FLANDERS MAKE

DRIVING INNOVATION IN MANUFACTURING

Flexible assembly technologies – skill-based robot programming, computer vision and operator information support

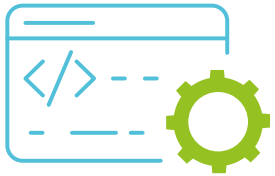
Smart Factories of Tomorrow: *Transitioning to Industry 4.0/5.0*

Maarten Witters

Flanders Make

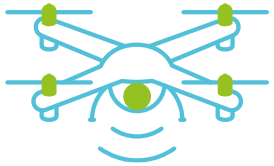
Strategic Research Center
Supporting the Flemish Manufacturing industry:

- Product & production technology and processes
- Digital transformation & Industry 4.0/5.0



End-to-end design operation

Leverage data and knowledge throughout the product lifecycle and value chain



Motion products

Validated products & product architectures

Production

Validated assembly solutions, using robotics & automation

Flanders Make in numbers

1200
Projects a year

106
Mio Revenue

58
Ongoing European projects

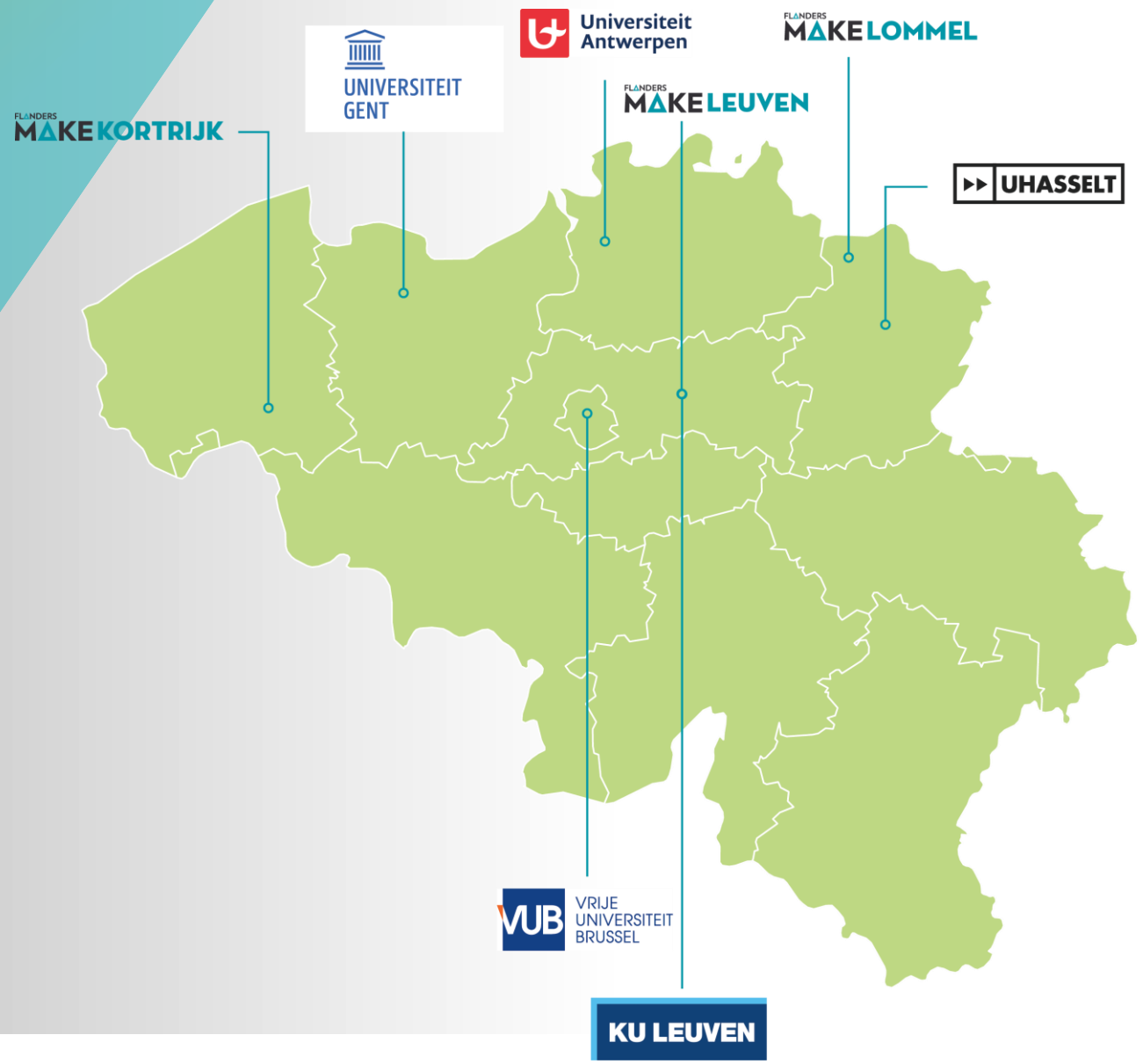
18
New European projects in 2023

+200
Member companies

+950
Staff workers

Close to the industry

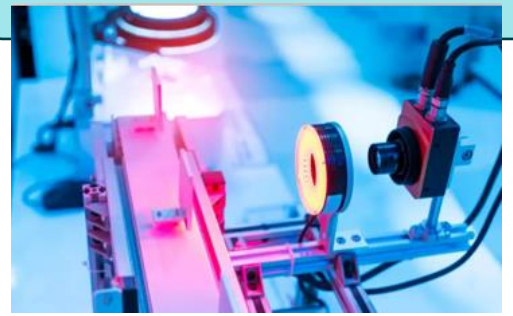
with co-creation centers and core-labs at the 5 Flemish universities



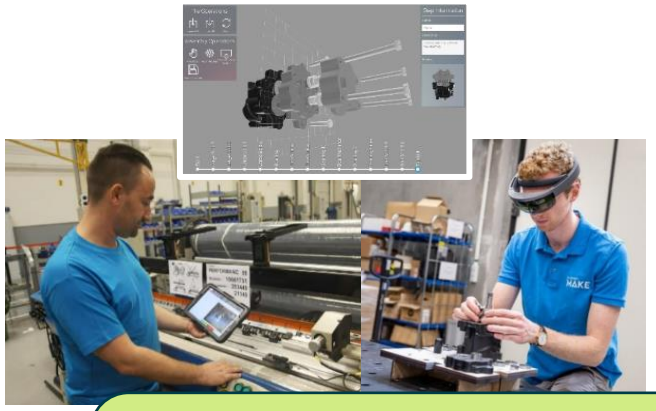
An intensive collaborative innovation ecosystem

enabling a profound and integral business transformation

Vision technologies for machines, production and assembly systems, easy configurable from CAD models



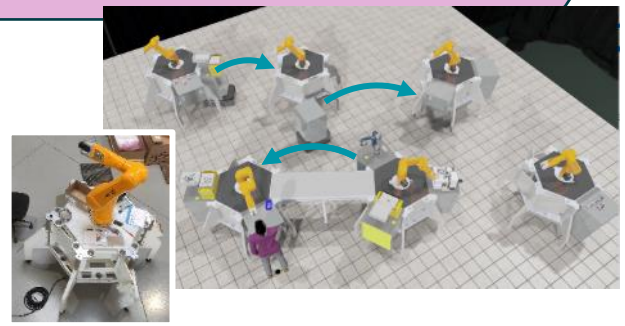
Digital Production



Cognitive and physical supportive systems for a more effective worker in a context of sustainable work

Assembly Systems

Smart robotics and flexible automation, ensuring optimality for varying product volumes in mass customized production, based on service-oriented architectures



ProductionS Corelab

Production Employee Information Systems

Vision 4 Production

Creation of actionable insights via the smart use of data and domain knowledge realizing actionable intelligence to respond to flexibility and resilience opportunities and threats proactively and reactively

Robots are widely used in assembly but ...

… not in flexible assembly

EXHIBIT 2 | While the Costs of Advanced Industrial Robots Fall, Their Performance Is Steadily Improving

TOTAL SYSTEM COSTS OF A TYPICAL SPOT-WELDING ROBOT IN THE U.S. AUTOMOTIVE INDUSTRY

FUTURE COST TRENDS

Project management
Has consistently been 5–10 percent of total system costs; absolute costs are expected to decline

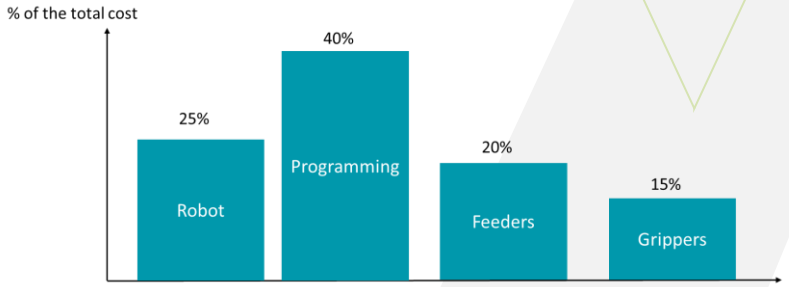
Systems engineering (such as programming, installation)
Cost reductions are expected to slow because possible gains in offline programming have mostly been achieved

Peripherals (such as safety barriers, sensors)
Costs will continue to drop as a result of the removal of safety barriers

Robot (including software)
Minimal declines are expected because pricing is close to material costs, and production volume for the auto industry is already high

Sources: ABB, *Economic Justification for Industrial Robotic Systems*, 2007; International Federation of Robotics, *World Robotics: Industrial Robots*; expert interviews; BCG analysis.
Note: Because of rounding, not all numbers add up to the totals shown.
[1]Values are in nominal U.S. dollars.

- Fast robot programming is key for flexible assembly



Source: Mauro Ononi, KTC, Sweden, 2003, Automatic Assembly Systems

Source: https://www.bcg.com/publications/2015/lean-manufacturing-innovation-robots-redefine-competitiveness

Key ingredients for flexible robot systems

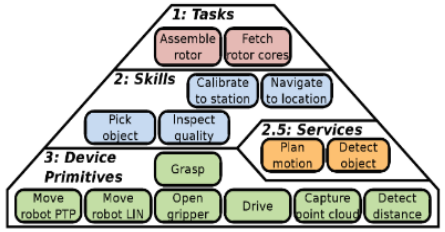
Human/robot collaboration

AI

Modular gripping systems

Skill-based robot programming

- pick&place
- glueing
- insertion
- sensor DP



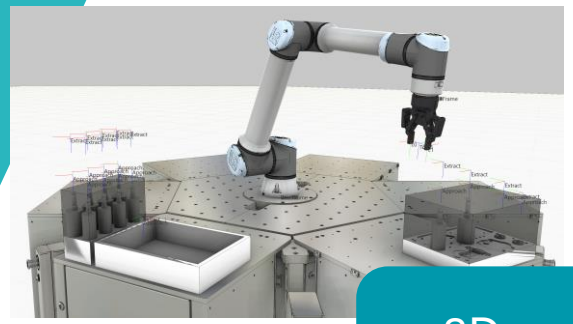
Hardware-independent parametric skills

hardware-specific device primitives

Mobility

Computer vision

Skill based programming & operation can drastically reduce programming time



Product Assembly Recipes

Assembly Order

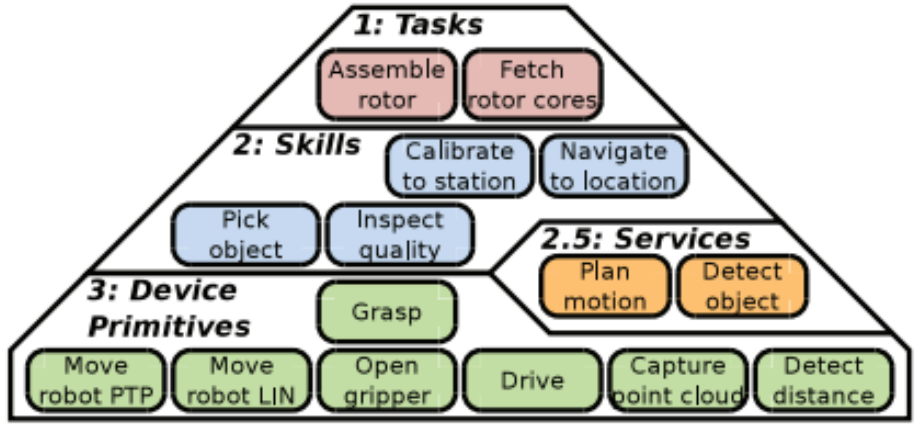
3D assembly world model

Skill scheduler

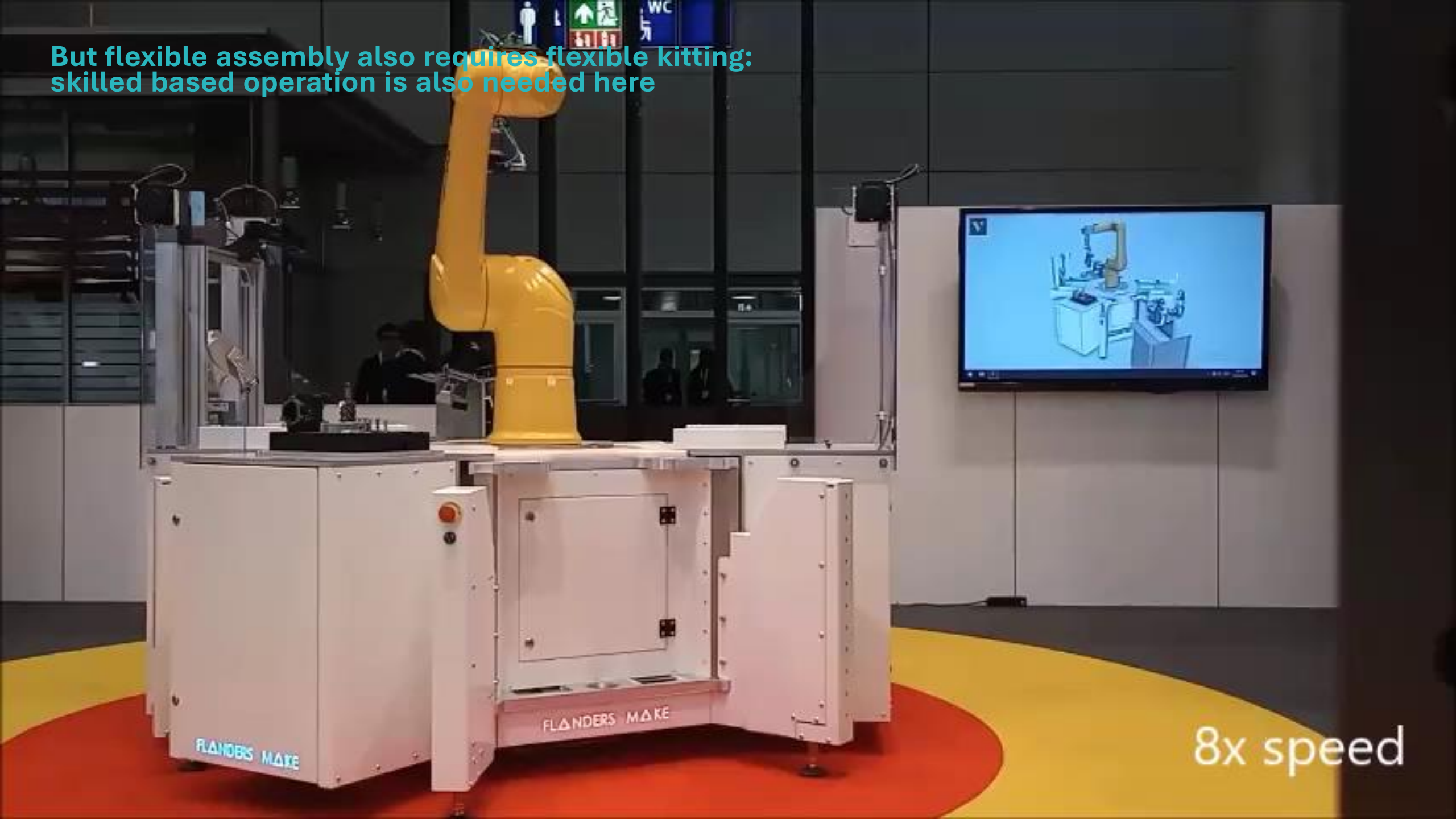
Robot Skill library

Programming
Teach-in
Self-learning

Basic robot skill execution & monitoring

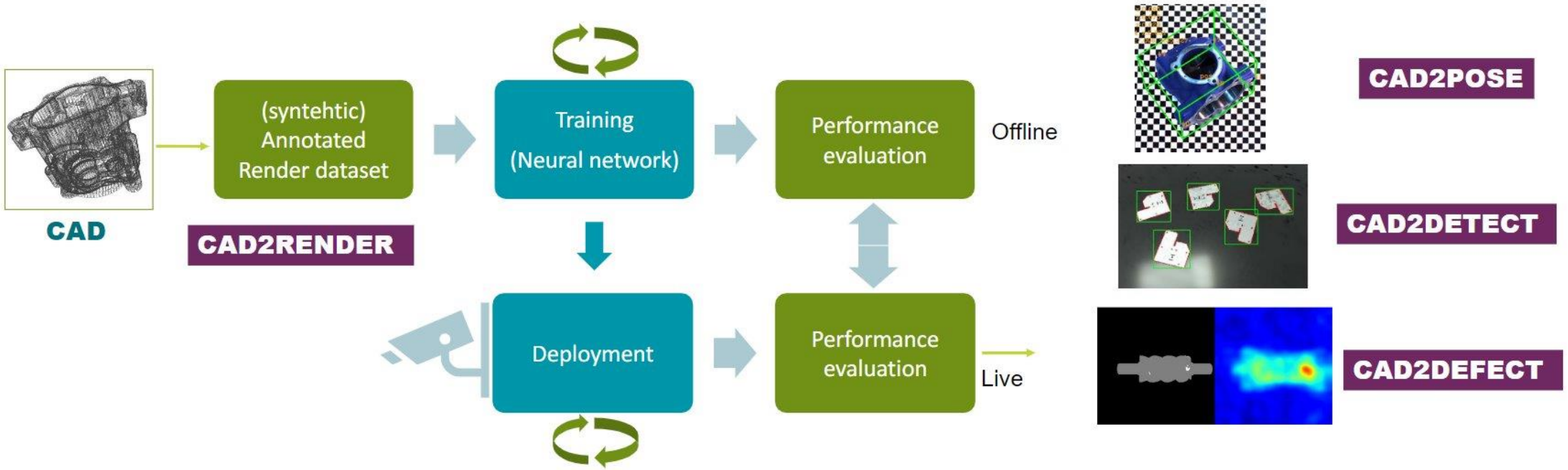


Source: https://doi.org/10.1016/j.rcim.2018.03.008


But flexible assembly also requires flexible kitting:
skilled based operation is also needed here
FLANDERS MAKE
FLANDERS MAKE
8x speed

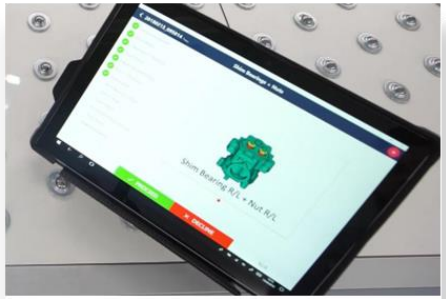
Low-cost vision solutions: synthetic data generation & cheap(er) cameras

- CAD2DETECT: train a detector using only CAD data for 2D cameras
- CAD2POSE: train a 3D pose detector using only CAD data for 2D cameras

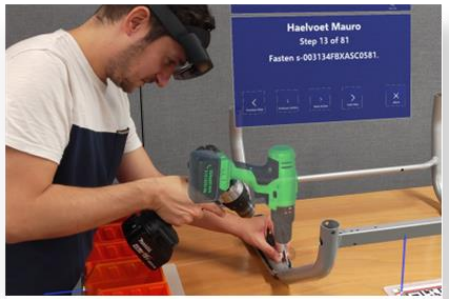


Operator Guidance

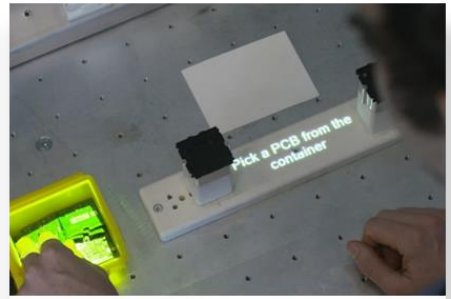
Desktop



Smartphones & Tablets



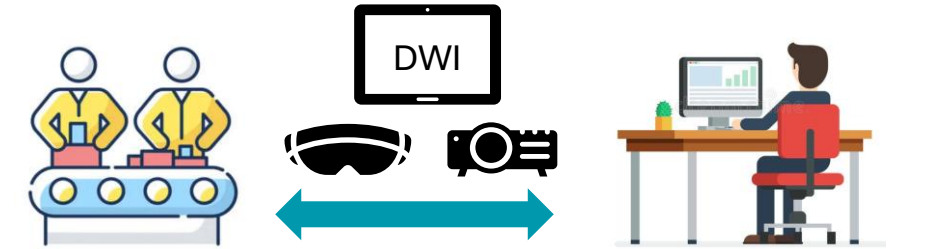
Wearables



Projected AR

BUT

1. All these solutions depend on the **manual** entry of the instruction content
2. There is a need for **personalized**, **context-aware** and **interactive** instructions



1 min
of work

25 min – 100 min
of preparation

Generation of Digital Work Instructions from CAD

High mix, low volume manufacturing

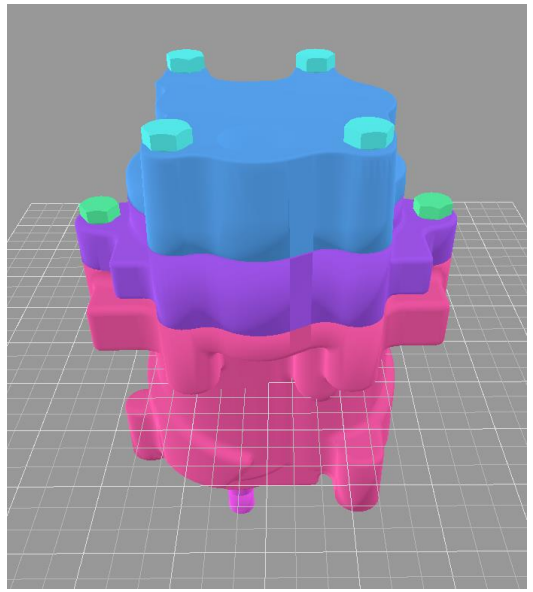
↓

High amount of instructions

↓

Time/Cost-intensive process of instruction creation

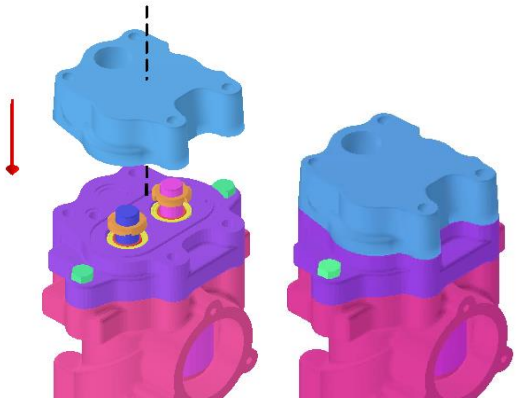
CAD Model available



Assembly sequence

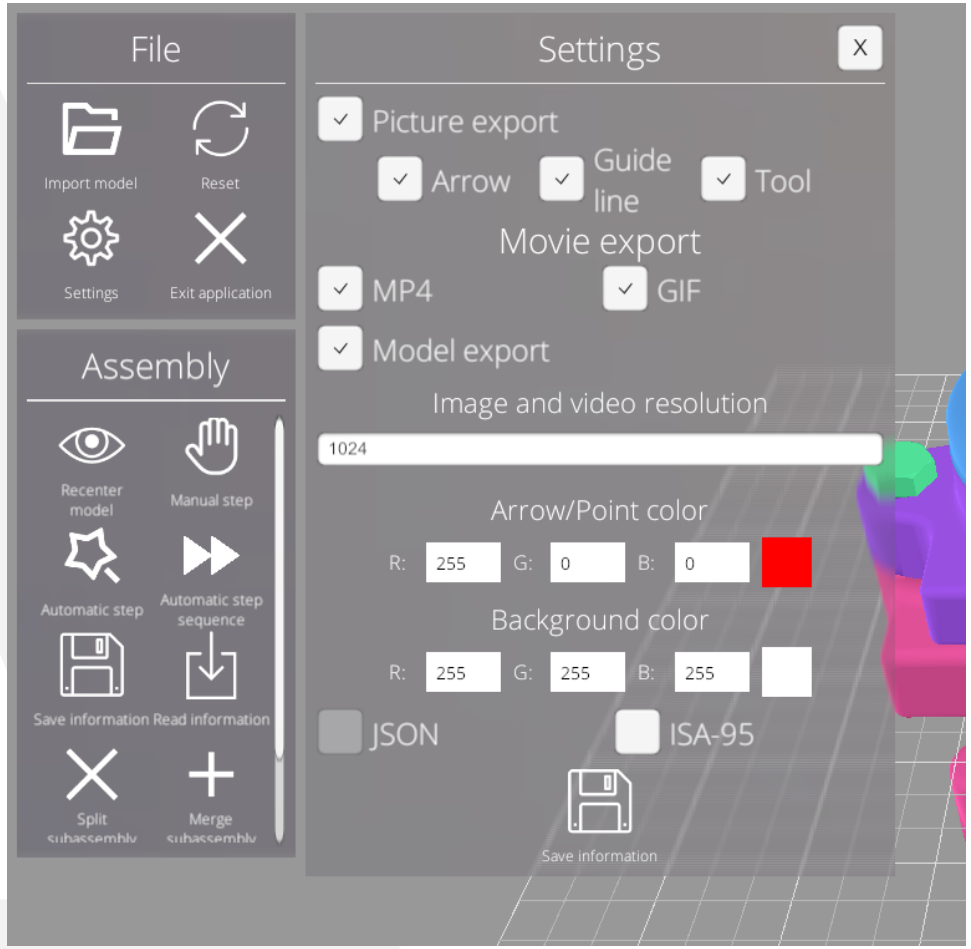
Work instructions

Step 11: Insert 'Bearing sealing' into assembly



Description Image Animation

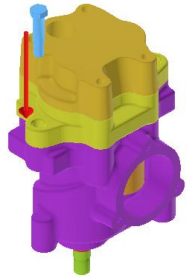
Transferring this information to other technologies



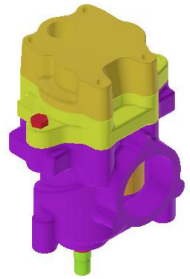
Text

Step 17: Insert part 'Bolt_Short_1' into the assembly

Image



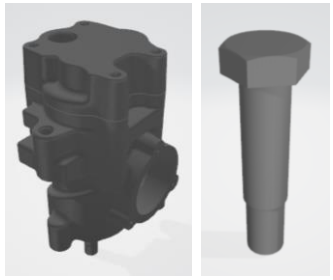
Video



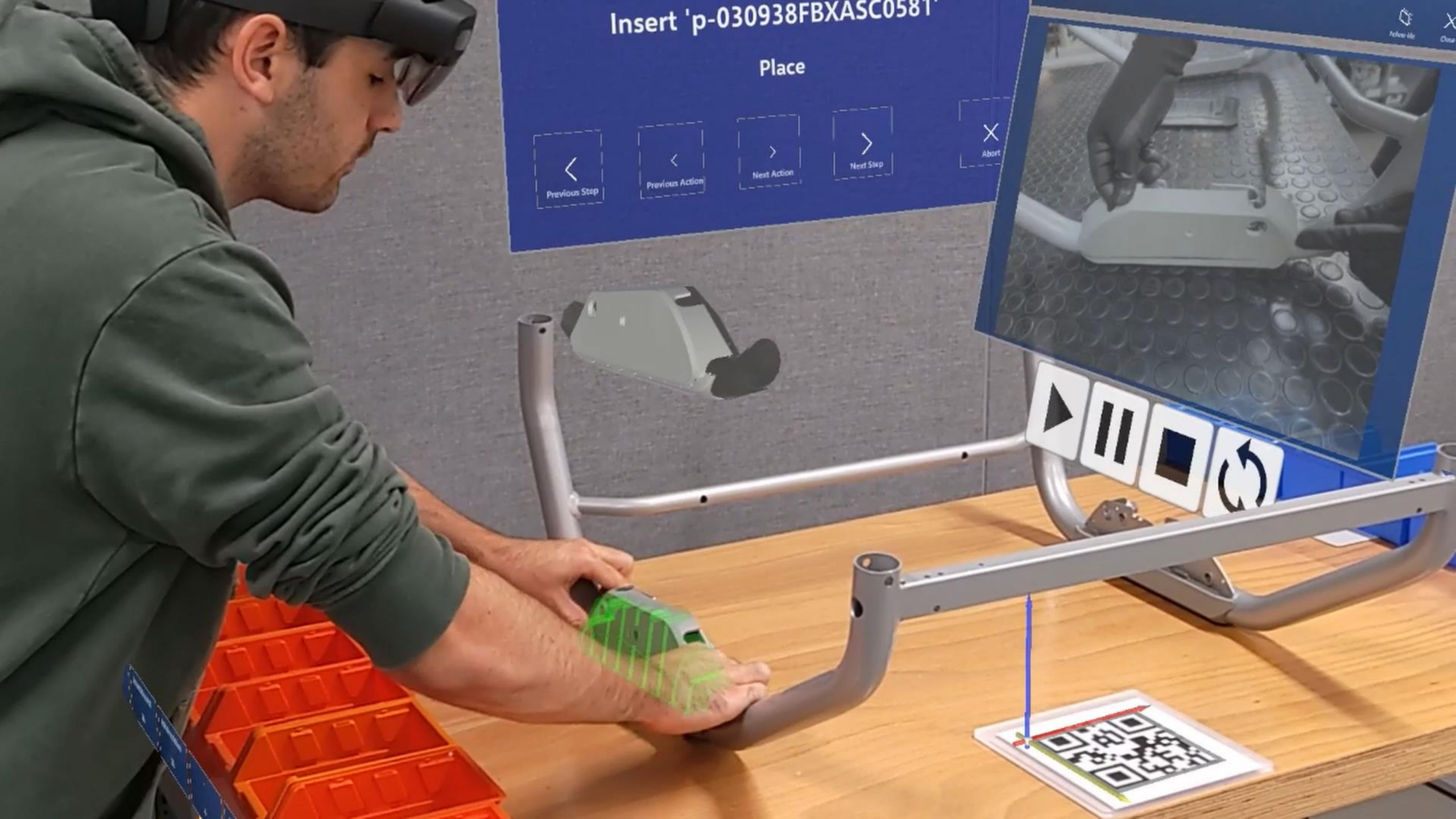
Variables

- AR
- Operation
- State tracker

3D Models

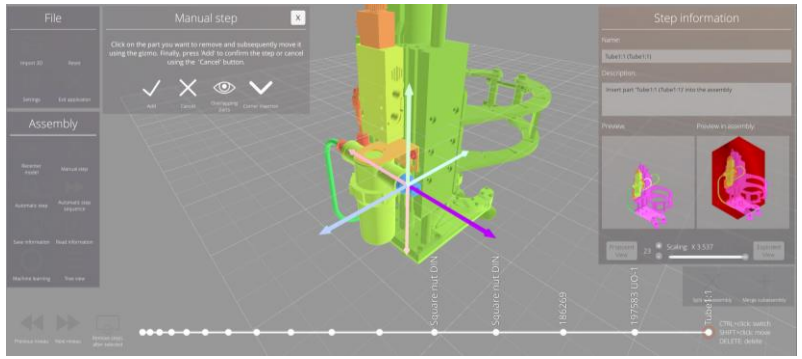


- DWI platforms
- AR platforms
- State tracker
- ...

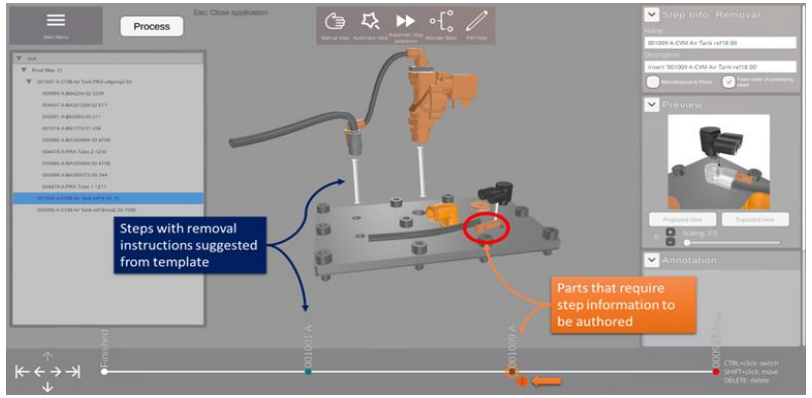

Insert 'p-030938FBXASC0581'
Place
Previous Step
Previous Action
Next Action
Next Step
Abort

Examples of values

Up to 70% time reduction in creation of DWI using CAD2DWI



Up to 96% time reduction in case of product families*

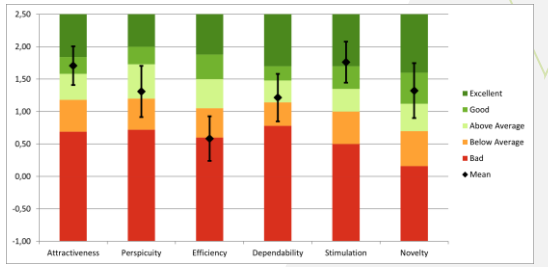


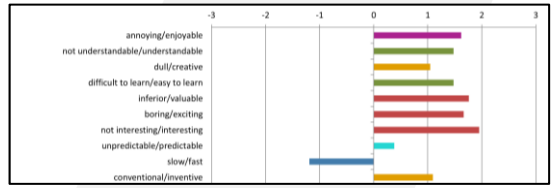
*use case dependent

Efficiency AR in DWI

	Total Time	Total Errors
Digital Instructions	12:02	7,01
AR Instructions	**10:23**	**2,59**

Digital Assistant User experience



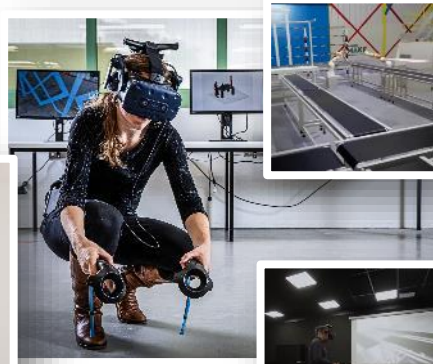


ProductionS - Infrastructure

Robotic Systems Lab

DWI

Operator5.0 Lab



AR/XR/VR

Operator monitoring

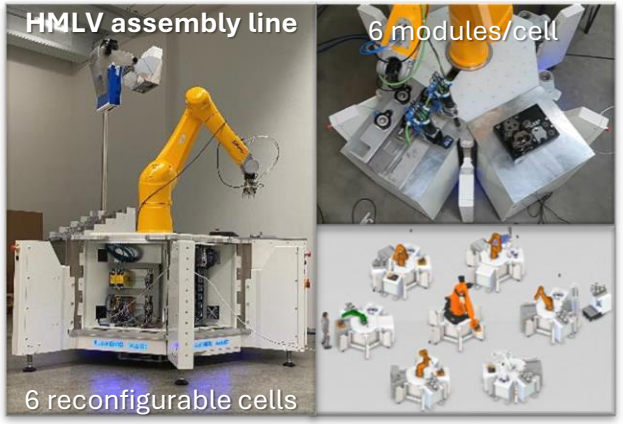
Mobile Make Lab

Vision Systems Lab

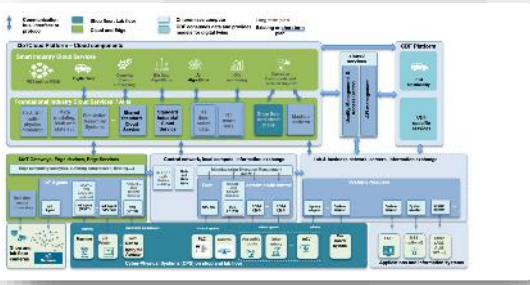
Vison Sensor Tunnel

1D->3D Sensors

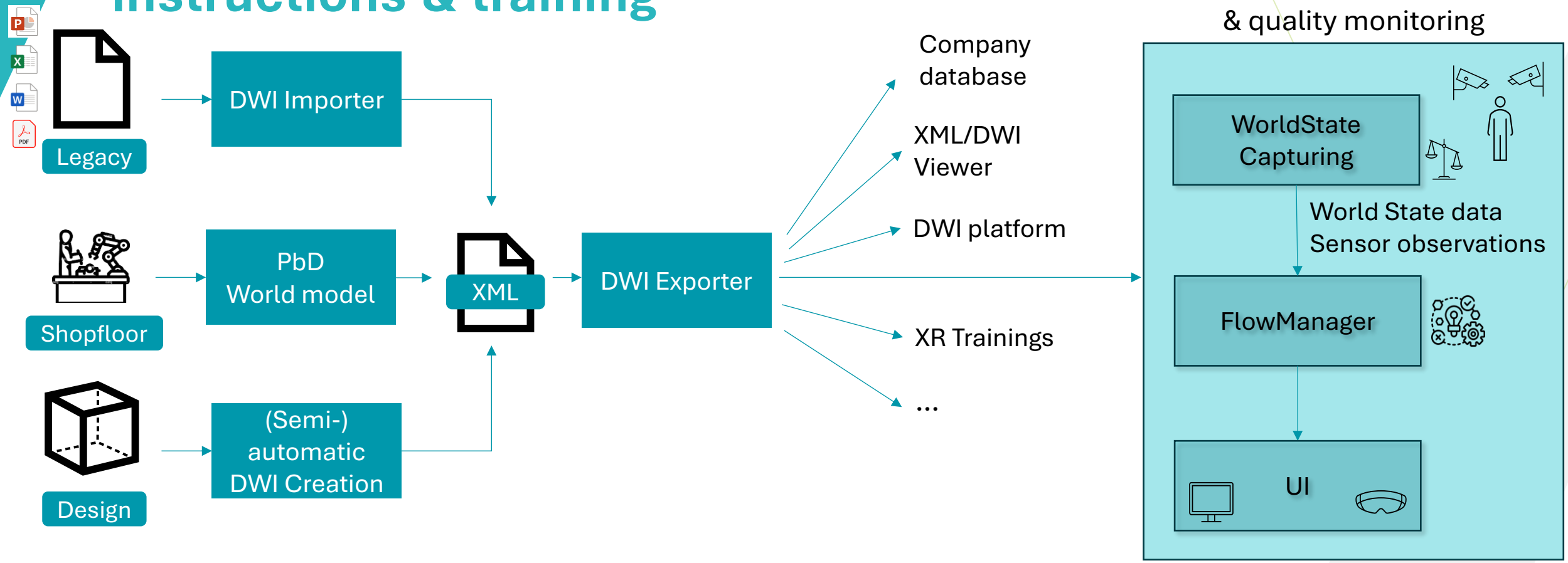
Flexible Assembly Systems Lab



Industrial IoT Lab



Easy creation and deployment of interactive instructions & training



Seamless workflow for building Operator Guidance (Digital Work Instructions & Monitoring) from Legacy, Design & ShopFloor information