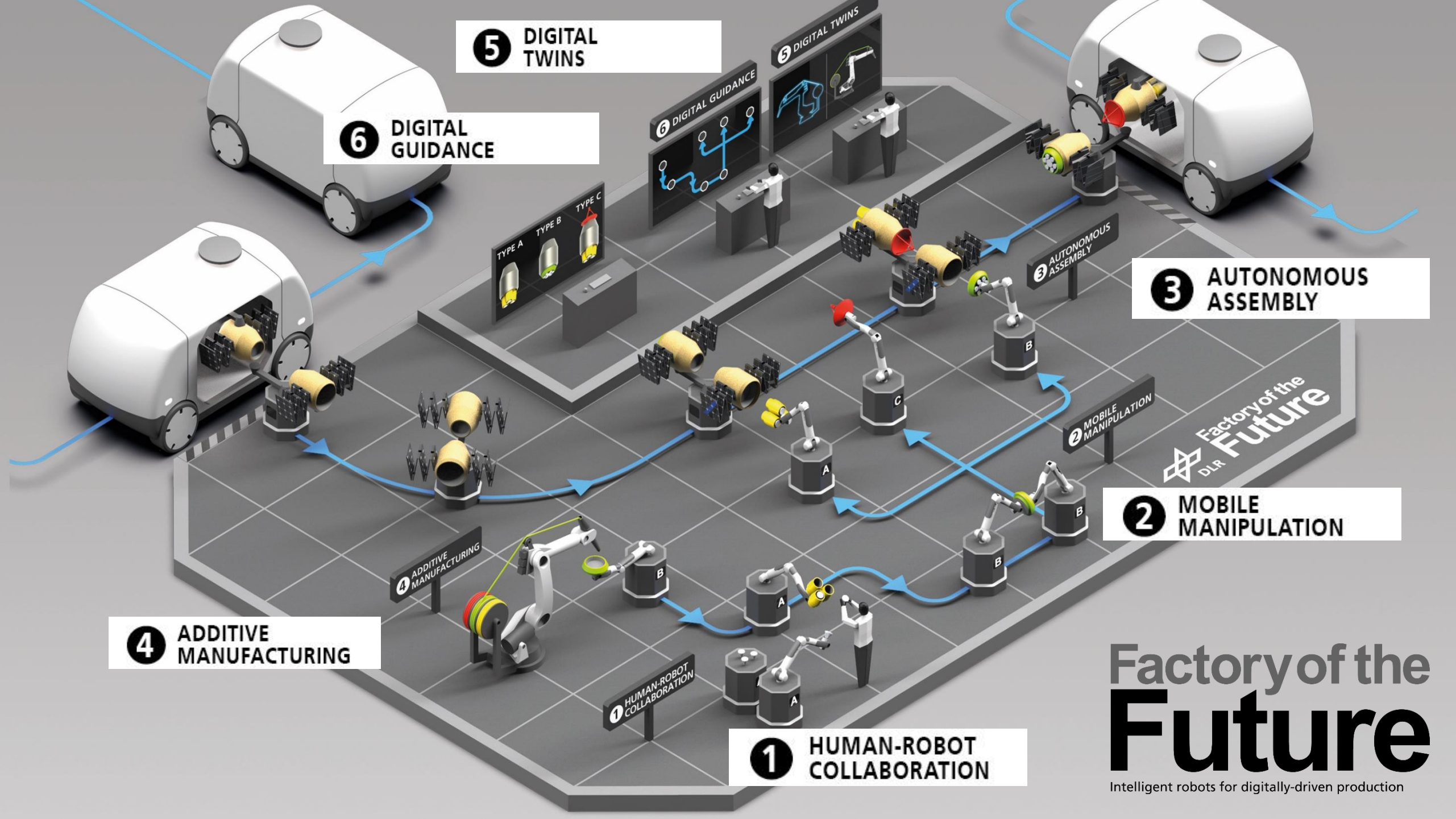
Variable Arbeitsstation: Beispiel Fenstermontage AUTOMATICA 2018





- Flexible Nutzung von Werkzeugen
- Anpassbar mit geringerem Aufwand
- Keine spezialisierten Halterungen


DLR


5 DIGITAL TWINS
6 DIGITAL GUIDANCE
TYPE A
TYPE B
TYPE C
3 AUTONOMOUS ASSEMBLY
2 MOBILE MANIPULATION
4 ADDITIVE MANUFACTURING
1 HUMAN-ROBOT COLLABORATION
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3 AUTONOMOUS ASSEMBLY
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Intelligent robots for digitally-driven production

Factory of the Future

Intelligent robots for digitally-driven production

1 HUMAN-ROBOT COLLABORATION

Intelligent robotic assistants and their human co-workers interact via intuitive, multimodal programming interfaces and share their workspace in safe and efficient industrial applications.

2 MOBILE MANIPULATION

Mobile autonomous production units fitted for carrying out a variety of back-work like tasks help to overcome static shop floor layouts.

3 AUTONOMOUS ASSEMBLY

Intelligent autonomous robots assemble individually customized products using advanced planning algorithms, sensors and modular adaptive robotic skills.

4 ADDITIVE MANUFACTURING

Data analysis and digital tools improve manufacturing methods resulting in complex and individual parts with optimized geometries and improved component properties.

5 DIGITAL TWINS

Accurate digital models represent both the product and the optimized production processes, saving costs, time and engineering efforts.

6 DIGITAL GUIDANCE

Mass customization is a cornerstone in future manufacturing. Digital Guidance helps to minimize set-up-times by autonomously adapting facilities and controlling workflows.

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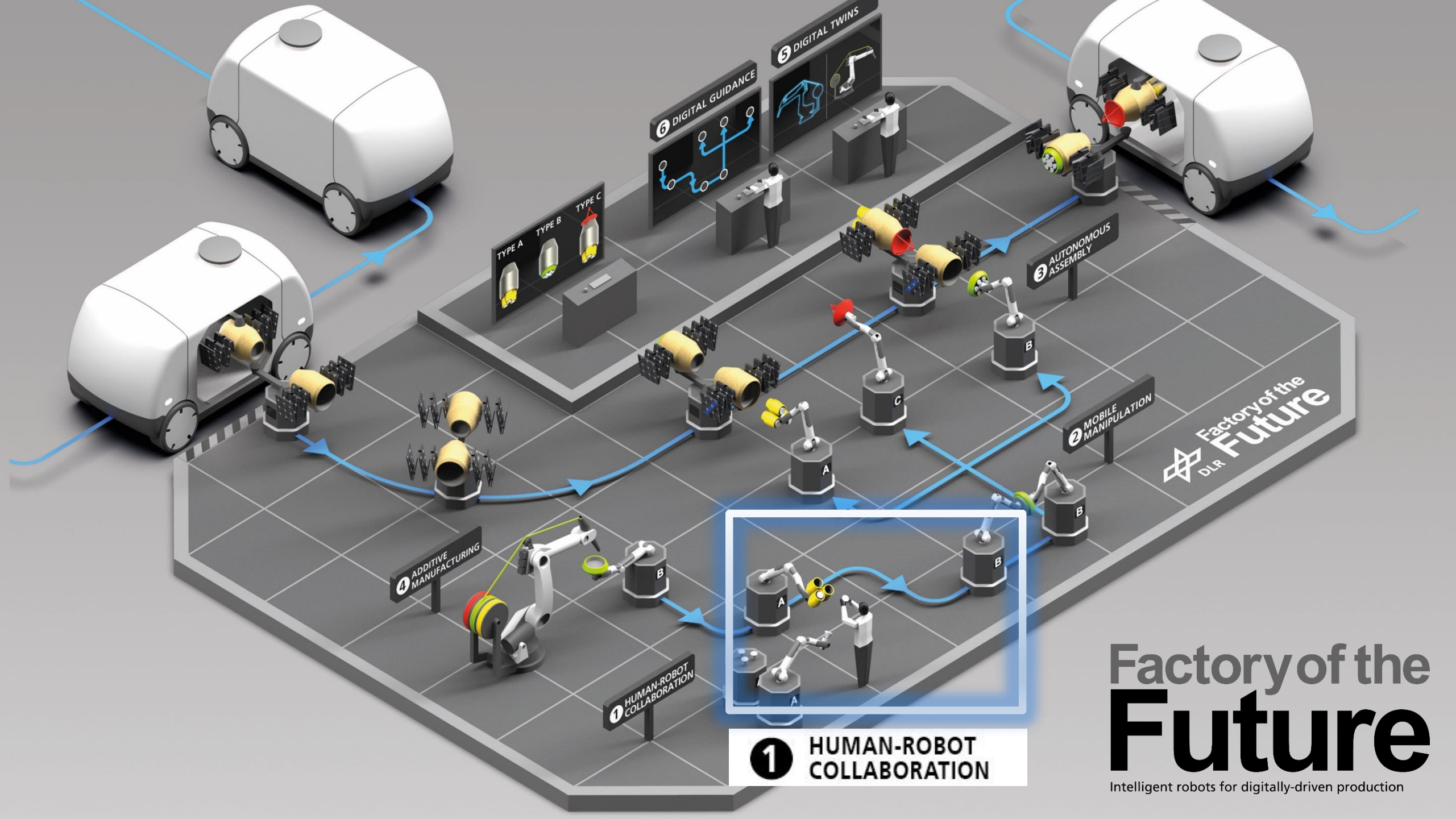
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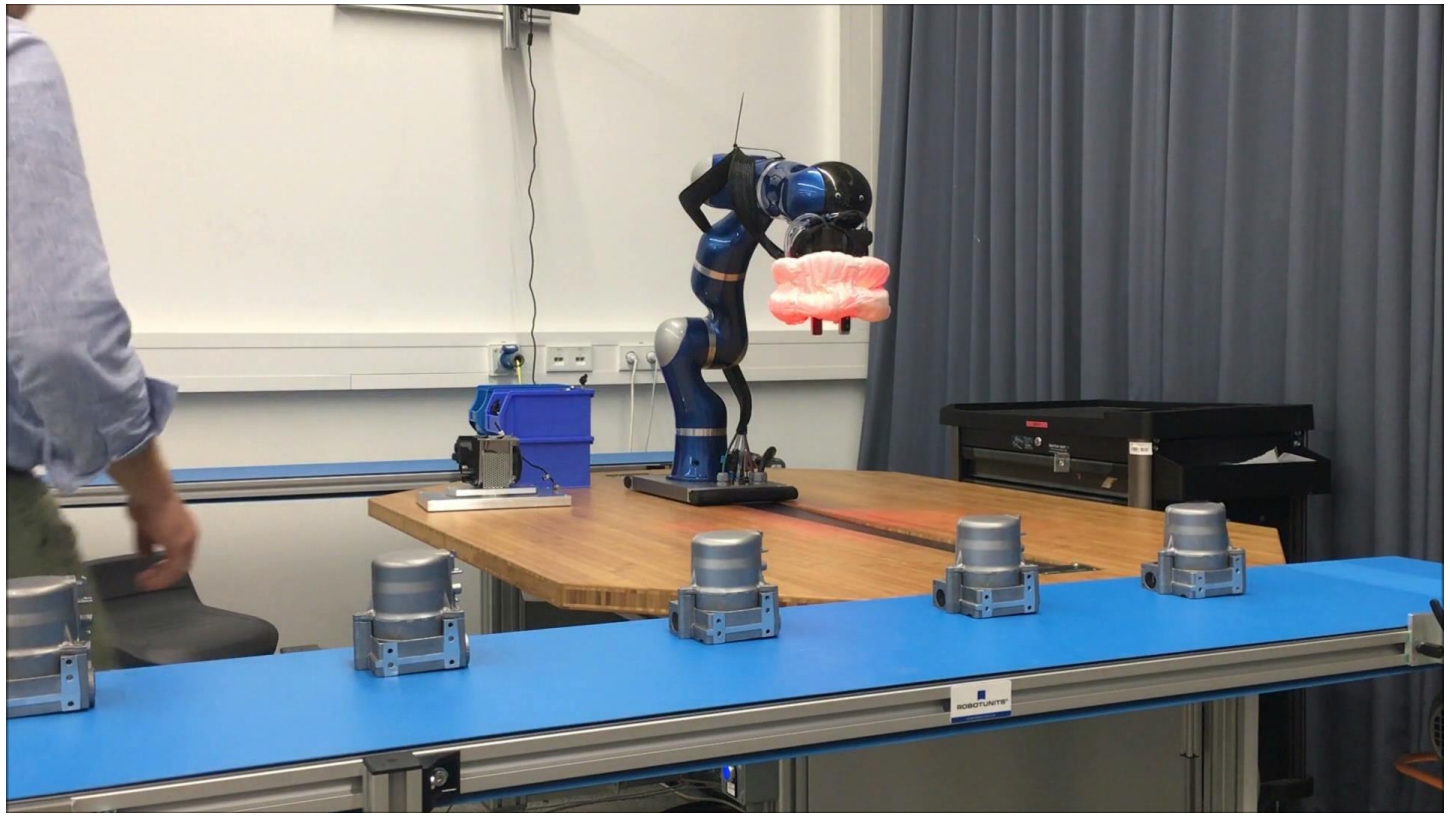
HRC – Sichere Interaktion



Weitschat, Roman und Vogel, Jörn und Thielmann, Sophie und Höppner, Hannes (2017) End-Effector Airbags to Accelerate Human-Robot Collaboration. In: IEEE International Conference on Robotics and Automation ICRA. International Conference on Robotics and Automation (ICRA), Singapur.

HRC - Intuitive Programmierung

- **RAFCON** (Expert)
  Open Source-Tool zur Programmierung und Ablaufsteuerung von Roboteranwendungen

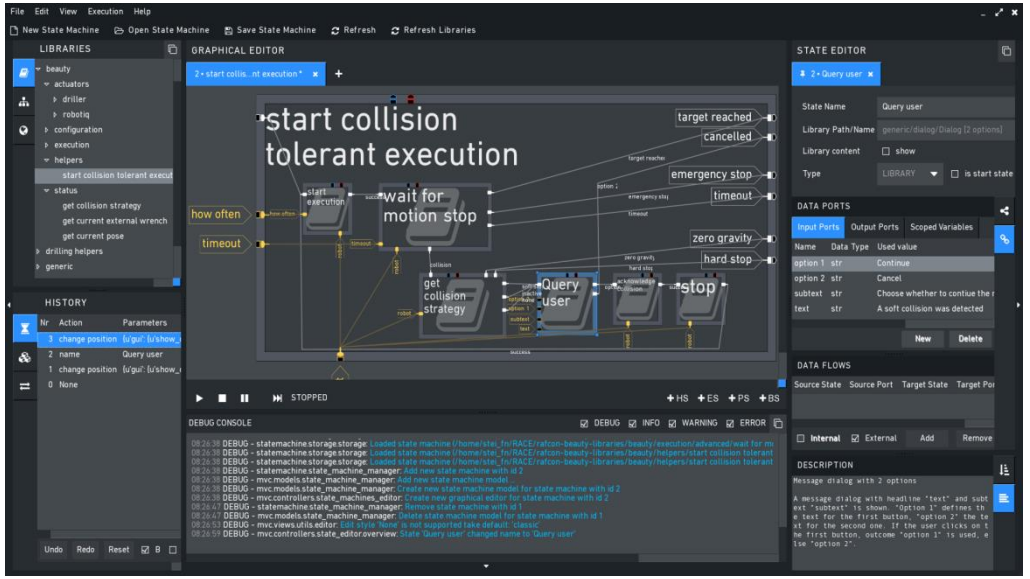
  https://dlr-rm.github.io/RAFCON/

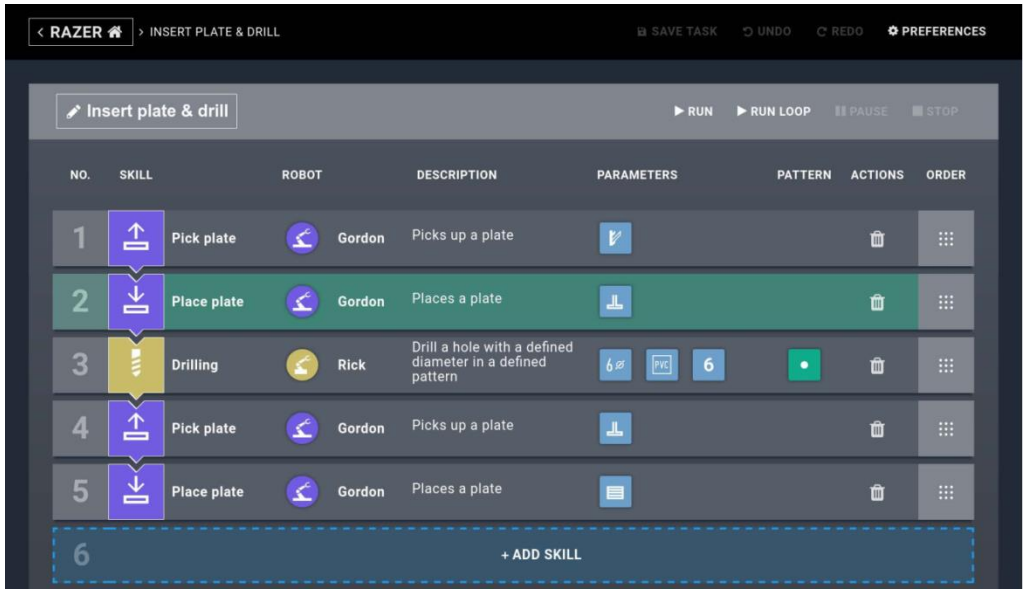
- **RAZER** (User)
  Anwendernahes Tool zur intuitiven graphischen und interaktiven Programmierung

  https://elib.dlr.de/119124/

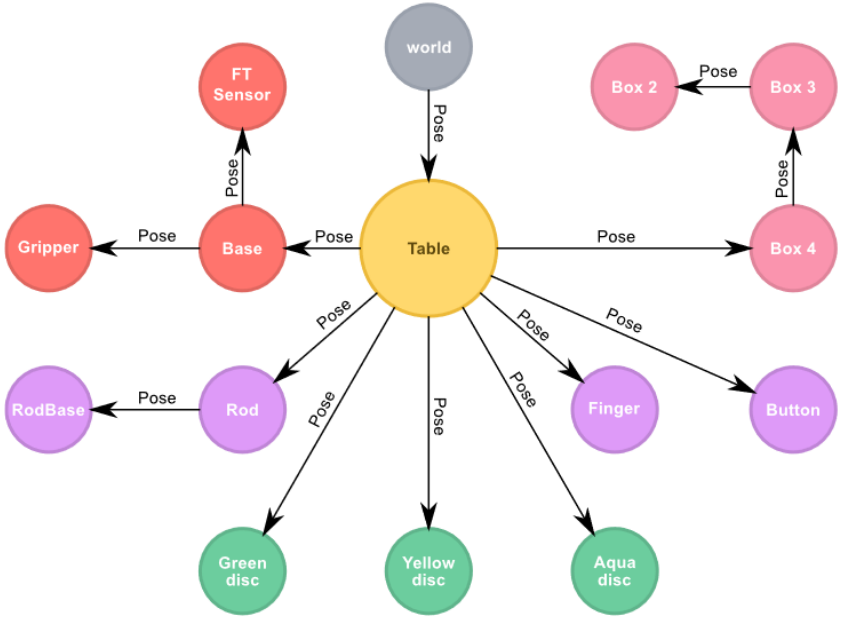
- **TLPbD** (Task-Level Programming by Demonstration)
  Aktuelle Forschung

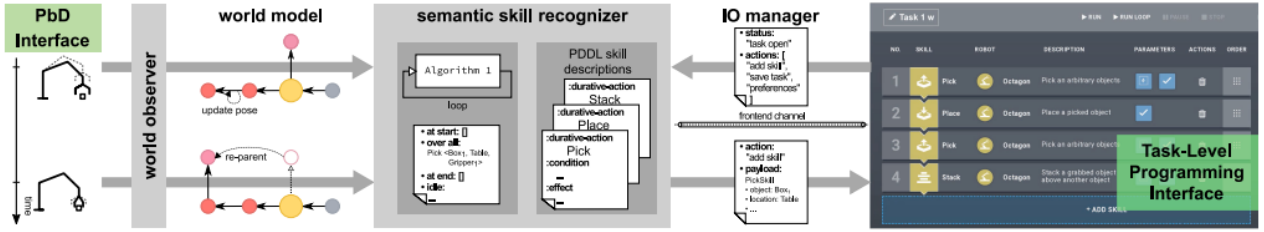
  https://elib.dlr.de/128339/

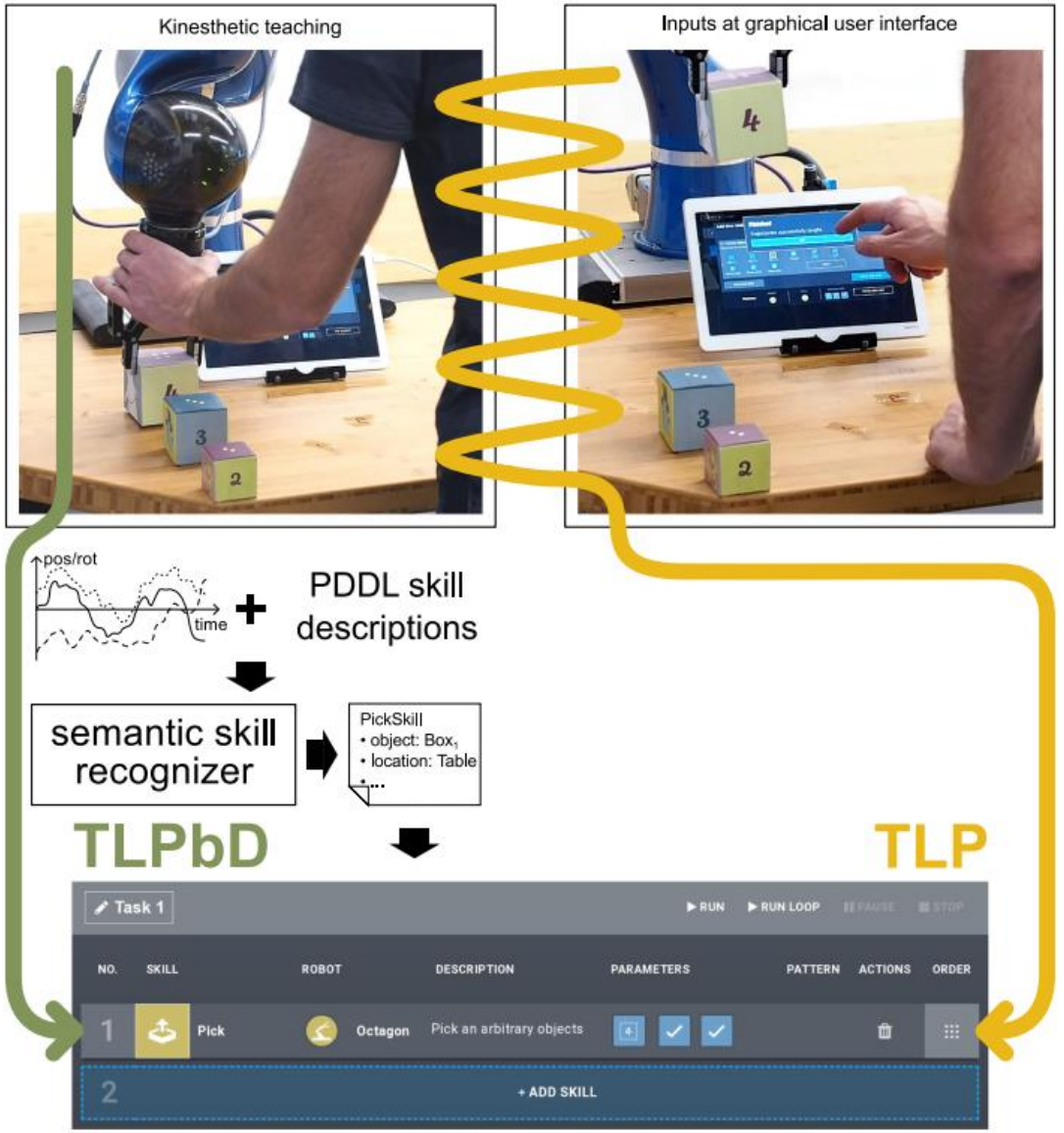




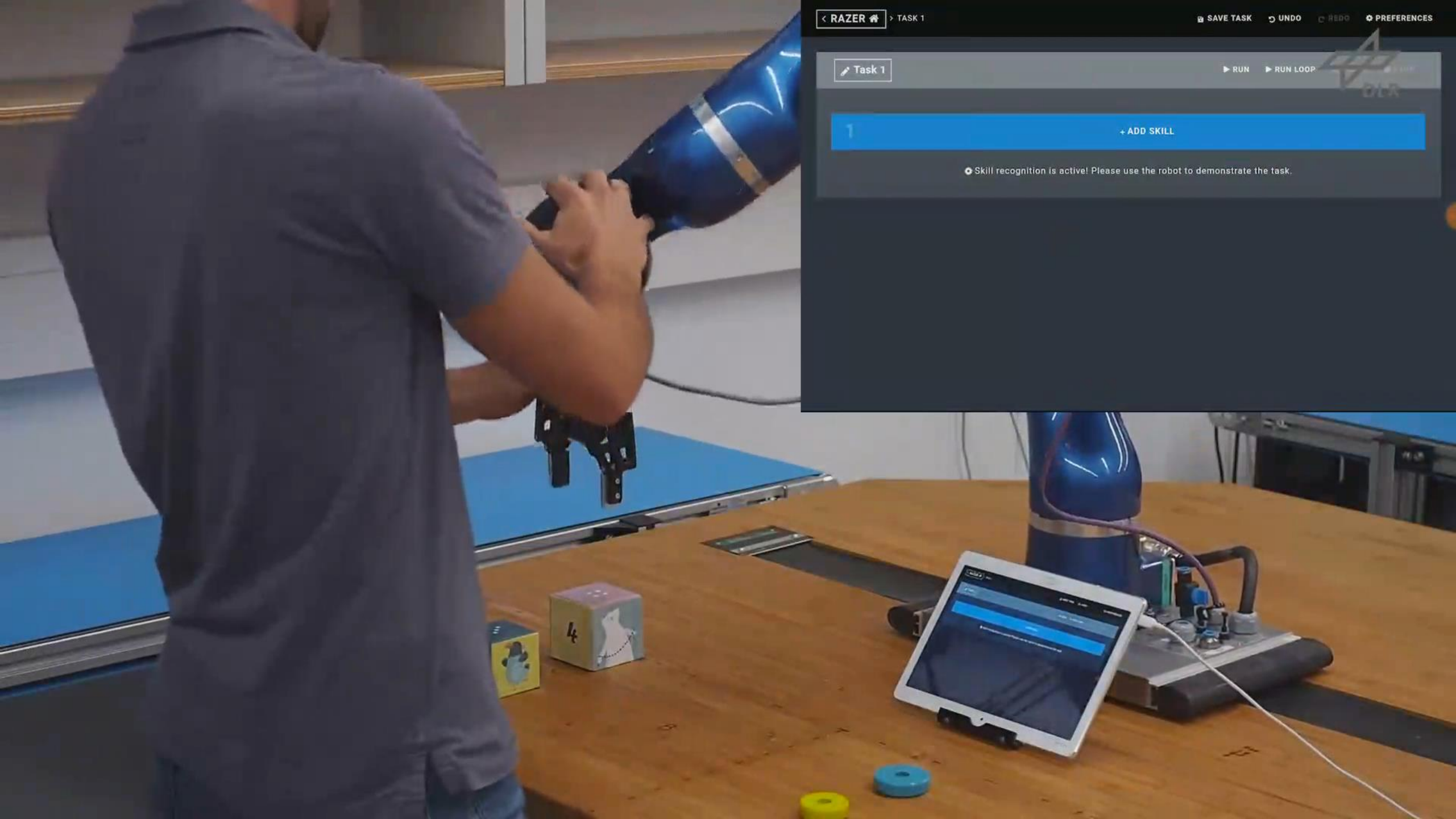
TLPbD (Task-Level Programming by Demonstration)

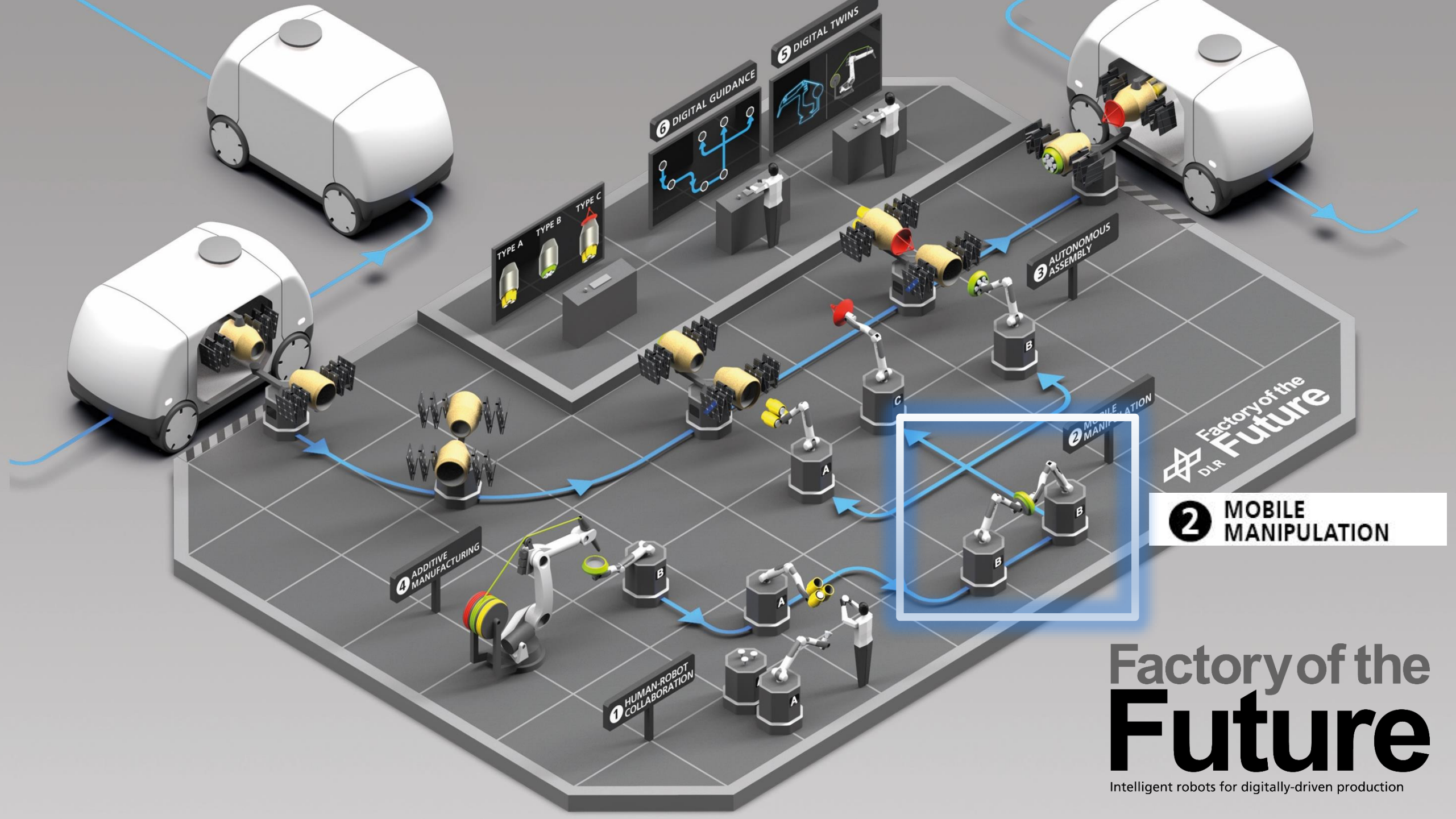






Steinmetz, Franz und Nitsch, Verena und Stulp, Freek (2019) Intuitive Task-Level Programming by Demonstration through Semantic Skill Recognition. IEEE Robotics and Automation Letters, 4 (4), Seiten 3742-3749. IEEE - Institute of Electrical and Electronics Engineers. DOI: 10.1109/LRA.2019.2928782 ISSN 2377-3766


RAZER
TASK 1
SAVE TASK
UNDO
REDO
PREFERENCES
Task 1
RUN
RUN LOOP
1
+ ADD SKILL
Skill recognition is active! Please use the robot to demonstrate the task.

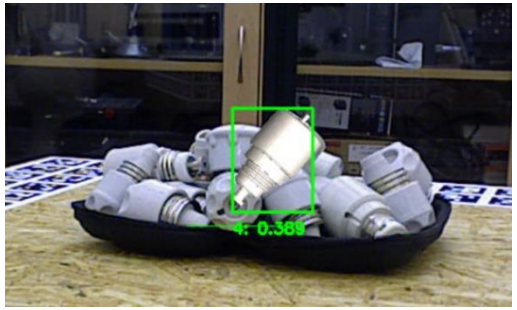


Factory of the Future

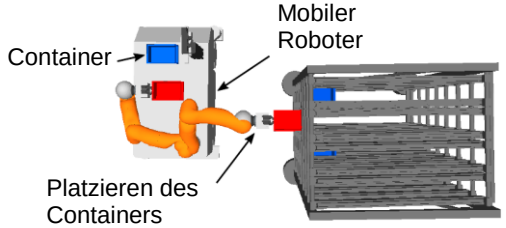
Intelligent robots for digitally-driven production

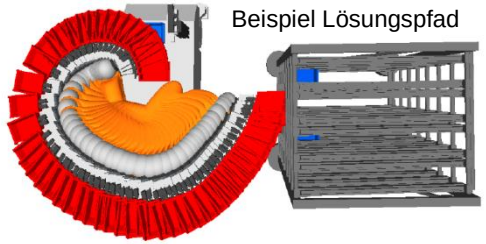
AIMM – *Autonomous Industrial Mobile Manipulator*

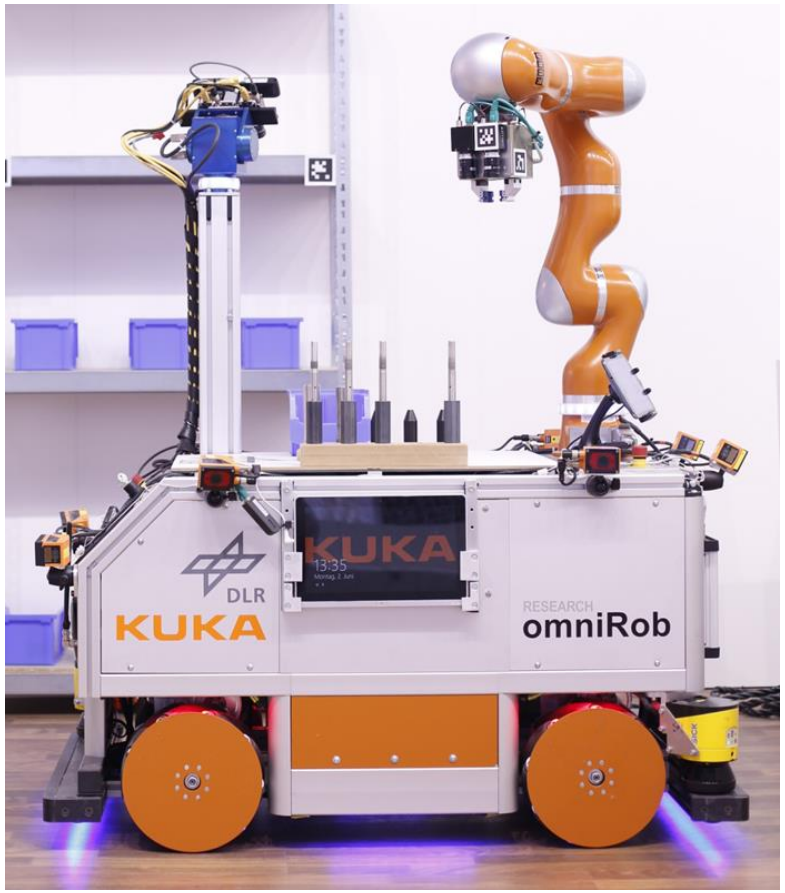
- **Perzeption**
  z.B. Objektlokalisierung mit neuen Lernverfahren:
  https://github.com/DLR-RM/AugmentedAutoencoder



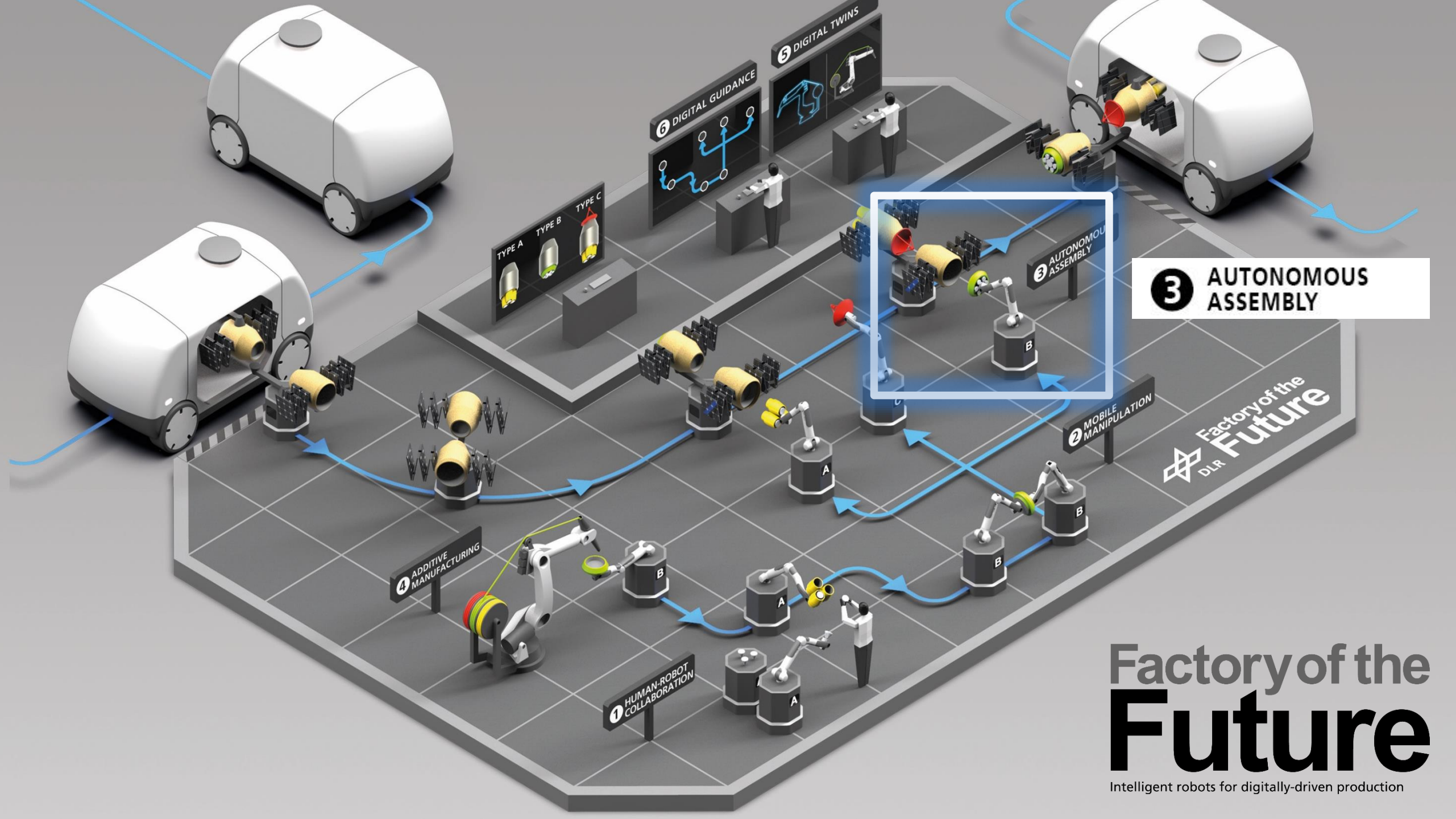
- **Bahnplanung und Navigation**
  z.B. Robot motion planning library (RMPL)







Lehner, Peter und Albu-Schäffer, Alin (2018) The Repetition Roadmap for Repetitive Constrained Motion Planning. IEEE Robotics and Automation Letters, 3 (4), Seiten 3884-3891. IEEE - Institute of Electrical and Electronics Engineers. DOI: 10.1109/LRA.2018.2856925 ISSN 2377-3766



3 AUTONOMOUS ASSEMBLY

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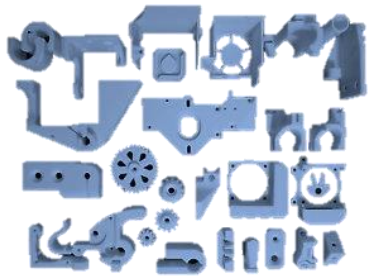
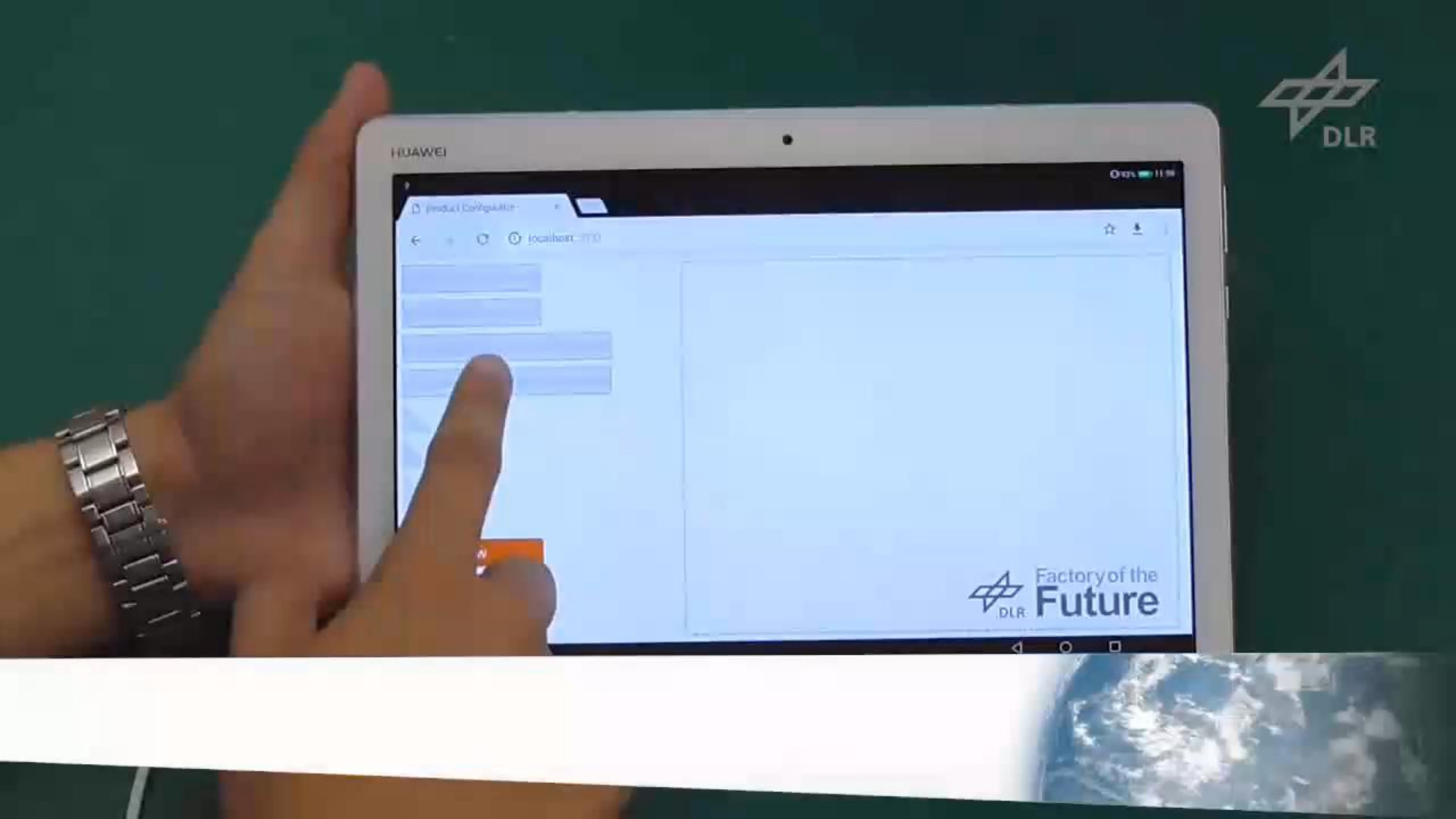
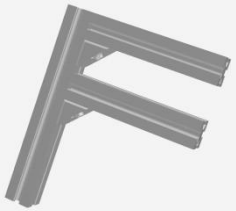
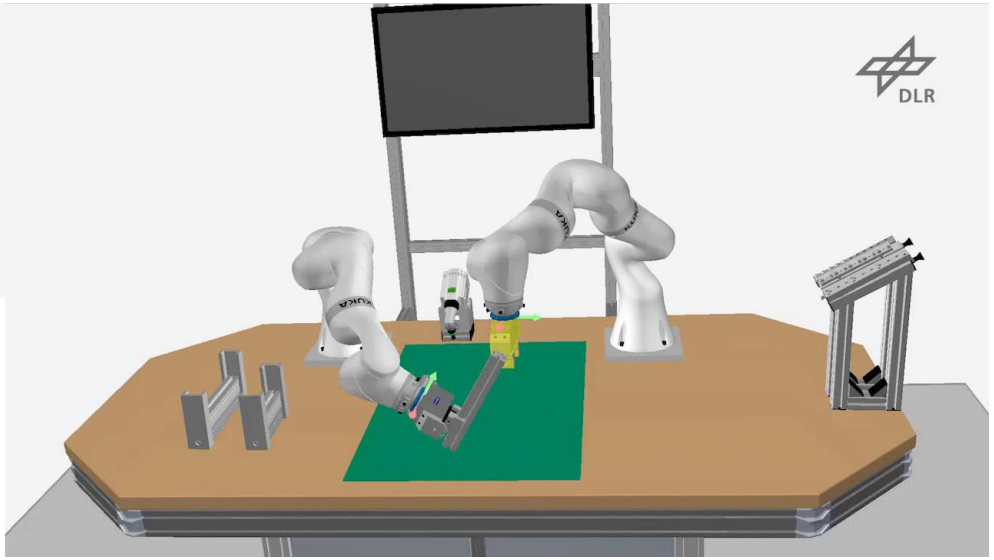
Intelligent robots for digitally-driven production

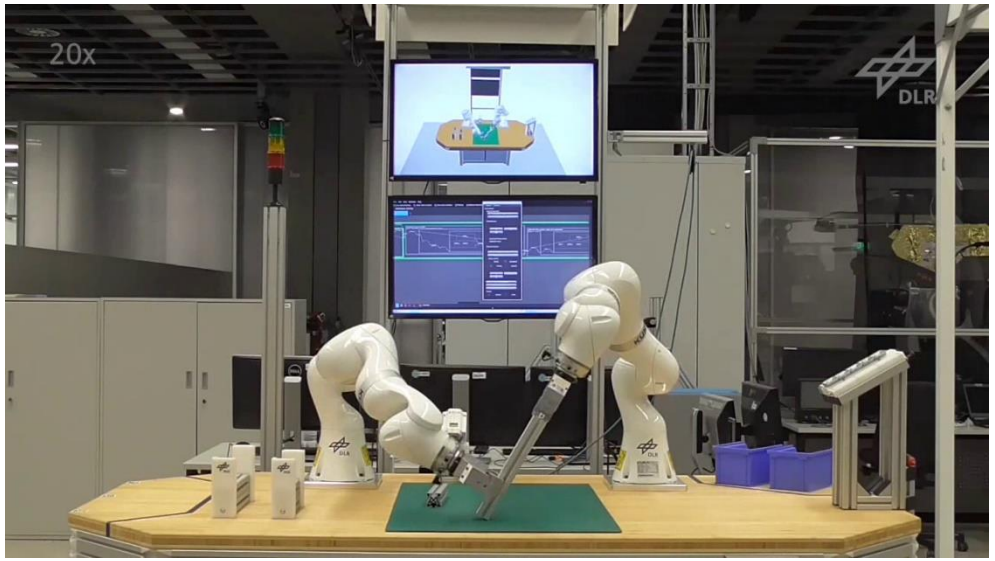
Autonome Montage - Produktion von Einzelstücken auf Knopfdruck

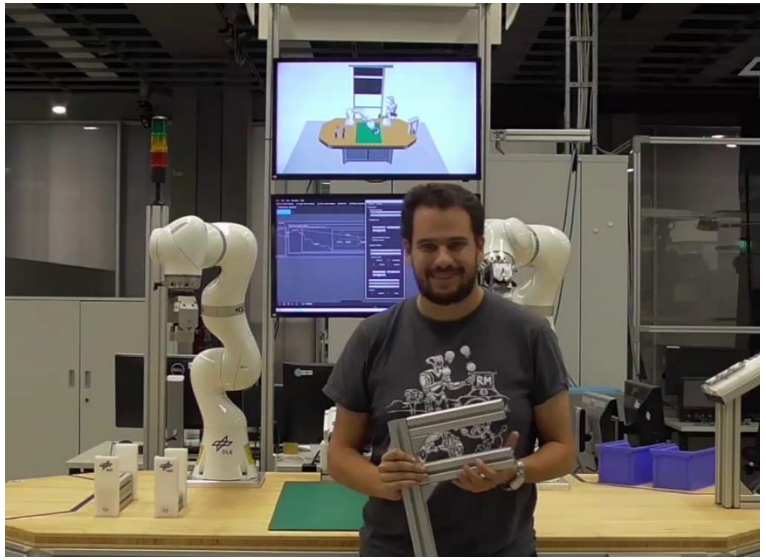



DLR
HUAWEI
Factory of the
DLR Future

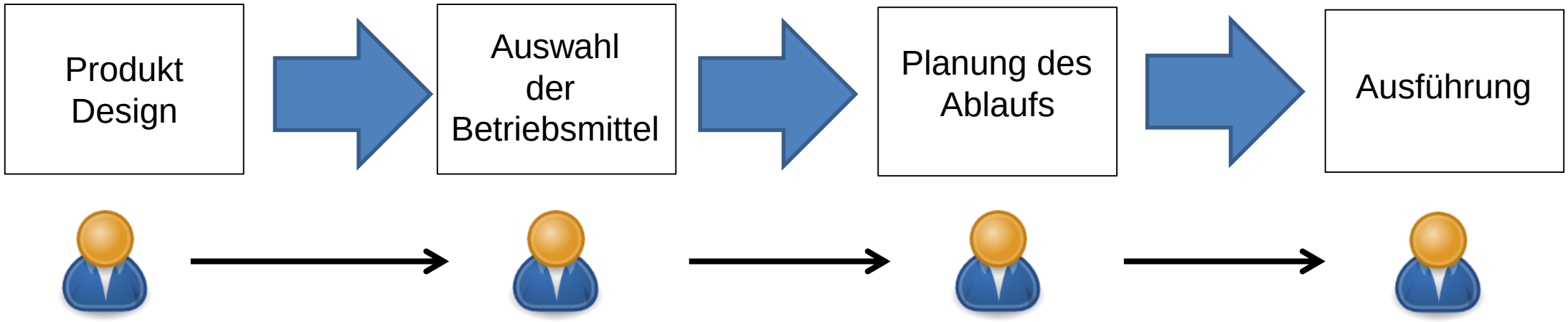


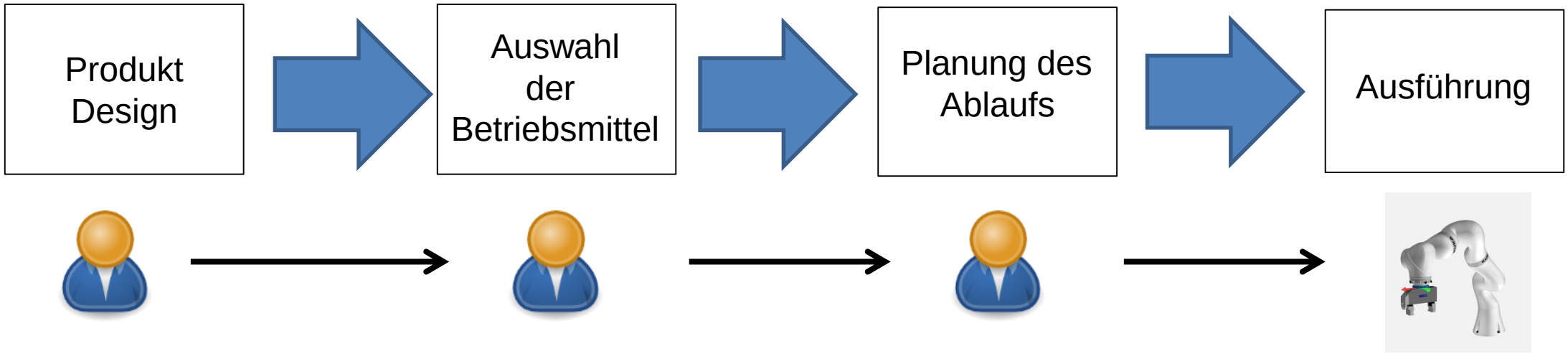






Rodriguez Brena, Ismael Valentin und Nottensteiner, Korbinian und Leidner, Daniel und Kassecker, Michael und Stulp, Freek und Albu-Schäffer, Alin (2019) Iteratively Refined Feasibility Checks in Robotic Assembly Sequence Planning. IEEE Robotics and Automation Letters. IEEE - Institute of Electrical and Electronics Engineers. DOI: 10.1109/LRA.2019.2895845 ISSN 2377-3766


Produkt Design
Auswahl der Betriebsmittel
Planung des Ablaufs
Ausführung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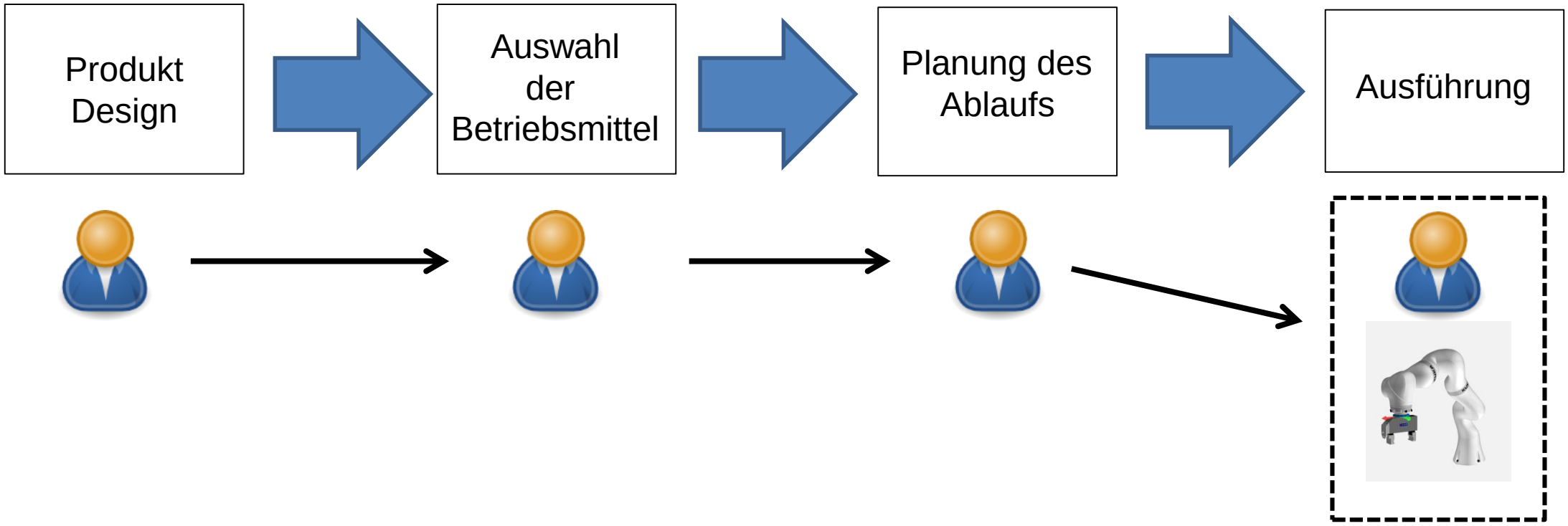
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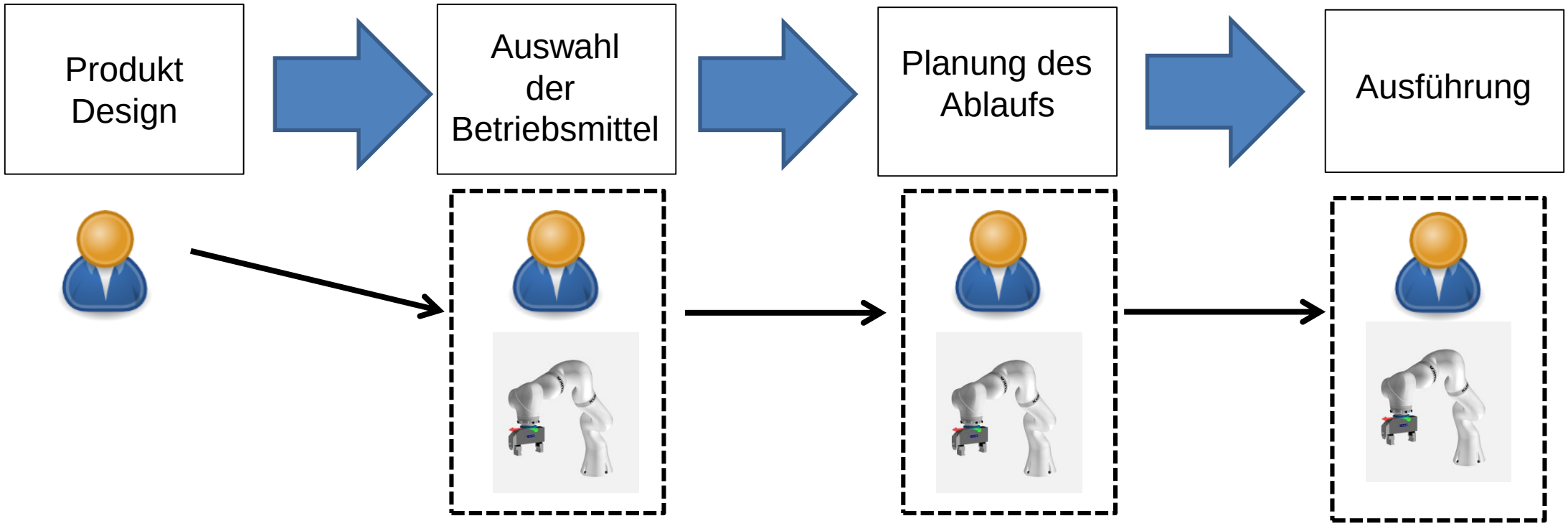
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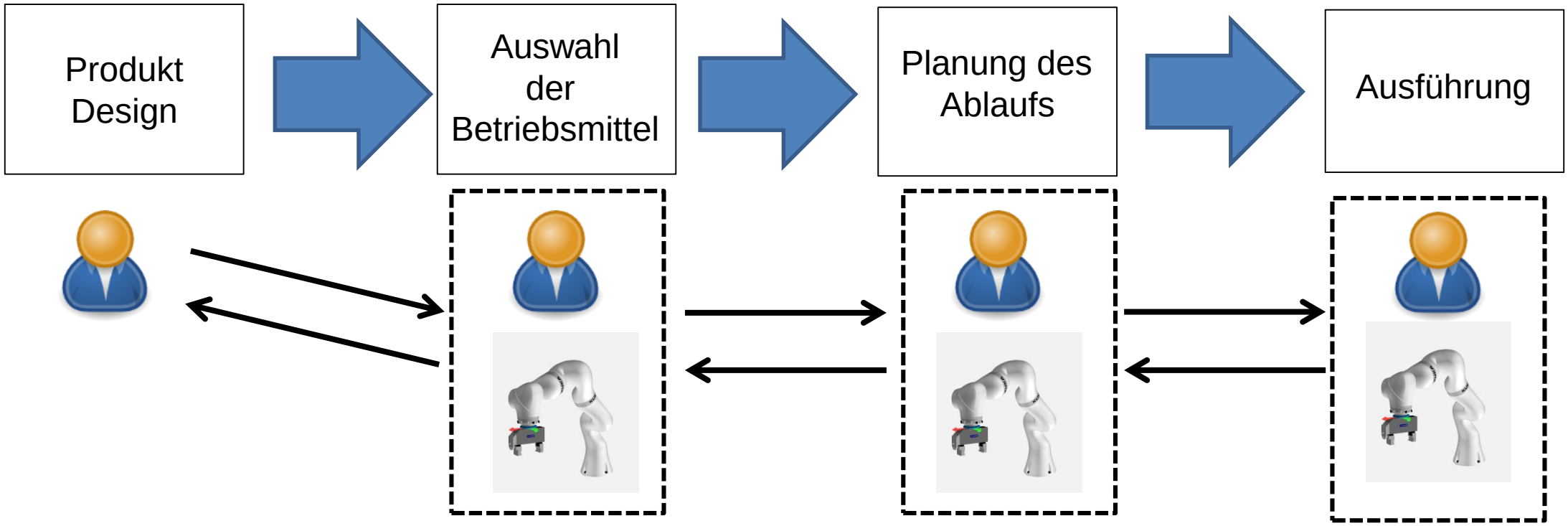
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Auswahl der Betriebsmittel
Planung des Ablaufs
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Vielen Dank für Ihre Aufmerksamkeit!

Kontakt RM - Produktion der Zukunft:

Korbinian Nottensteiner
Teamleiter Autonome Montage, Domänensprecher Produktion der Zukunft

Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Institut für Robotik und Mechatronik (RM)
Abteilung Kognitive Robotik

Münchener Str. 20
82234 Weßling

https://rmc.dlr.de/rm/de/staff/korbinian.nottensteiner/