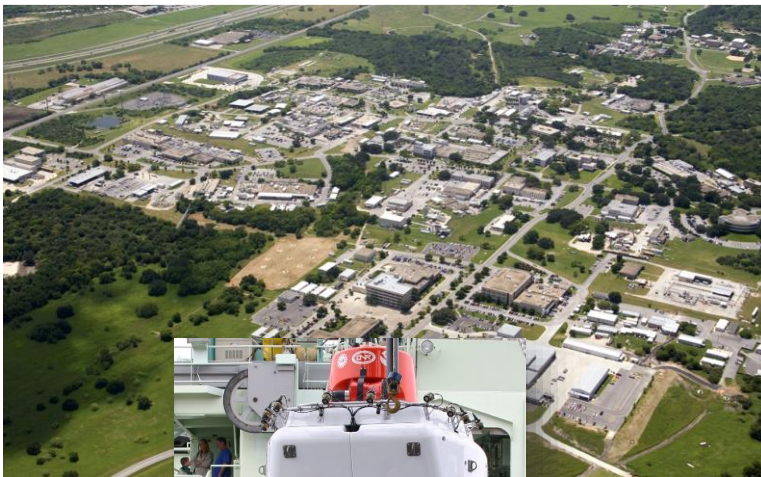


# Lowering the Barrier for Industry Personnel to Leverage Open Source

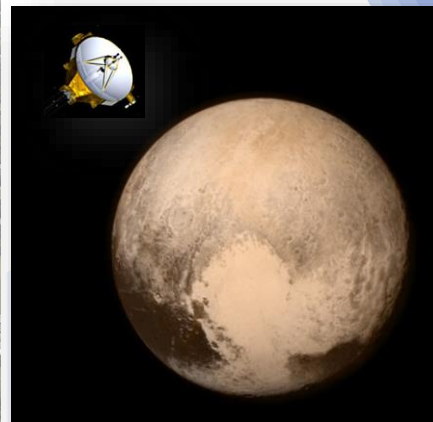
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Matt Robinson, RIC-Americas Program Manager  
Southwest Research Institute

# SwRI: Deep Sea to Deep Space



Alvin submersible



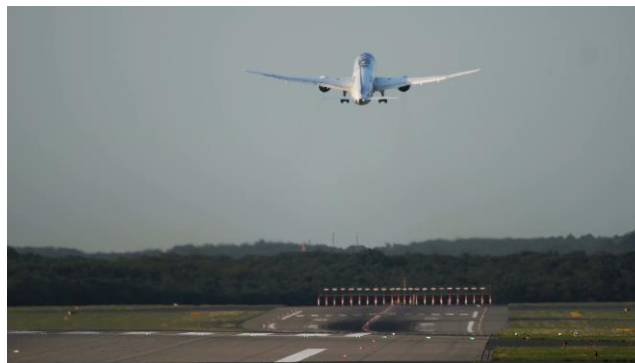
New Horizons,  
Pluto

## Southwest Research Institute Characteristics

- Est. 1947
- San Antonio, Texas, USA
- Independent, Not for profit
- Applied RDT&E Services
- Natural Science and Eng.
- FY 2019 Revenue: \$674M

# SwRI Advanced Systems Development

- Sharing information between multiple traditional industrial systems and tools
- Managing dynamic manufacturing environments
- Manage noise that is inherent to factories
- Reduce reliance on hard to find skill sets and accelerate operations where high mix/low lot is required
- Custom Mobile Robots
  - Bring the process to the part
  - Share information between systems
  - Improved agility
  - Multi-Process
  - Efficiently manage high mix of product



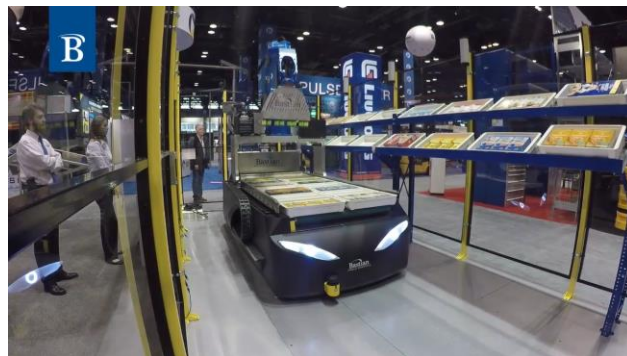
Reference: [robotics.swri.org](http://robotics.swri.org)

# Getting Systems into Production

- Enabling foundation
- The right partners
- Plan – concept through sustainment



Source: <https://github.com/swri-robotics/euler>



Basition Solutions, ProMat 2017

# Strategy for Development

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

Messages,  
Topics

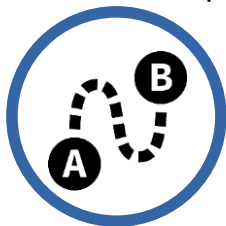
ROS 1 / ROS 2 / Middleware Layer

Independent of ROS

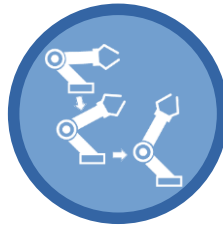
Build ROS1 or  
ROS2, these are  
independent



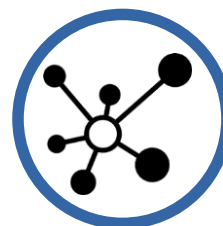
Collision  
Detection



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

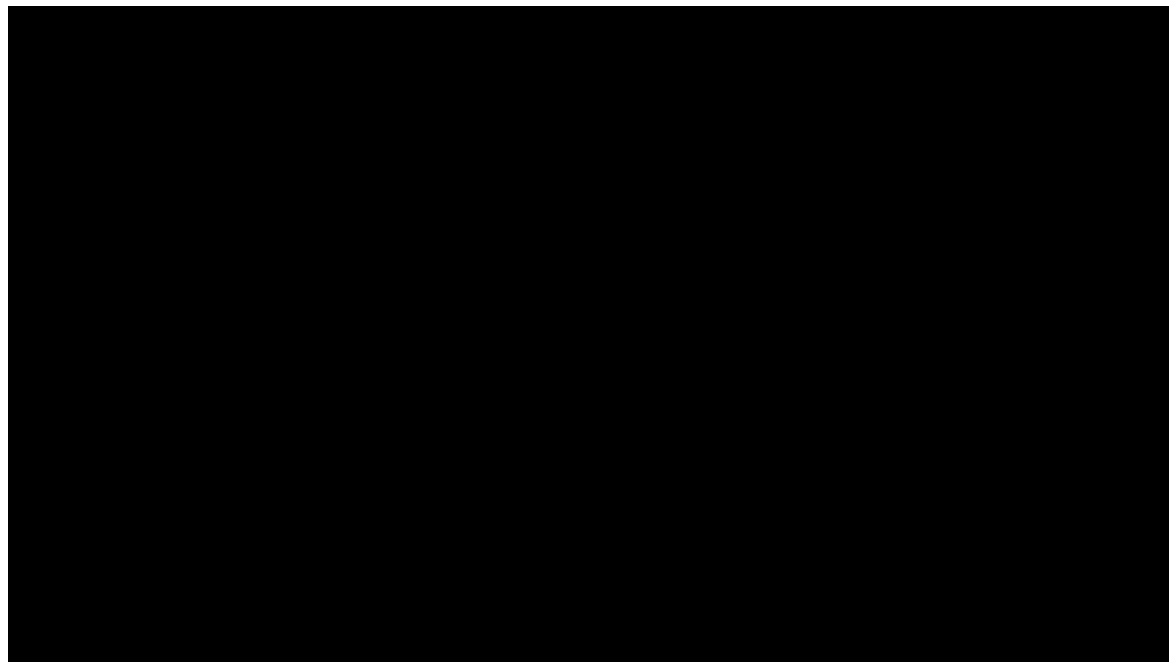
# Tech Vision Supported by Industry

- **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**



# ROS-I Americas Applications

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# Ease of Use & Human Robot Interaction

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- Accelerate adoption through capability that works the way people work
- Programming robots in a way that is intuitive
- Reduce barriers to adoption to foster pull
- Provide tools to enable manufacturing engineers to be self sufficient relative to adding parts and operations to systems



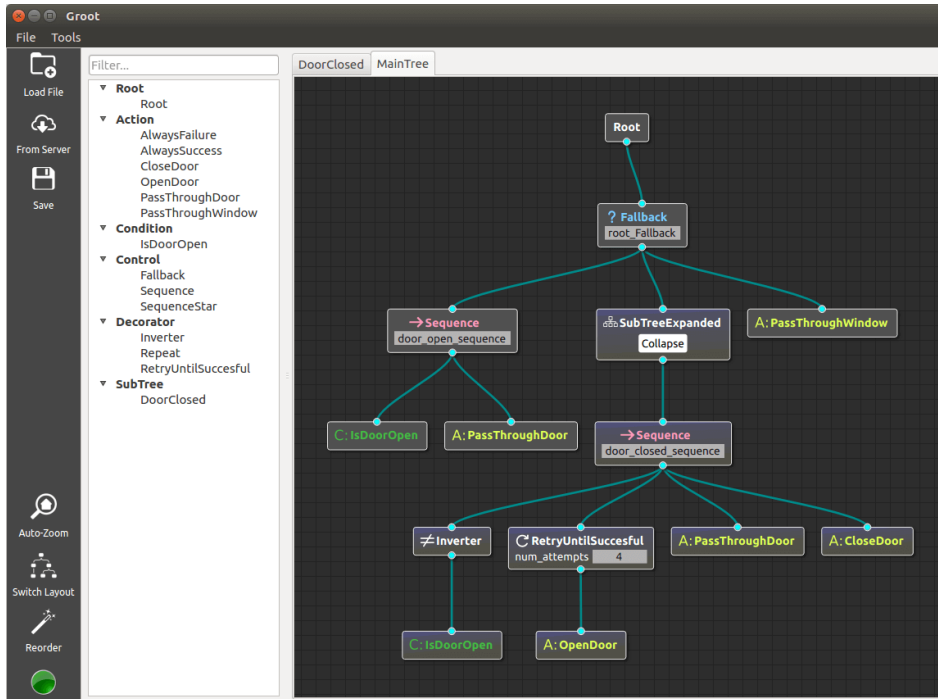
# Ease of Use Tools

- Offline Toolpath Planner
  - Updated capabilities
  - Refactored raster planners
- Visual Programming
  - Recently open-sourced
- ROS Workbench
  - Grab and Go
  - Target Mfg Engineers
  - Enable Application Set Up
  - Adding new process/parts



[https://github.com/swri-robotics/visual\\_programming](https://github.com/swri-robotics/visual_programming)

# ROS Workbench



- Allow non-software developers create complex system leveraging ROS
- Lower the barrier to entry for small and large business new to automation.
- Increase Industry Adoption and reduce bugs
- Is it possible to get these advanced capabilities into platform that is more model driven, not CS SW dev ops?

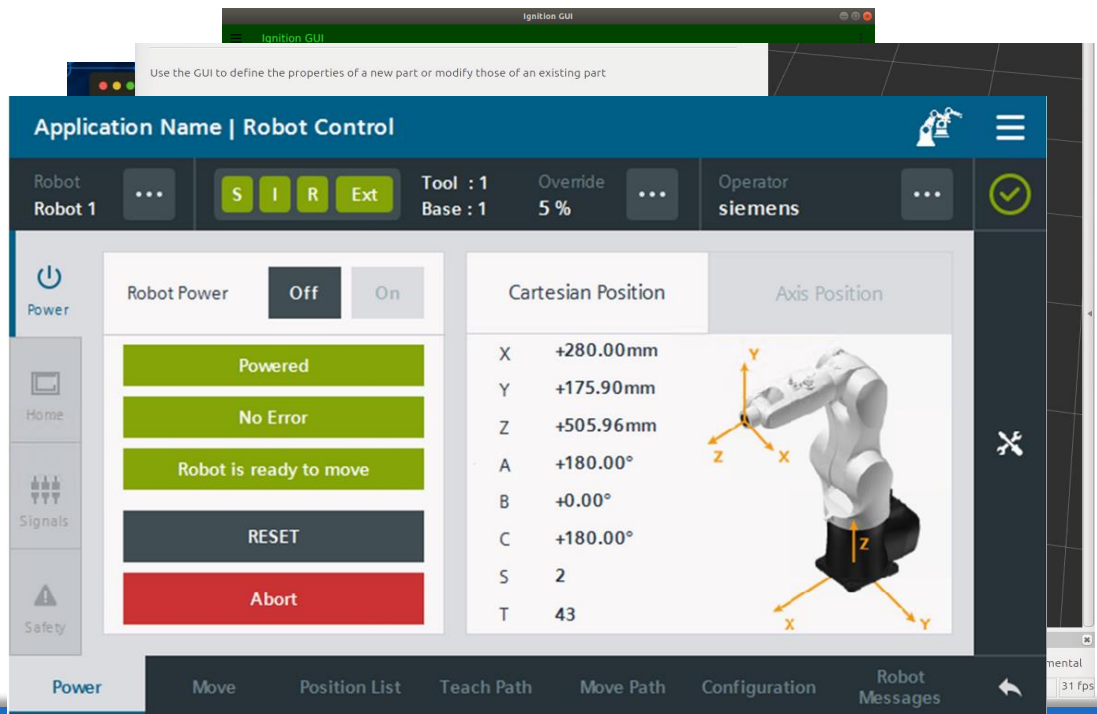
# Model Driven Programming

**Game Programming**

**Unreal 4 vs Unity 5**

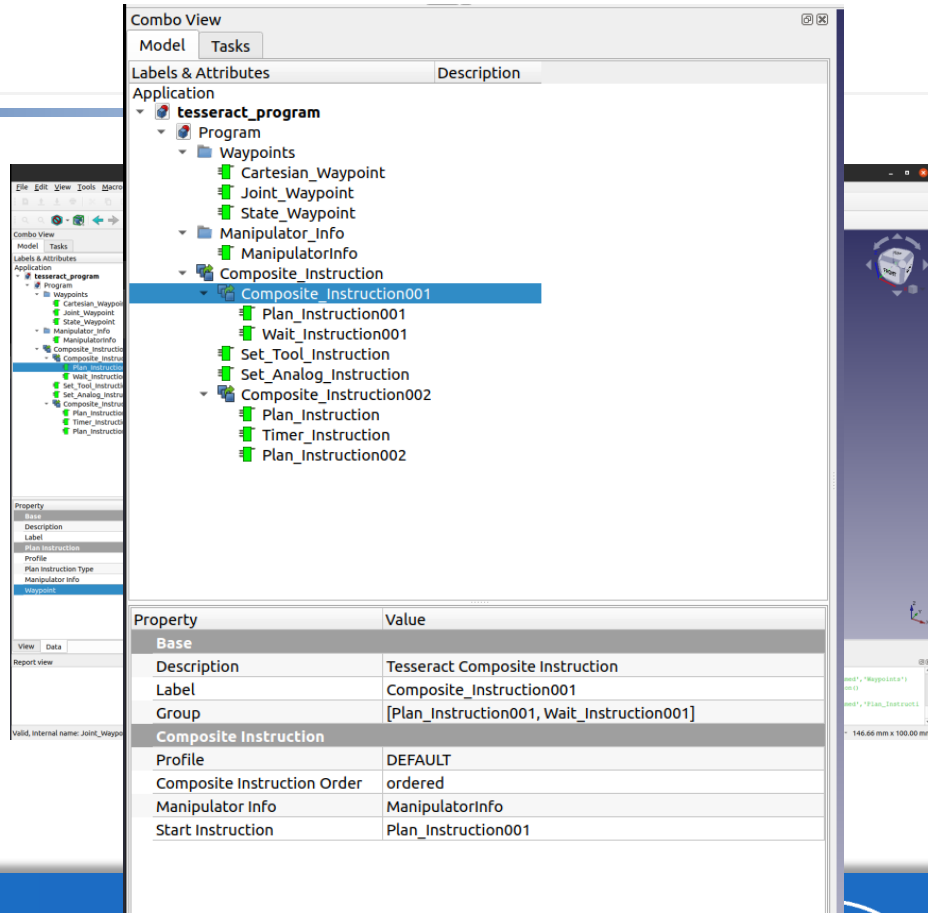
# Simple Editors

- Numerous simple end-user editing tools
  - Environment Editor
  - Kinematics Editor
  - Planning Pipeline Editor
  - Planning Profile Editor
  - Command Language Editor
  - Tool Path Editor
  - Execution Editor
  - Runtime HMI



# Early Work

- Evaluating development environment
- Working with FreeCAD
- Creating user screens
- Integration with ROS toolsets



The screenshot displays the FreeCAD software interface. The main window is titled 'Combo View' and shows a tree view of the 'tesseract\_program' application. The tree structure is as follows:

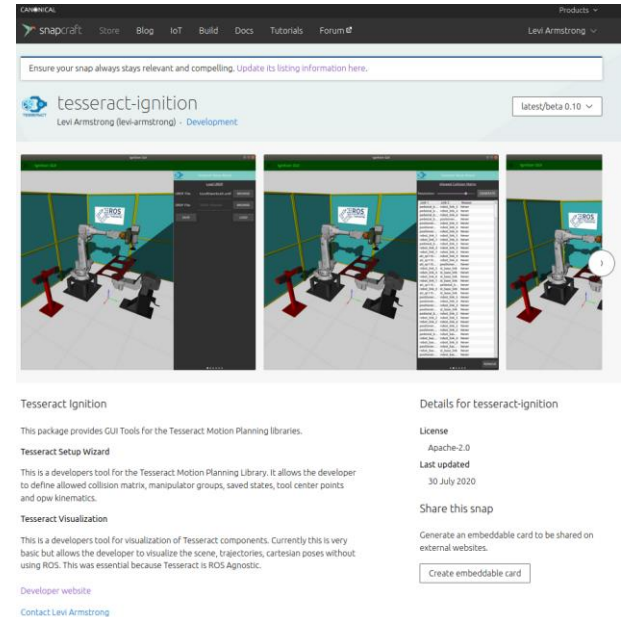
- tesseract\_program
  - Program
    - Waypoints
      - Cartesian\_Waypoint
      - Joint\_Waypoint
      - State\_Waypoint
    - Manipulator\_Info
      - ManipulatorInfo
    - Composite\_Instruction
      - Composite\_Instruction001
        - Plan\_Instruction001
        - Wait\_Instruction001
        - Set\_Tool\_Instruction
        - Set\_Analog\_Instruction
        - Composite\_Instruction002
          - Plan\_Instruction
          - Timer\_Instruction
          - Plan\_Instruction002

The Property panel at the bottom shows the following data:

Property	Value
<b>Base</b>	
Description	Tesseract Composite Instruction
Label	Composite_Instruction001
Group	[Plan_Instruction001, Wait_Instruction001]
<b>Composite Instruction</b>	
Profile	DEFAULT
Composite Instruction Order	ordered
Manipulator Info	ManipulatorInfo
Start Instruction	Plan_Instruction001

# Deployment

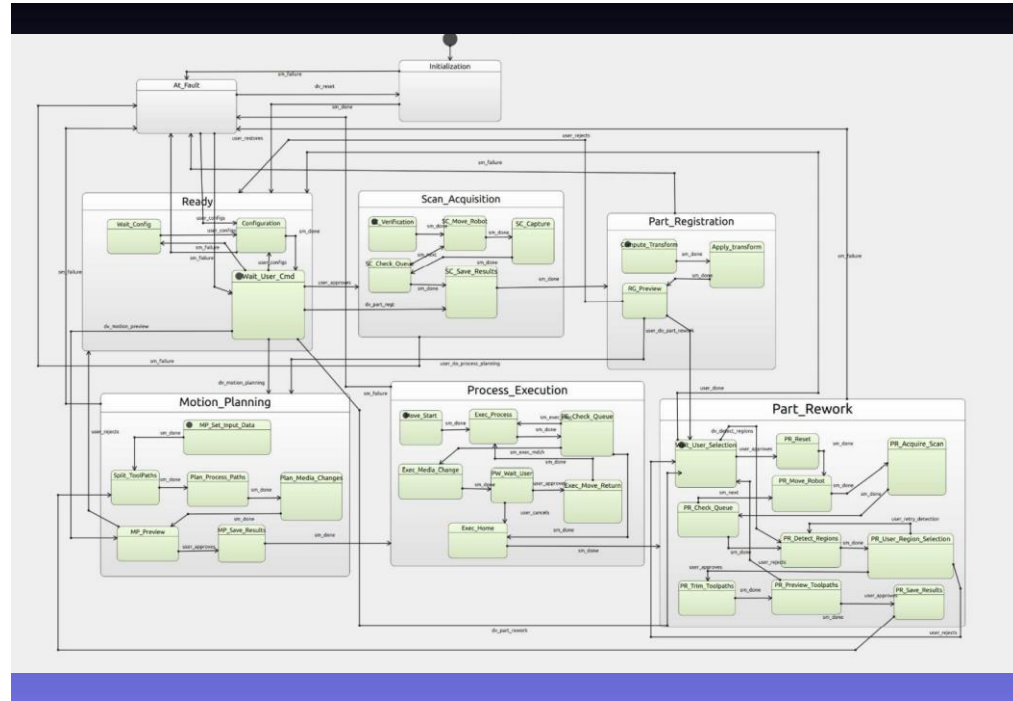
- The Workbench deployed using App Stores/Cloud Solutions:
  - Branding will be important (logo and trademark)
  - Ubuntu SnapStore, Windows MSIX App, Cloud-based deployment
- Focused Technical Project as a Trial Deployment Use Case
  - Robotic Blending – Milestone 5



The screenshot shows the Snapcraft website for the 'tesseract-ignition' snap. The page header includes navigation links for Snapcraft, Store, Blog, IoT, Build, Docs, Tutorials, and Forum. The user profile for 'Levi Armstrong' is visible in the top right. The main content area features the snap name 'tesseract-ignition' and the developer 'Levi Armstrong (levi-armstrong) - Development'. Below this, there are three preview images of the snap's interface. The 'Details for tesseract-ignition' section provides information about the package, including its license (Apache-2.0) and the last update date (30 July 2020). A 'Create embeddable card' button is also present.

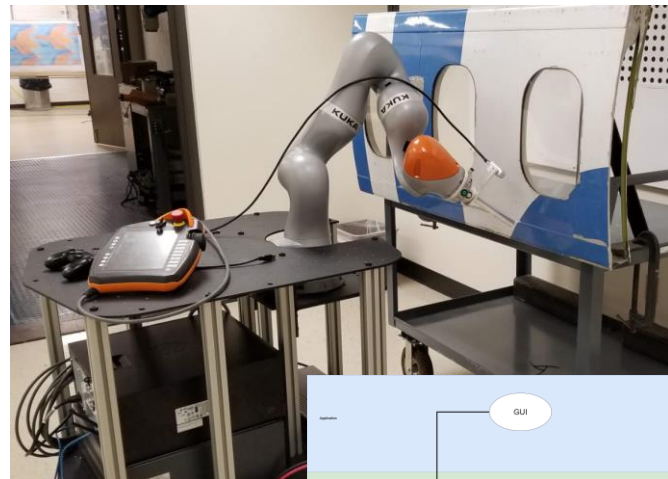
# Additional Open Source Tools

- ROS\_SCXML
- YAK/Open3D
- Descartes Light
- Noether
- Tesseract
  - Geometry
  - Motion Planning
  - Process Planning

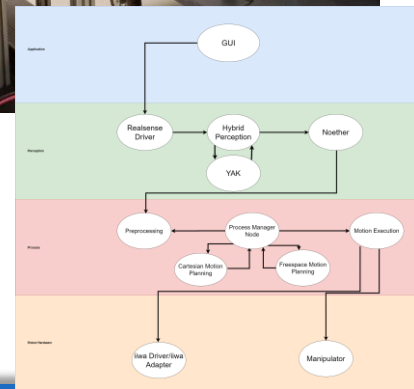


# Deploying ROS2 into Production

- Leverage stated benefits of ROS2 to build production system
  - Launched initial effort in early 2019; Total of 6 units commissioned
- At the time little ROS2 interface packages
  - Robots & sensor drivers
- Leveraged bridge and ported key components that were required
  - Leveraged the middleware agnostic strategy
  - Ported motion planning pipeline Tesseract to ROS2 (pure CMake)
- Lessons learned in creating system-specific ROS2 packages
- DDS experience gained/optimization
- Put the first mobile manipulation ROS2 system into production



Created demo system based on first ROS2 production system



Reference: [Lessons from a ROS2 Collaborative Industrial Scan-N-Plan Application](#), [Building Out a ROS2 Mobile Scan-N-Plan Demonstration](#)



# Further Open-Source Advancements

- Collaboration Initiatives

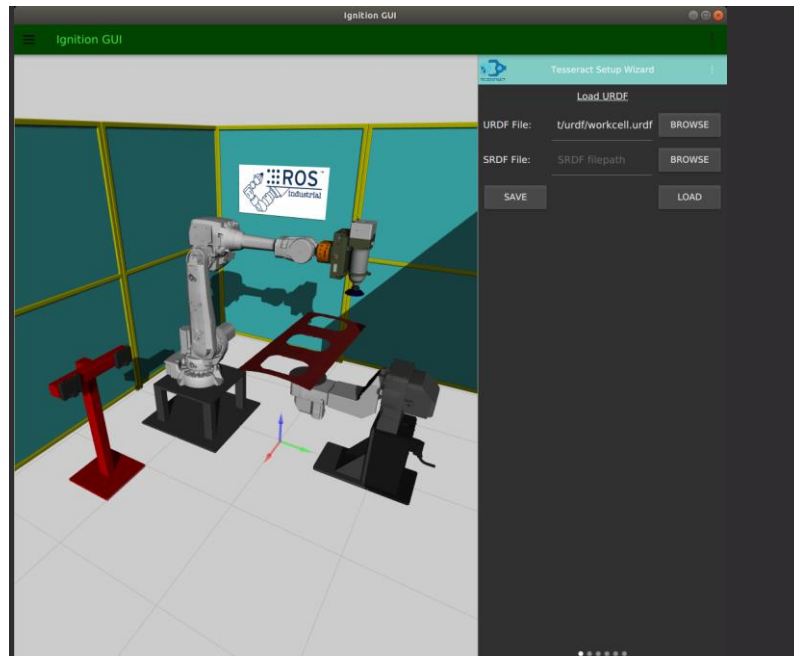
- ROS2 UR Driver - PickNik, Universal Robots, FZI Research, TU Delft, and Spirit AeroSystems
- Simulink & ros\_control – MathWorks & TU Delft
- Robot Raconteur – ARM Institute, RPI, Wason Technologies

- Real-time planning

- Responds to environment updates
- Dynamic optimization
- Improved performance via on-hardware testing

- Descartes Light

- Boost graph-based solving
- Improved performance
- Migrating to ROS-I organization



<https://rosindustrial.org/events/2020/8/9/real-time-robotic-planning-for-industrial-robotics-ignition>

# Take Aways

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- ROS-Industrial program area has been running as an open-source project for nearly 10 years
- It has been a key initiative to change how industrial automation is approached and solutions delivered
- Looked at across industry as the place to start if using open source, ROS specifically, in an industrial application
- Playing a key role in both the adoption and acceptance of ROS 2 for industrial use cases
- Ease of use enables adoption, but requires shared solution approach and education of end-users and industry stakeholders

# Resources for the Community

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- ROS-Industrial
  - Home: [rosindustrial.org](http://rosindustrial.org)
  - Documentation: [wiki.ros.org/industrial](http://wiki.ros.org/industrial)
  - Code: <https://github.com/ros-industrial>;  
<https://github.com/ros-industrial-consortium>
  - Training: [http://ros-industrial.github.io/industrial\\_training/](http://ros-industrial.github.io/industrial_training/)
  - ROSin: <http://rosin-project.eu/>
- Upcoming Events (<https://rosindustrial.org/events-summary/>)

# Thank You

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