Introducing Your Presenters

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Advancing Open-Source for Industry

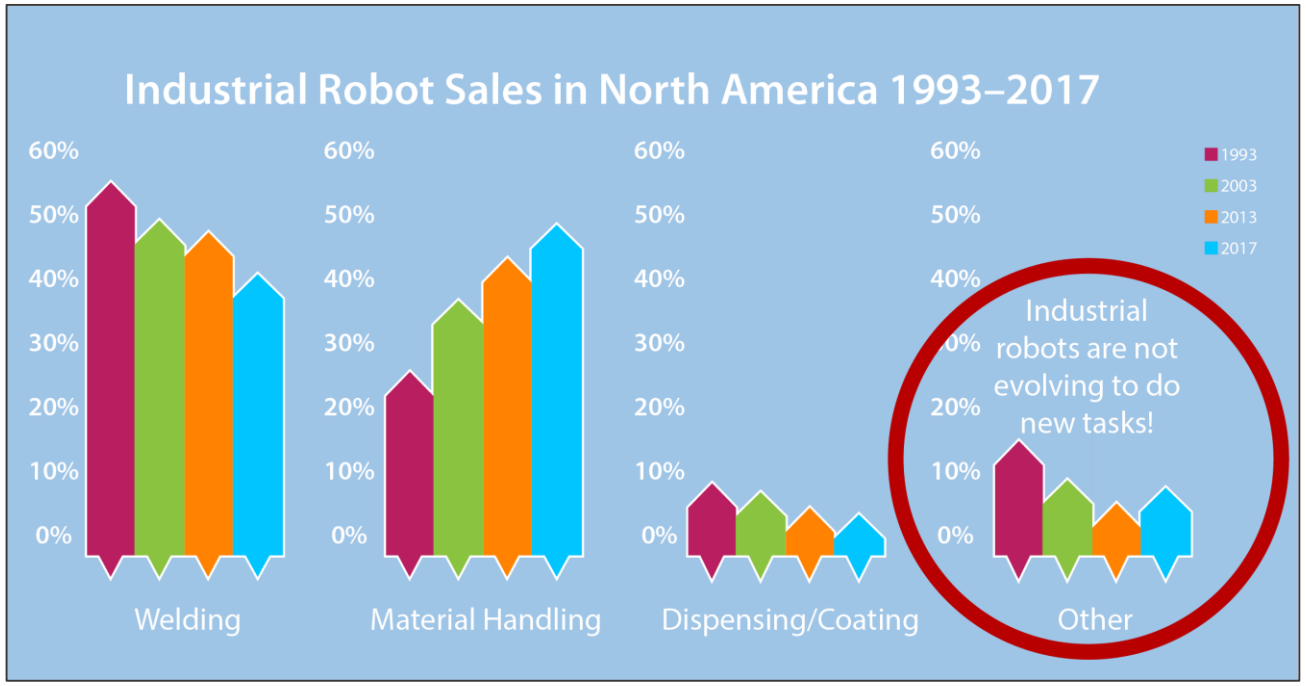
SwRI®
SOUTHWEST RESEARCH INSTITUTE

Advanced Remanufacturing and Technology Centre
ARTC

Fraunhofer
IPA

Industrial Robotics – Silos & Stagnation

Stagnated Due to Reliance on Large-scale Manufacturers that Leverage Sheer Volume to Offset Cost and Limitations



Typical Large Auto OEM

Custom SwRI Solution

ROS industrial

A Disruption in Software for Automation

Enter ROS – Robot Operating System

- Open Source
- Established to prevent re-inventing the wheel
- Maintained by Open Robotics
- Reusable Software Components
- >1,000,000 user downloads/mo

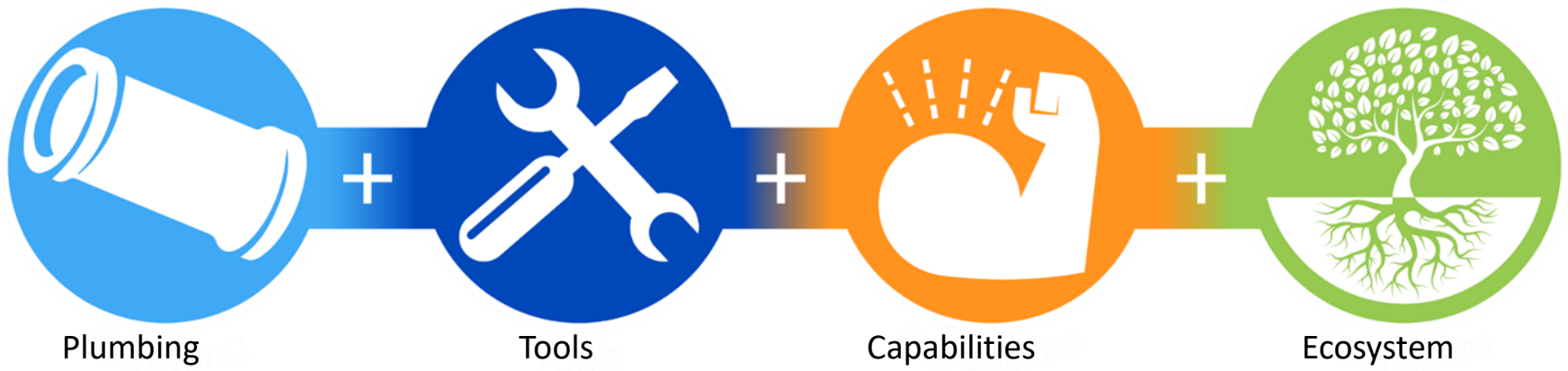
ROS

is…

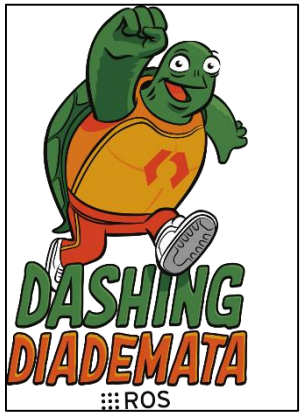
A **Middleware** Framework

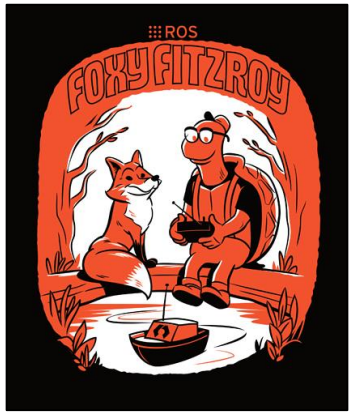
An International **Open-source** Project

A Library of **Free Software and Tools** for Robotic Development



ROS Releases and Journey to Industry





2008
- PR2 and ROS start at a research platform for universities and research institutes

Jan 2010
- ROS 1.0 is released with tutorials
- 12 releases between 2010-2018

Dec 2017
- First Beta release of ROS 2.0 for general use

Dec 2018
- Actions support
- Navigation package

May 2019
- Multi-axis robot motion planning

Jun 2020
- Latest release

10 Year Development Cycle

ROS 2.0 Industrial Use

Start using for next generation platform development

ROS industrial

Source: Open Robotics Presentation at ROSCON 2018 (Updated)

Goals for ROS 2.0

product-ready

Use **industry-standard middleware** (e.g., DDS)

Build in **security** from the beginning

Support **Linux**, macOS, and **Windows**

mission-critical

Support **real-time control**

Static analysis (e.g., MISRA)

Document design choices

Support safety certification

...but also familiar

Keep the core concepts from ROS 1

Distributed systems

Federated development

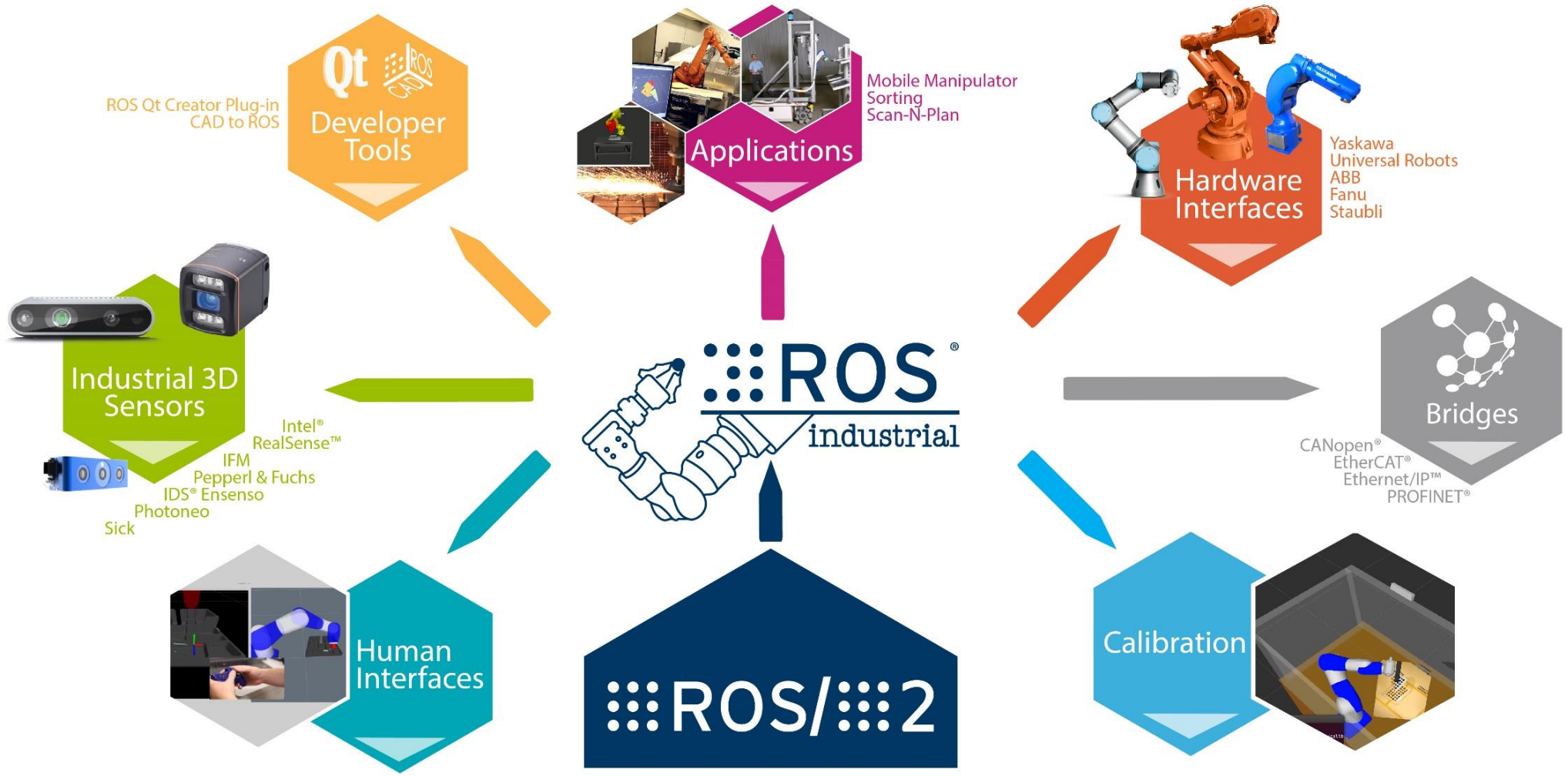
Permissive open source license – allows for commercial hybrid model

Important for mass-scale industry adoption

ROS industrial

Source: Open Robotics Presentation at ROSCON 2018 (Updated)

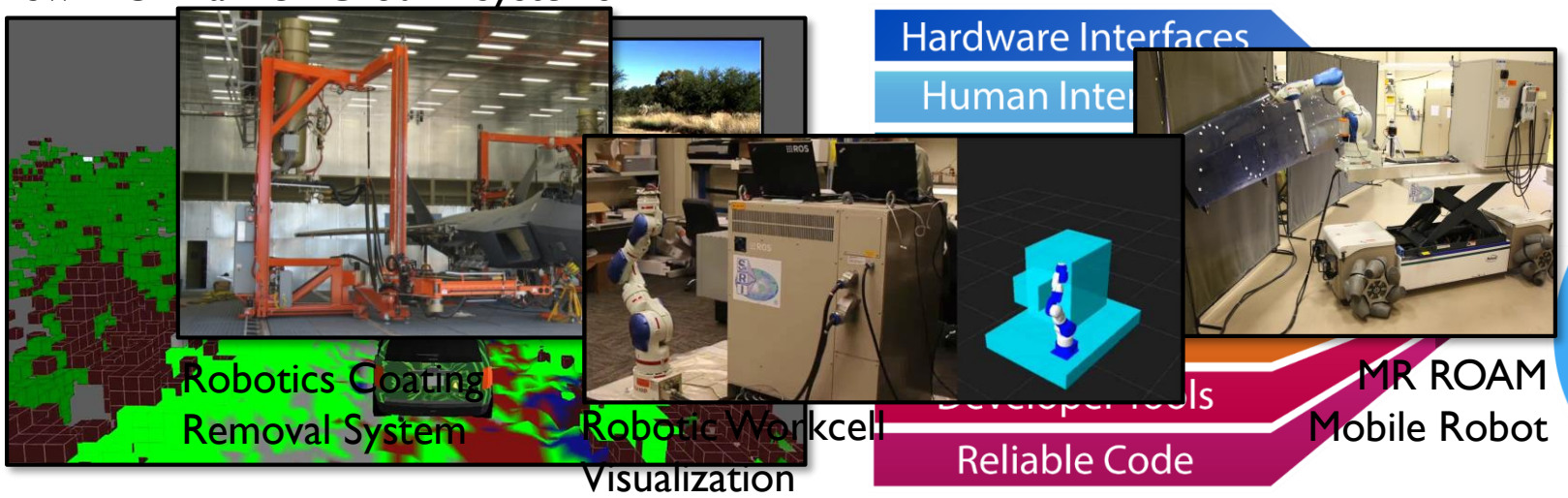
What is ROS-Industrial?



ROS-Industrial Timeline

2010 SwRI Adopts ROS → **2011** ROS-I Inception → **2012** ROS-I Launch → **2013-2016** ROS-I Consortium

SwRI Unmanned Ground Systems



Robotics Coating Removal System

Robotic Workcell Visualization

MR ROAM Mobile Robot

Enable Global Leverage of Regional Development

Introduction to ROS-Industrial Consortium

- A Global Consortium with regional presence:

Fraunhofer IPA

Fraunhofer IPA, Germany

SwRI
Southwest Research Institute

Southwest Research Institute, Texas

Advanced Remanufacturing and Technology Centre
ARTC

Advanced Remanufacturing and Technology Centre, Singapore

Tech Vision Supported by Industry

- **ROS-Industrial Consortium** acts as an ecosystem where different players – end-users, equipment providers, system integrators, institutes of research and training partners **come together to advance and proliferate Open Source robotics**

Strategy for Capability Development

Environment Layer (MoveIt, Tesseract, Dart, etc.)

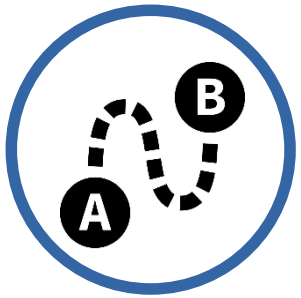
Messages, Topics

ROS 1 / ROS 2 / Middleware Layer

Build ROS1 or ROS2, these are independent

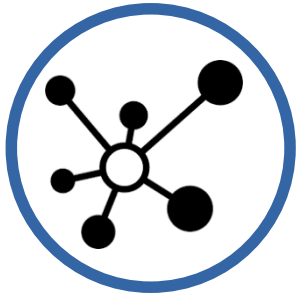
Independent of ROS

Collision Detection



Motion Planners

Kinematic Solvers



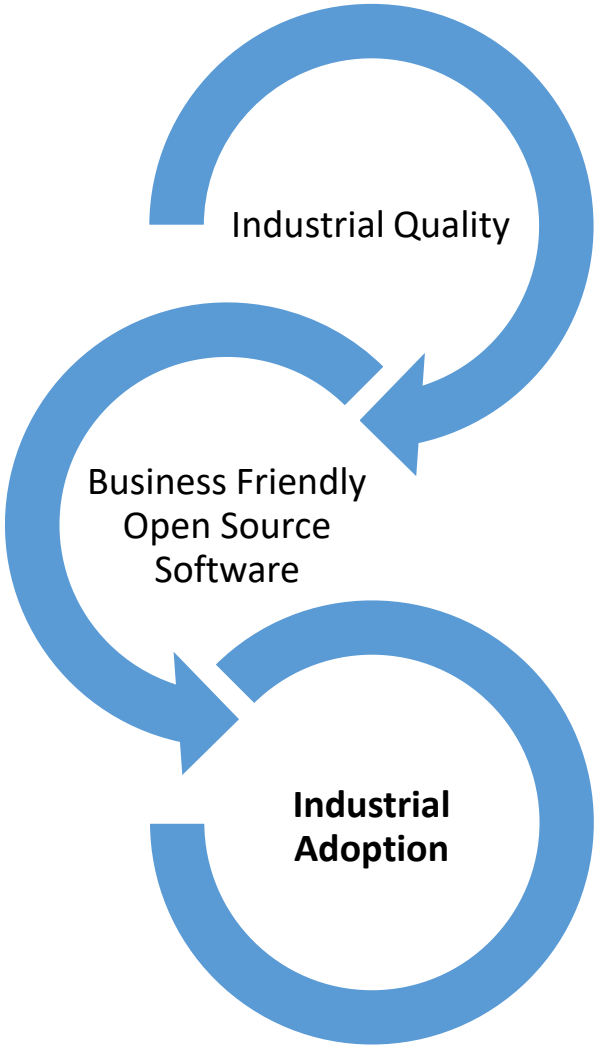
Connectivity Structure

Continue to support deployed end-user ROS1 systems with new capabilities as they are developed even if for a ROS2 solution

What Can ROS-I Do?

Industry Quality and Commercial Adoption

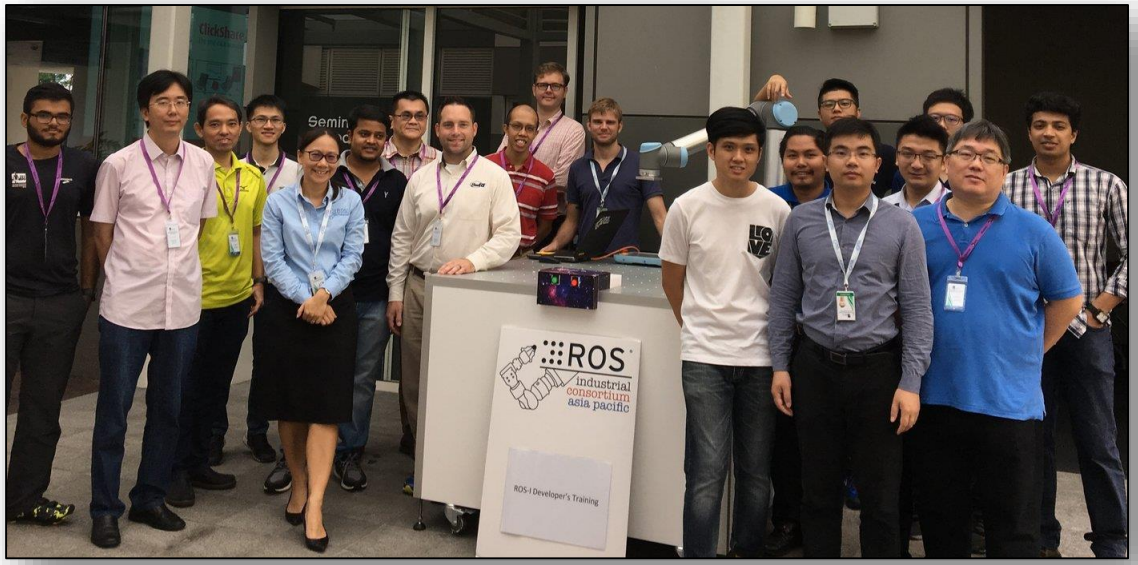
Robot Operating System packages adopts business friendly software licensing that do not taint Intellectual Property (allows for hybrid Open Source and proprietary solutions)



ROS-Industrial supports development of formal software development processes, and provides standardized automation tools for quality assurance for ROS modules

Collaboration

On-site at BMW Regensburg

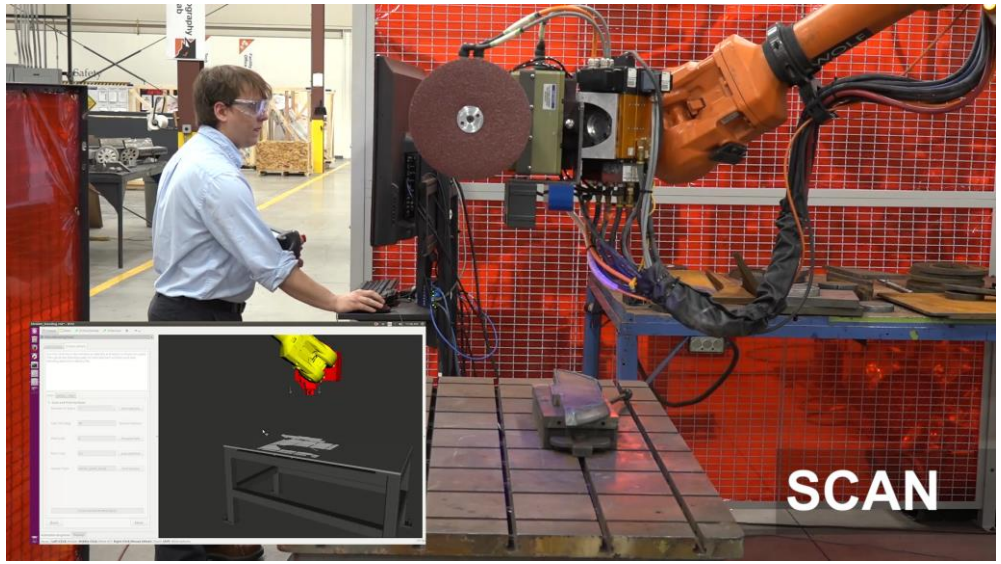


Training Co-Development

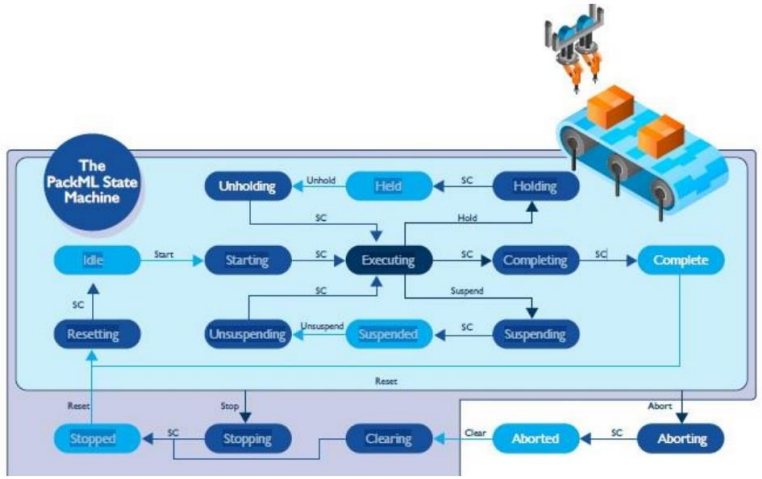
Pre-competitive Focused Technical Projects between Industry Members (https://youtu.be/PWCpehyKnTY)

NIST-MTConnect-ROS Interoperability
- Follow on MTConnect-OPC-UA-DDDS

Joint Industry & Collaboration Projects



Tech Demonstration of Robotic Blending Milestone 4
Caterpillar, 3M, GKN Aerospace, Wolf Robotics
https://youtu.be/PWCpehyKnTY



PackML (Packing Machine Language) state machine commonly used by PLCs in packaging

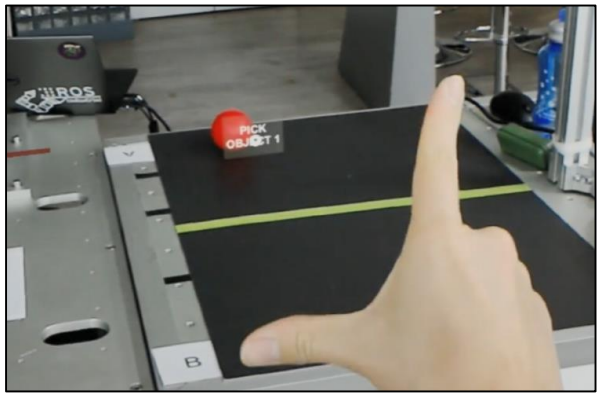
PackML FTP now available in ROS2 – Collaboration across regions and industry members
https://vimeo.com/378683073

Augmented Reality Teaching

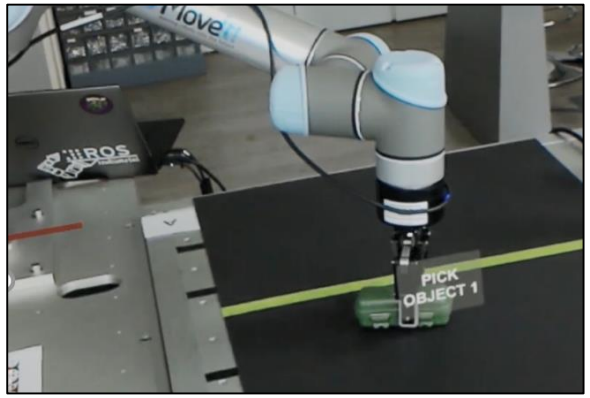
- **Problem Statement/Objectives**
  - Scalability of robotics solutions are hampered by the need of skilled engineers/technicians to program robots
  - Human robot collaboration requires improved safety visualization

- **Benefits**
  - Provides an operator with a simple user interface that can be used to program instructions for the robot directly in its deployment environment interacting with both static and dynamic objects in the robot's work cell

1) Operator utilizes an Augmented Reality headset (Microsoft Hololens) – ARTC developed an interface between ROS and Hololens/Unity

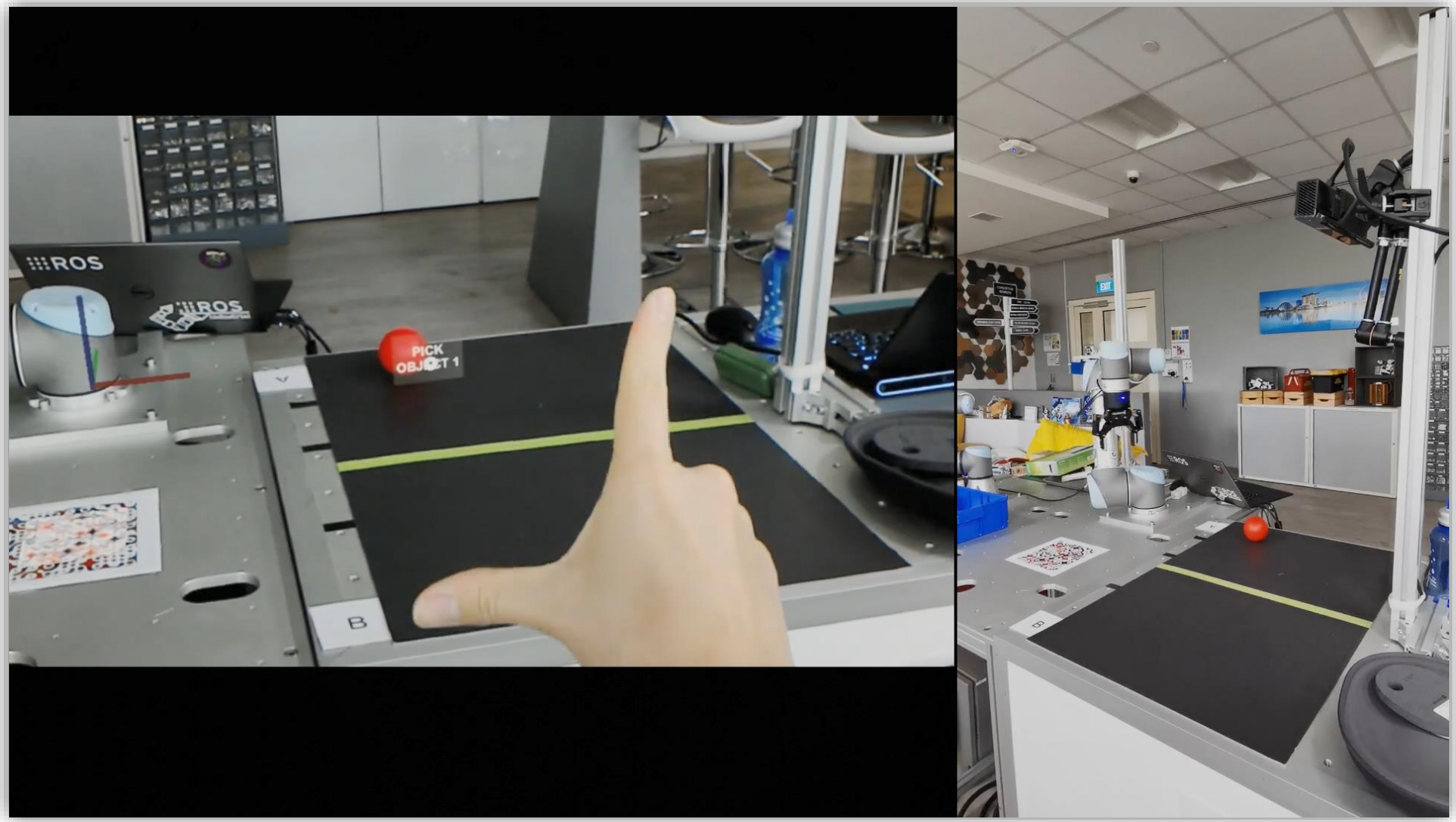


2) Through the headset UI, the operator can instruct the robot to perform tasks through simple hand gestures



3) Robot has now "learned" the task and could replicate it autonomously

Augmented Reality Teaching

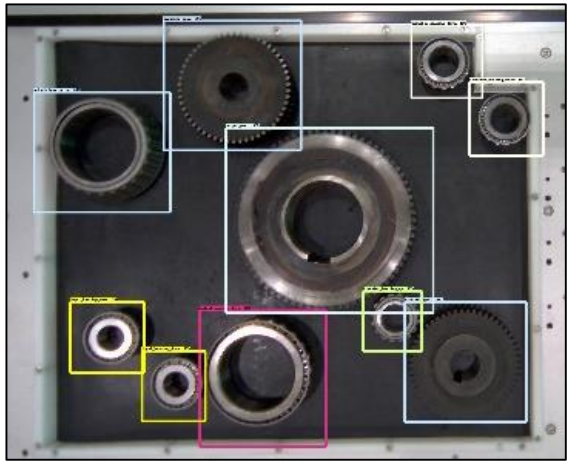


Model-based Teaching of Robotics

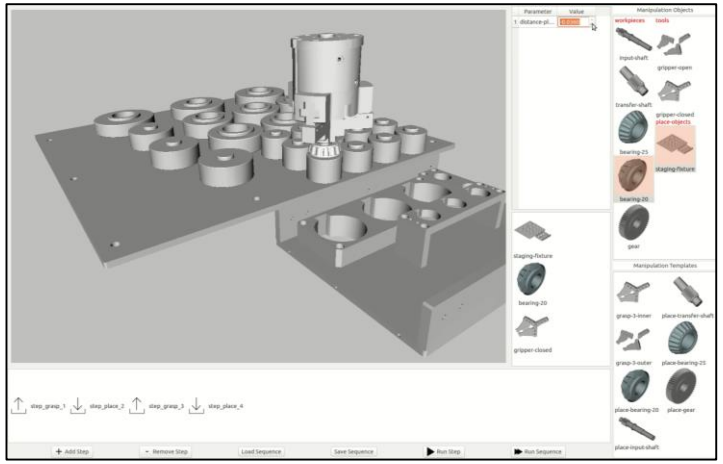
- **Problem Statement/Objectives**
  - A cobot is used in a gearbox assembly line to reduce human intervention in heavy and dangerous tasks. However, the objects to-be-picked currently have to be in precise predefined positions which is sometimes not feasible in an agile shopfloor environment
  - To automate cobot movement generation based on 2D/3D computer vision, allowing personalised order without re-programming the cobot

- **Benefits**
  - 3D computer vision based system is used to detect the gearbox parts placed anywhere on the tray. Optimal, collision-free robot motion are generated automatically based on this visual input
  - Process sequence is modeled as a state-machine that invokes the different devices and software modules

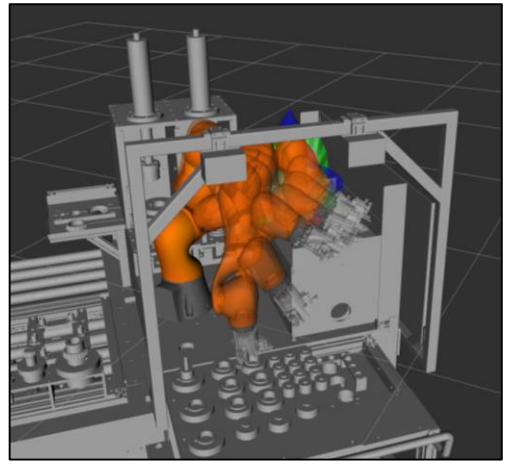
1) Cobot station for gearbox assembly



2) Detection of gearbox parts on a tray

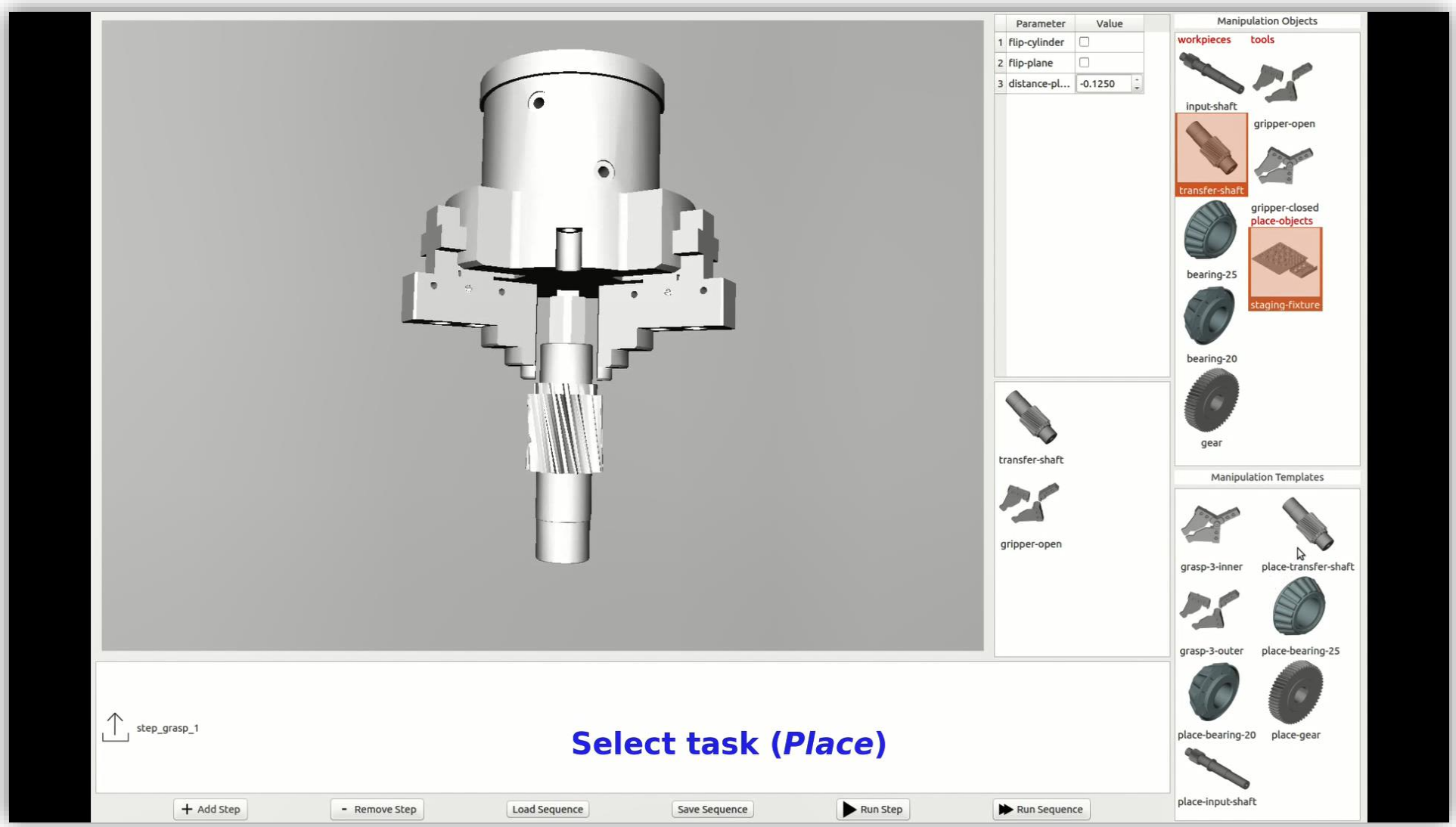


3) Modular programming GUI

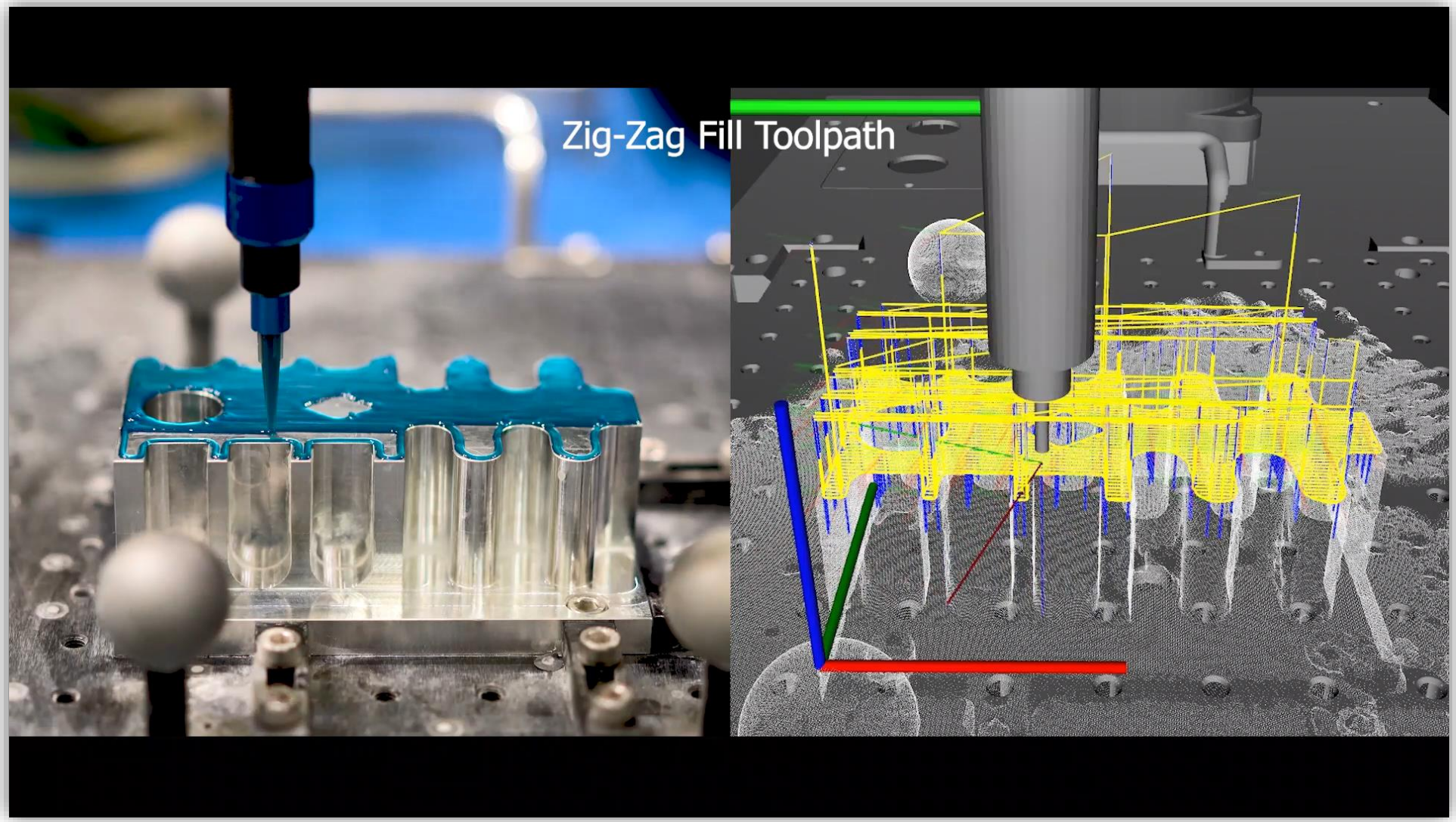


4) Collision-free motion planning

Model-based Teaching of Robotics



High Mix Dynamic Toolpath Generation – Masking Application

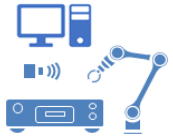


Interoperable Large Scale Deployment of Robots - Robotics Middleware Framework (RMF)

- **Challenges in Multi-fleet Deployments**

Lack of Interoperability
- Lack of communication and integration between robots, medical devices, building infrastructure and health IT systems

Infrastructure Constraints
- Need to interface with lifts and doors
- Dedicated routes and lifts for robot



Lack of Realistic Test Environment
- Challenging and expensive to test effectiveness of large scale deployment of robotic solutions

- **Robotics Middleware Framework provide**
  - **Connectivity to enterprise systems** and peripherals through open interfaces
  - **Interoperability** between mobile and fixed robots as well as edge devices
  - **Integration with building** infrastructure (lifts, doors)
  - **Task and fleet scheduling**, traffic control
  - **Simulation capabilities**
- **Developed in Singapore for Healthcare sector by:**

Centre for Healthcare Assistive & Robotics Technology (CHART)

HOPE technik

GOVTECH SINGAPORE

IHiS Because IT's in Healthcare

open robotics

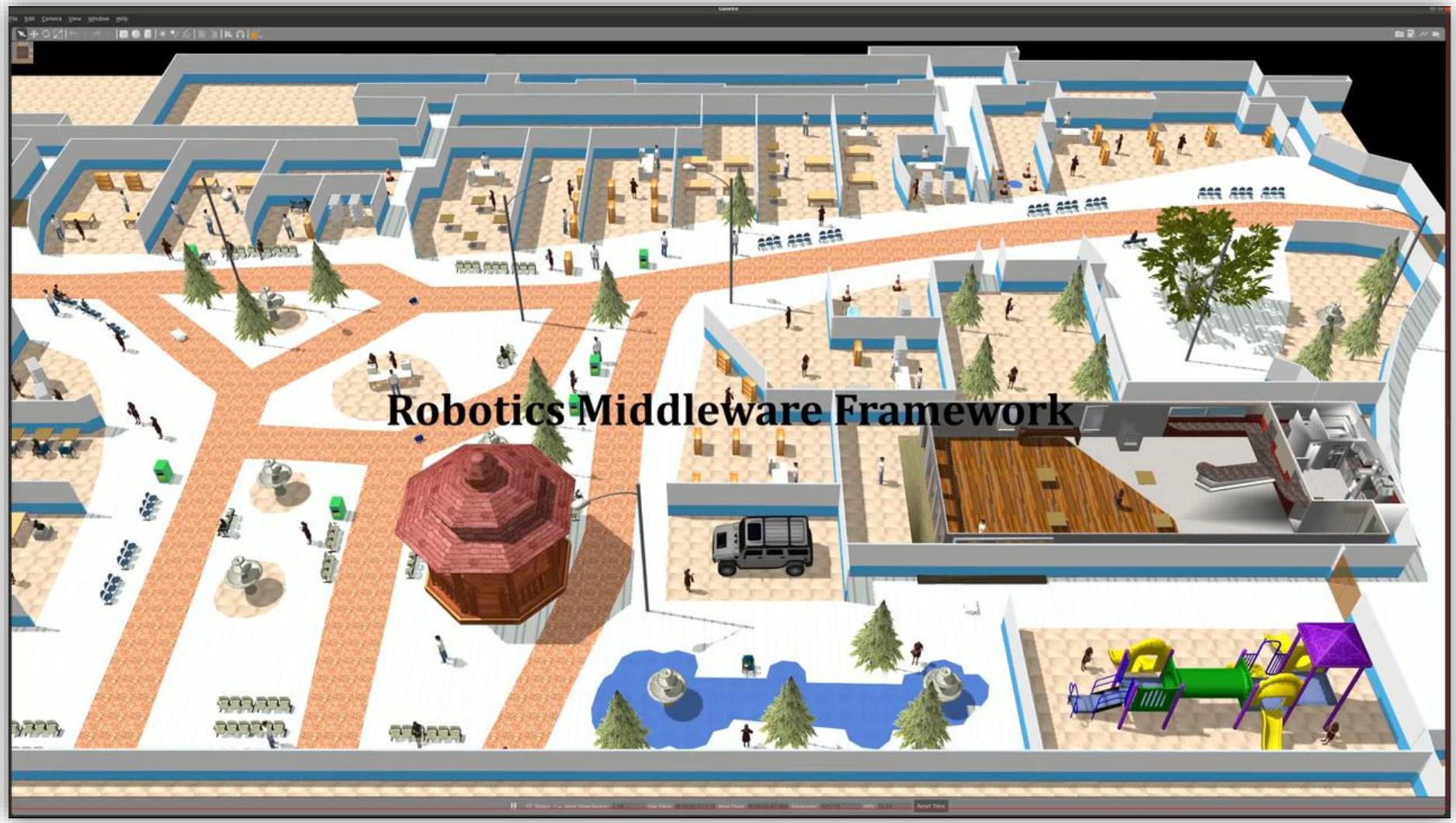
ROS industrial

RMF Beyond – Warehousing, Manufacturing, Facilities…

Collaborators:

Advanced Remanufacturing and Technology Centre
ARTC

open robotics



ROS industrial

Advanced Remanufacturing and Technology Centre
Video Link: https://vimeo.com/osrfoundation/review/405803151/c43403489d

Europe

&

Private funding

Public funding

ROSIN – EU support for ROS

Pitch to the funding agency (EC):

- "sweat equity" of OSS: those who put the work have a say
- instead of funding yet another framework, foster EU's role in ROS with public €

4-years, ~8 million EUR H2020 project (1.2017-12.2020)

- Builds upon what exists; sustainable results after its completion
- Key actions to make ROS better, business friendlier, more accessible
- (Extra goal:) cluster other EU-based publicly funded activities using ROS

This project has been funded by the European Union's Horizon2020 research and innovation programme under grant agreement No 732287

FH AACHEN UNIVERSITY OF APPLIED SCIENCES

ABB

Fraunhofer IPA

tecnalia Inspiring Business

IT UNIVERSITY OF COPENHAGEN

TU Delft

ROS industrial

ROSIN – EU support for ROS

better

Software Quality

ROS-I best practices and tools: continuous integration, unit testing, code reviews

ROSIN further improves on them with code scanning, automated test generation, model-in-the-loop testing

rosin-project.eu/software-quality-assurance

business friendlier

New components

ROSIN FTPs: 3.5 Million € to third parties for ROS-Industrial development. Develop missing components or improve existing ones.

Commercial release template (licensing, etc)

rosin-project.eu/ftps

more accessible

Education

ROSIN summer schools: Educate students

ROS-I academy: Educate professionals

Education projects: Fund your ROS education initiative

rosin-project.eu/education

ROSIN – EU support for ROS

MotionBuilder

Champion: PAL Robotics S.L., Spain

ROSin Ljubljana

Champion: Univers… Sloveni…

ROS Training Fallenbrunnen

Champion: Institut für Weiterbildung, Wissens- und Technologietransfer, Germany

ros_cont…

Champion

Saxion

Champion: Saxion University of Applied Sciences, Netherlands

MoveIt 2 – Real… Control and ROS… Migration

Champion: PickNik… Ireland

https://github.com/ros…/moveit2

ROS and FIONA -based environment manipulation for agricultural data acquisition

Champion: Canonical Robots, Spain

RCLAda, … for ROS2

Champion

https://githu…

Center for Advanced Training on Robotics and Open Source, ACT-ROS (Education Project)

Champion: Universidad Rey Juan Carlos , Spain

RobotCraft (Ed… Project)

Champion: Ingen…

Virtual Robotic Laboratory and Learning Materials for ROSin (Education Project)

Champion: Inovasyon Muhendislik Ltd. Sti., Turkey

ROSinTartu (Ed… Project)

Champion: Unive… Eston…

https://github.com/u…/robotont

ROBIN

Champion: INESC TEC, Portugal

https://github.com/ScalABLE40/robin

ROS-MDD

Champion: CEA LIST, France

Robust and reliable GPS-free localization algorithm for aerial robots applied to industrial applications

Champion: Advanced Center For Aerospace Technologies (FADA-CATEC), Spain

https://github.com/fada-catec/amcl3d

ROS End-Effector

Champion: Istituto Italiano di Tecnologia, Italy

https://github.com/ADVRHumanoids/ROSEndEffector

ROS2 Integration Service

Champion: eProsima - Proyectos y Sistemas de Mantenimiento SL, Spain

https://github.com/eProsima/ROS2-Integration-Service

ROsBOBO

Champion: MANUFACTURA DE INGENIOS TECNOLOGICOS SL, Spain

https://github.com/mintforpeople/robobo-gazebo-simulator

Industrialization in EU: piTasc + Drag & Bot

- Easy robot programming for industrial robots
  - Everyone can program a robot
  - Simple graphical user interface
  - Control any industrial robot
  - Advanced force controlled assembly processes
- Start-up company **Drag & Bot**
- Systems in deployed in industrial operation

Automatic Wiring of Control Cabinets

RITTAL Fraunhofer IPA

Fraunhofer IPA

pitasc: force controlled assembly

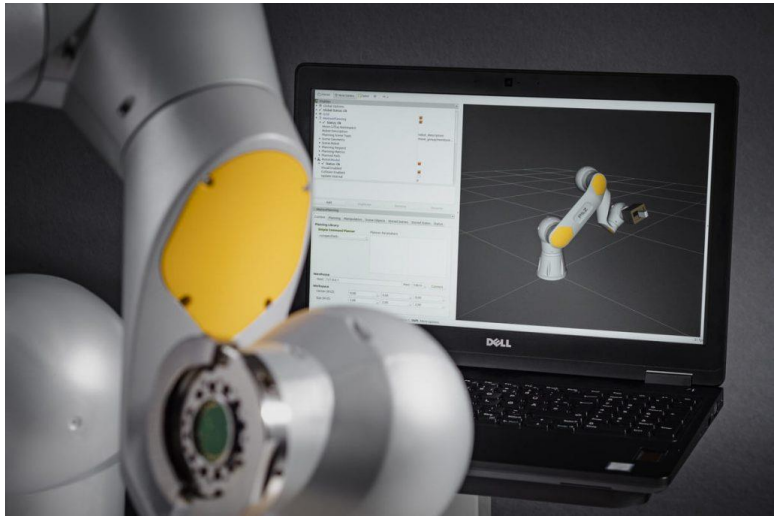
robust industrial assembly of plastic components

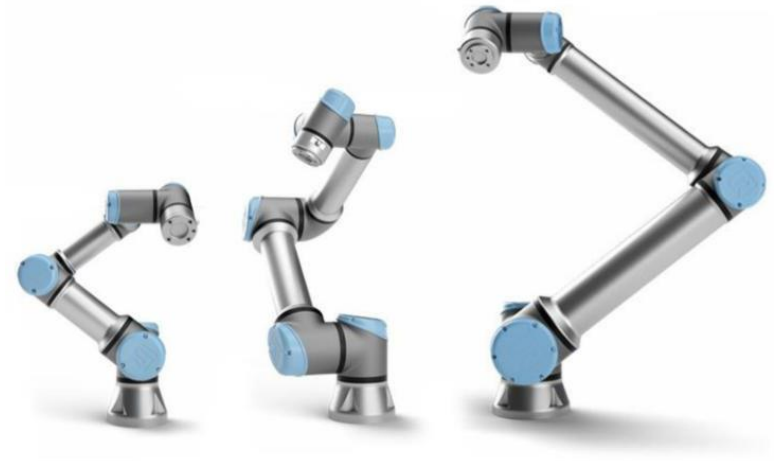
ROS industrial

Industrialization in EU: UR & Pilz & ABB

Robot OEMs start adopting ROS and see the value

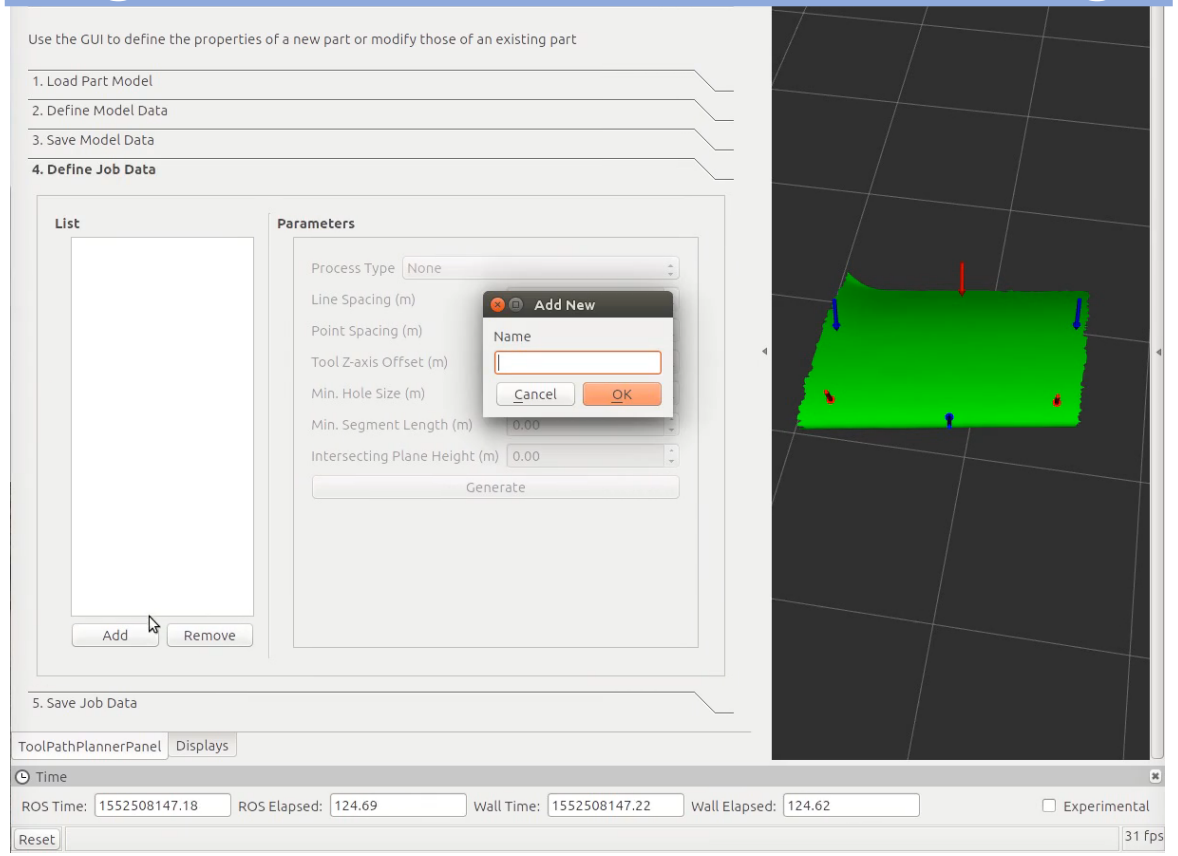
- **Pilz**:
  - Drivers for PRBT robot
  - Drivers for Sensors
  - Further packages i.e. industrial trajectory generation
  - Safety certification of ROS based control under way
- **UR**:
  - Drivers for UR robots
- **ABB:**
  - Support of the community effort & part of ROSIN project



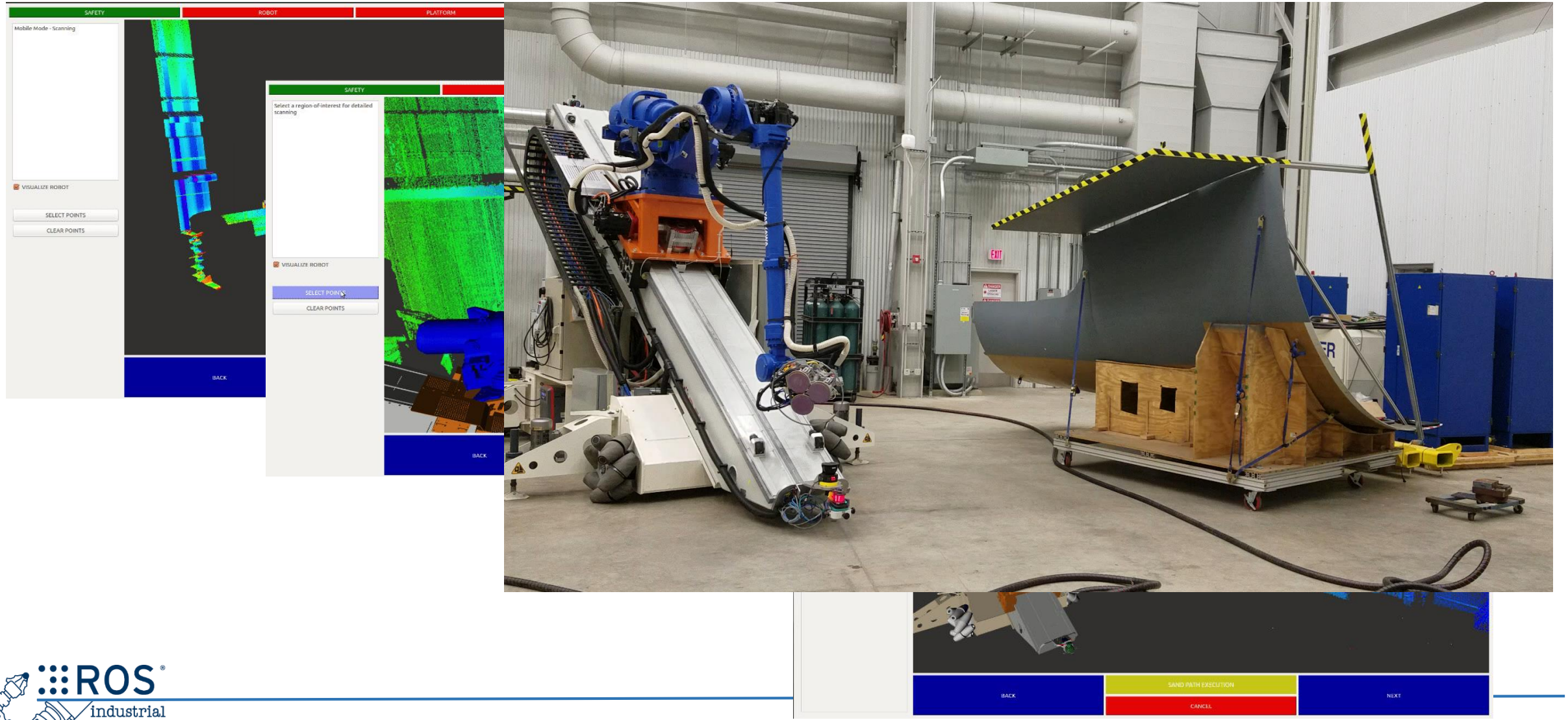


ROS-Industrial Integrator Deployment

Intuitive Process Application – Registration, Multi-Process Planning

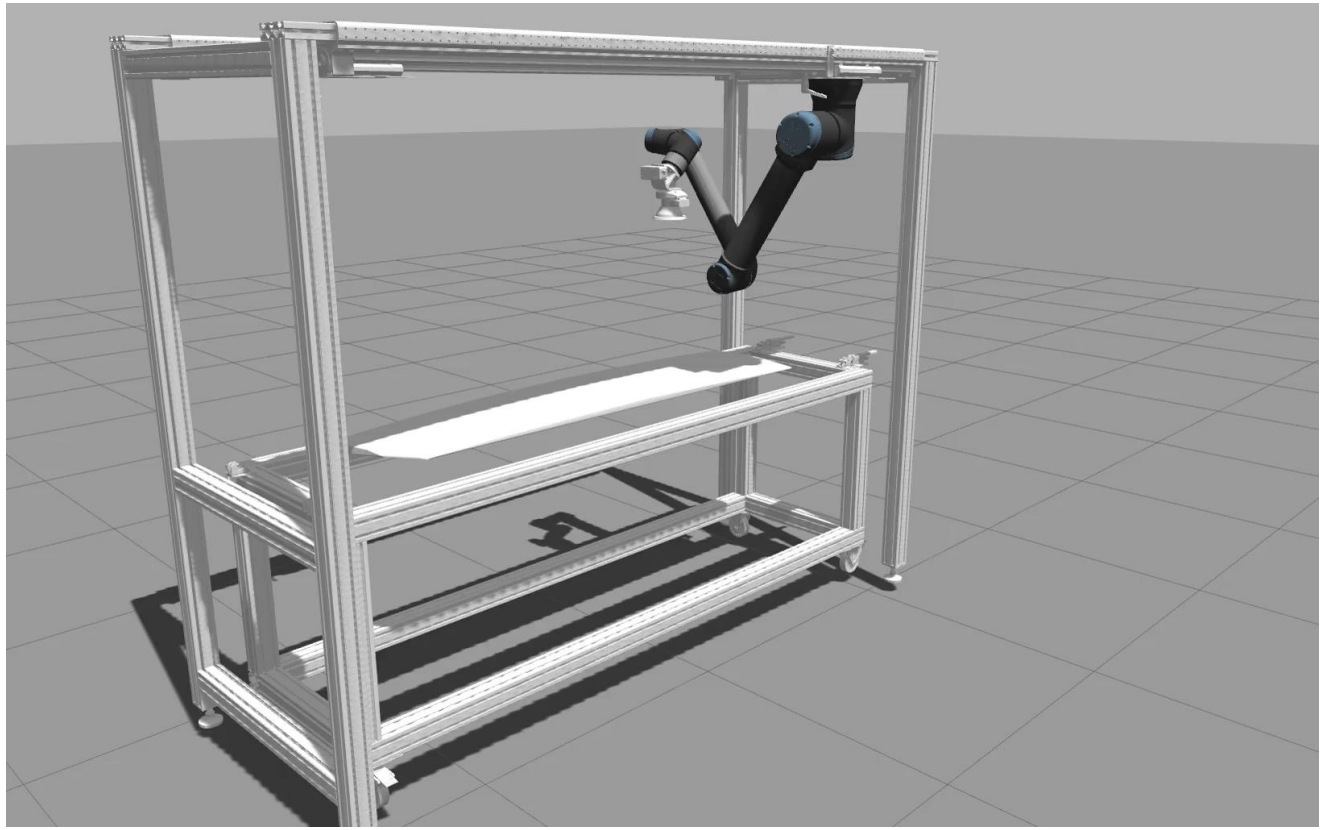


A5 – Agility in Aerospace Applications



ROS2 System Implementation

- In collaboration with Spirit AeroSystems and Wichita State University with funding provided via the ARM Institute
- Development of a Human-in-the-Loop collaborative composite sanding first article solution for aerospace components
- Full ROS2, with off-line path planning leveraging automatic path planning
- Trajectory optimization for motion execution
- Visual feedback on reach availability
- Velocity controlled trajectory execution
- Dynamic path planning based on human markings on the part



https://arminstitute.org/projects/collaborative-robotic-sanding-of-aircraft-panels/
https://github.com/swri-robotics/collaborative-robotic-sanding

Resources

ROS-Industrial

Home:	rosindustrial.org
Documentation:	wiki.ros.org/industrial
Code:	https://github.com/ros-industrial; https://github.com/ros-industrial-consortium
Training:	http://ros-industrial.github.io/industrial_training/
Upcoming Events:	https://rosindustrial.org/events-summary/
ROSin:	http://rosin-project.eu/

SwRI Robotics:	https://www.swri.org/industries/industrial-robotics-automation
ARTC:	https://www.a-star.edu.sg/artc
Fraunhofer IPA:	https://www.ipa.fraunhofer.de/en.html