Industrial IoT/AI/Wireless and Cooperation between Germany and Japan
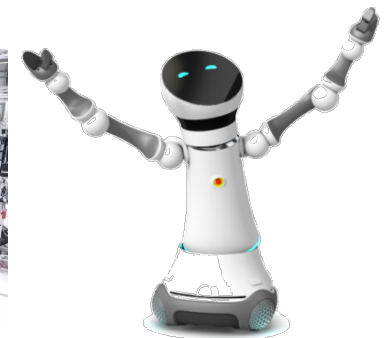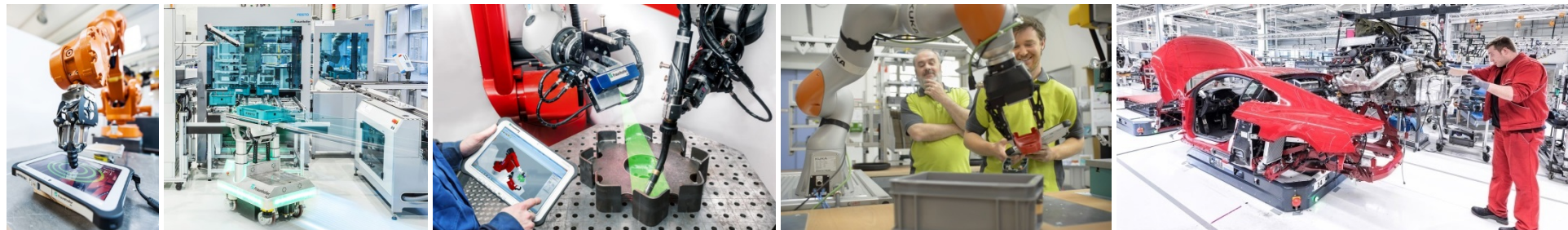
Martin HAEGELE

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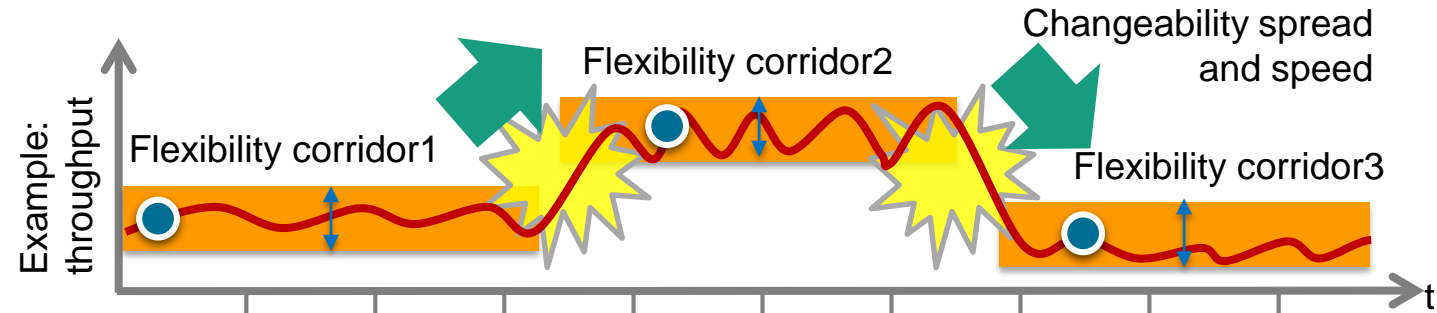
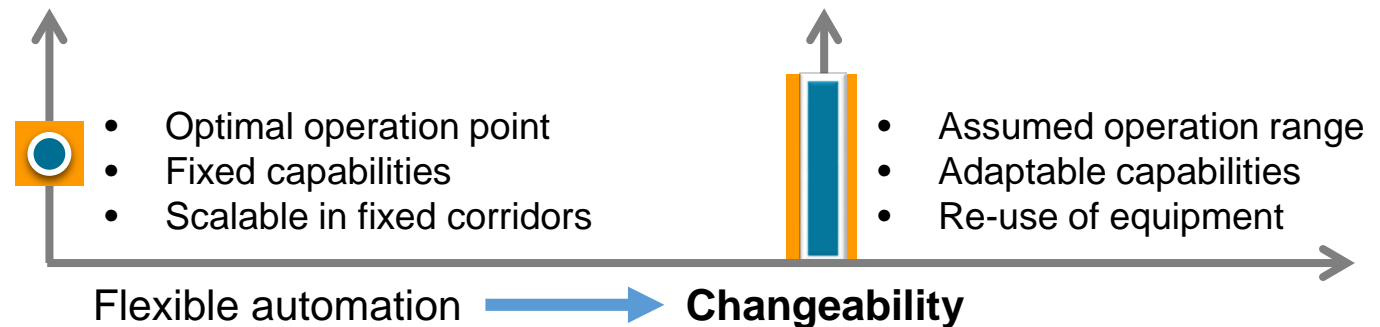Martin.Haegele@ipa.fraunhofer.de, Tel.: +49 711 970 1203

Source: Fraunhofer IPA, Audi

Drivers and enablers of changeable production: Throughputs, variants, lot sizes, technology change

Limitations of manufacturing automation flexibility

Beyond flexibility: Encompassing flexibility corridors through agility

- Optimal operation point
- Fixed capabilities
- Scalable in fixed corridors

- Assumed operation range
- Adaptable capabilities
- Re-use of equipment

Flexible automation → **Changeability**

Changeable production enablers

Mobility | Variable degree of Automation | Modularity, Scalability | Minimal geometric Pre-determination | Lean, universal equipment

Source: Westkämper, Nyhuis
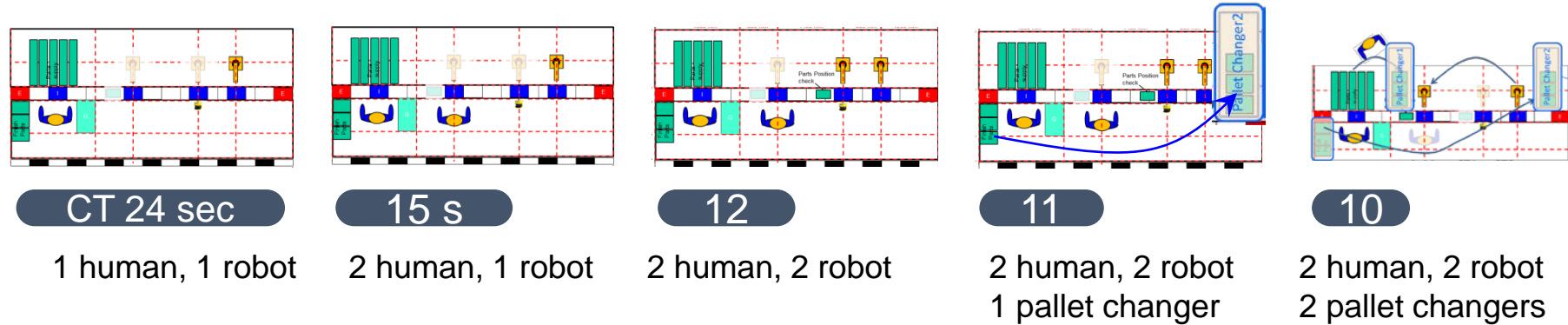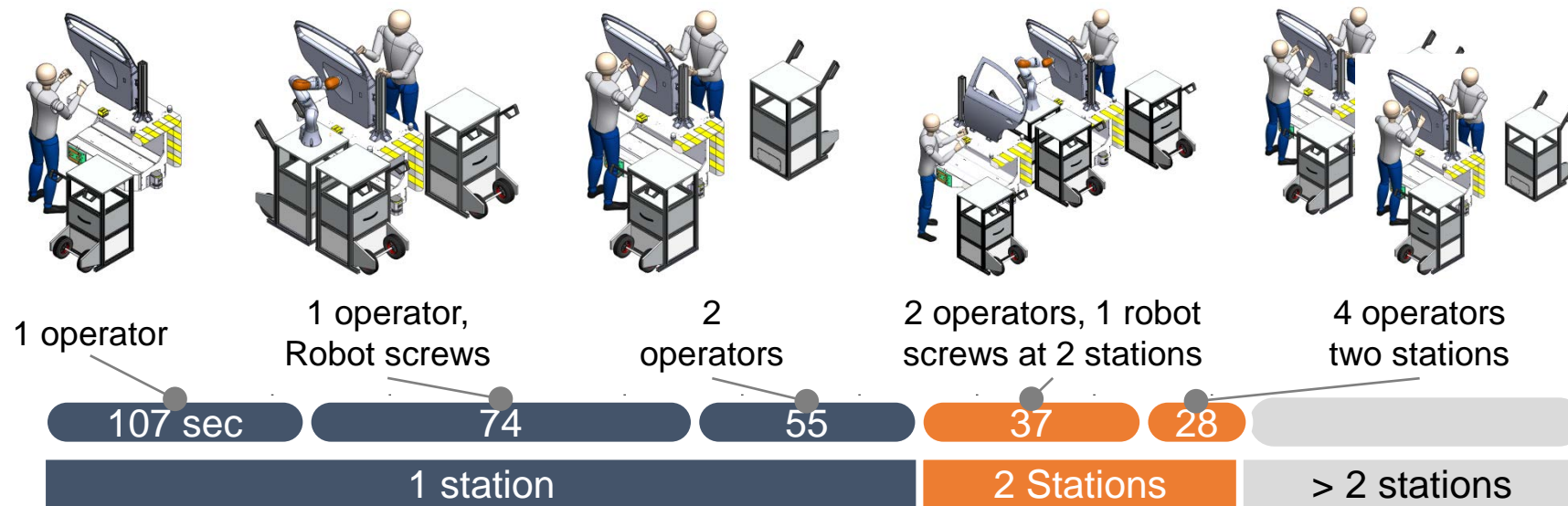
Changeable production (principle):
Variable layouts, degrees of automation

Changeable production: conveyor, no fences (human robot coexistence)

| CT 24 sec | 15 s | 12 | 11 | 10 |

| 1 human, 1 robot | 2 human, 1 robot | 2 human, 2 robot | 2 human, 2 robot
1 pallet changer | 2 human, 2 robot
2 pallet changers |

Changeable production: no conveyor (→mobile robots), no fences

| 1 operator | 1 operator,
Robot screws | 2
operators | 2 operators, 1 robot
screws at 2 stations | 4 operators
two stations |

| 107 sec | 74 | 55 | 37 | 28 | |

| 1 station | | | 2 Stations | > 2 stations |

Idea: A Cloud-Edge Navigation

Cloud Services

Agent

Agent

Agent

Agent

Agent

Agent

Agent
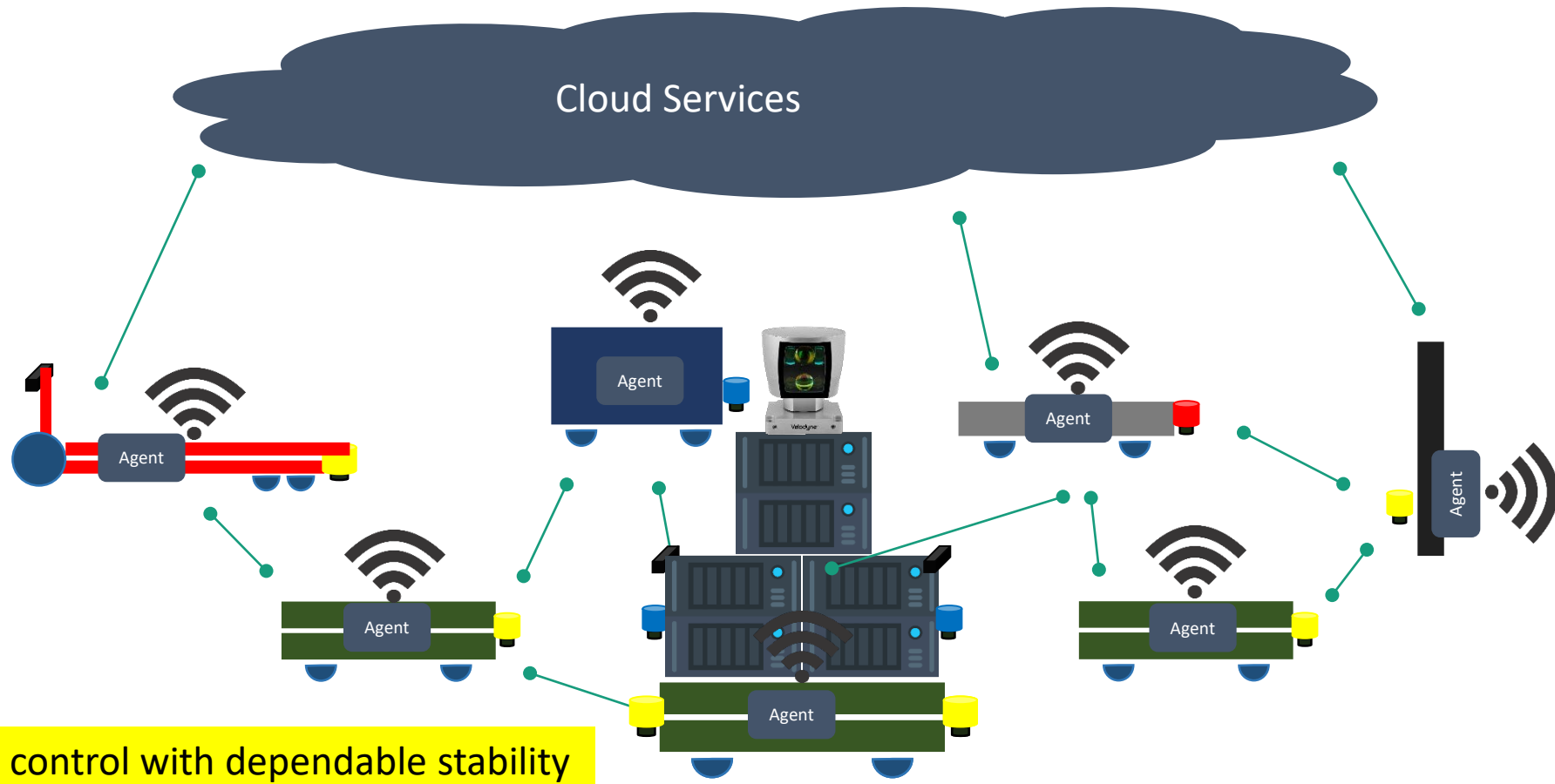
Conventional

→ Wireless control with dependable stability <50ms cycle time, factory floor suitable

Idea: Wireless control with dependable stability for robot teams in manufacturing, logistics and services

Motivation: Autonomous mobile robots/mobile manipulation depend on wireless technology. Motion synchronization → dependable updates <50ms

Approach: Exploitation of a feasibility study on feedback control/coordination over multi-hop low-power wireless with provable closed-loop stability(*)

Demonstrator scenarios (coordination of mobile robots):

- Step 1: Team/fleet of mobile robots (logistics)
  - Trajectory optimization of teams of cooperating mobile robots AGV
  - Remote local planning/control for reactive collision avoidance. Local motion/trajectory planning do not run on mobile robots, provided as a services
- Step 2: As above for teams of mobile robots with manipulators

Benefits

- Enabler for fog-architectures (lean real-time/redundant communication)
- HW reduction for mobile robots, reduction of WiFi access points

Holistic Global Map with all AGVs' Global Paths · Cloud Server · Network · AGV · AGV · Local Path

Multi-Hop Wireless Network

Mobile Robot Manipulato

Wireless node · Sensors Actuators · Dual Processor Platform

Mager, F et al: Feedback Control Goes Wireless: Guaranteed Stability over Low-power Multi-hop Networks; https://arxiv.org/pdf/1804.08986.pdf