ROS-Industrial

European updates
Fraunhofer-Gesellschaft
Research and create innovations

At a glance
- World’s leading applied research organization
- Founded in Munich (headquarters) in 1949
- Over 30,000 employees divided among 76 institutes and research units
- Annual research budget of €2.9 billion; Fraunhofer generates €2.5 billion of this from contract research
- Research excellence is an overarching goal
- Industry-oriented services for industrial customers
Fraunhofer IPA
Innovation driver with a scientific reputation since 1959

### Key figures in 2021 in € million ¹)

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total budget</td>
<td>82</td>
</tr>
<tr>
<td>Operating budget</td>
<td>77²)</td>
</tr>
<tr>
<td>Investment budget</td>
<td>5</td>
</tr>
<tr>
<td>Industrial revenues</td>
<td>23</td>
</tr>
</tbody>
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### Additional Key Indicators

- Over 1,000 projects with industrial customers each year
- Approx. 1,200 employees at 9 locations (headquarter: Stuttgart)
- 24 patents granted (5 in Germany, 19 internationally)
- 870 publications

¹) All values incl. Fraunhofer Austria Research GmbH, Vienna, Business Unit Production and Logistics Management
²) Adjusted operating budget: increased by unburdening internal cost clearing in the amount of € 2 m with IPA value creation
Departement robots and assistive Systems
Innovating robotics since 1973

~ 70 employees
~ 40 robots
8 teams
11,5 M€ budget

Technologien

- Picking & Packing
- Welding
- Industrial Service Robots
- Assistance Robots
- Robot Programming
- Software Engineering
- Assembly Automation
- Safety
Software Engineering und System Integration

The team

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Some common problems in robotics

1. **Reusability** of software components is not very common in robotics.

2. **Composition** of a functional and reliable robot software systems is challenging.

3. **Validation** of robot systems is difficult.
Software Engineering und System Integration
Revolutionising robot software integration

We revolutionise robot software integration by:

- Providing model-driven integration tools that reduce programming and integration efforts drastically
- Supporting our customers system composition projects with our expertise and tools
- Providing test and experimentation environments for our customers to evaluate and boost their robot technology developments
- Enabling easy integrating of professional robot software with the robot operating system to leverage the most recent control, planning and sensing algorithms.

Integration Tools
System composition
System Testing
Robot Operating System
Software Engineering und System Integration
An opensource model-driven robot software toolchain

- Component Ecosystem
- BehaviorTree
- Software Application Design
- Industrial components

- eclipse
  - Software System Design

- GitLab
  - Cloud Storage Platform

- ROS
  - Execution Platform

- Industrial Robots
- ABB
- UNIVERSAL ROBOTS
- YASKAWA
- DENSO

- FESTO
- SCHUNK
- OMRON
- ctrlX
- PHOENIX CONTACT

Strictly Confidential
Software Engineering und System Integration
Software system model

Software system – Pilz Application

Software system – UR Application
Software Engineering und System Integration
Software application model

- Own library of skills for behaviour trees based on behaviortree.cpp
- Easy addition of new or existing skills
- Even skills that are not supporting ROS can be integrated
- Fast and error resilient development of robot applications
- Only minimal changes necessary when running on different robots
Software Engineering und System Integration

Deployment

- Direct integration into version control systems such as GitHub or GitLab
- Always know which model is deployed to which robot
- Integration with previous integration tests possible
Software Engineering und System Integration
Concepts deployed in different lines and robot cells

Testing line (2022)
- Manufacturing line with one manual station and 3 robot stations
- Configure production with recipes flexibly
- Define behaviour of stations with proprietary behaviour tree library written in Ladder

Testing line (Q1/2024)
- Manufacturing line with 3 robot stations
Reference robot cell
Ongoing effort – First iteration

Current status:
- Initial design done
- First two cells being setup

Component status:
- Robots:
  - Universal robots: U5e, UR10e (tested)
  - Denso: Cobotta Pro 900 (tested)
  - Yaskawa Motoman: HC10 (ordered)
  - Kuka: KR10 (ordered)
- PLCs:
  - Omron: NJ (OPC-UA driver – tested - proprietary)
  - Bosch Rexroth: CtrlX (PLC integrated driver – under development)
  - Phoenix Contact (PLC integrated driver - tested)
- Peripheral equipment:
  - Intel: realsense (tested)
  - Schunk: EGP grippers (tested)
  - Festo: VTEM (under development)
Reference robot cell
Ongoing effort – First iteration

**System features:**
- Mounting grid 50x50 mm (compatible adapter plates available or easily designed)
- Normal as well as top down mounting possible
- Built-in cabinet (DIN rail)
- Screen mount
- Space for robot controller, pneumatic cabinet and industrial PC
- Industry ready: safety guard locking and emergency buttons

**Services:**
- Cell including safety wiring, PLC and IPC: ~35k€
- Robots and applications can as well be designed

**To be open source’d:**
- Hardware specifications
- Software repositories
Standard robot cell
Deployment plan at IPA

Legend:
- Standard Robot Cell
- Mobile Robot Test range
- Conveyor belt
- Human work station
- Testbed storage
- Workplace
- Compute Cluster

Collaborative Manufacturing
High Speed Manufacturing

Vision Test Cell
Compute Cluster
Cobot Cell 1
Cobot Cell 2
Robot Cell 3
Robot Cell 4
Storage Area
Other efforts
Ongoing in Europe

- CANopen (IPA)
- Industrial CI (IPA)
- UR robot driver (Universal Robots & FZI)
- EtherCAT (ICUBE)
Contact

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