Title: Automation and Robotics at LANL

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Automation and Robotics at LANL

Bryan Steinfeld – Los Alamos National Laboratory

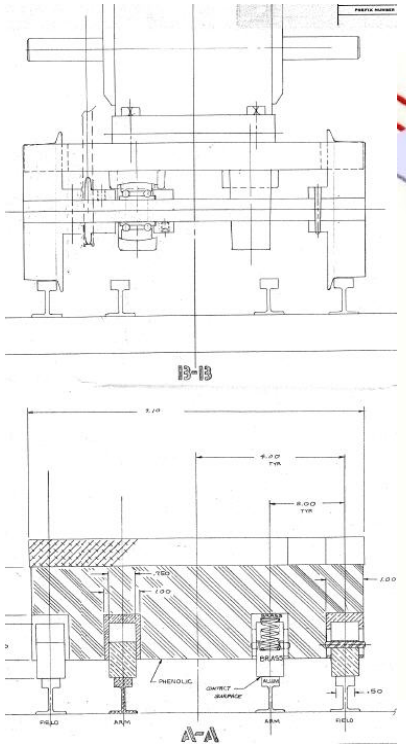
April 15, 2021

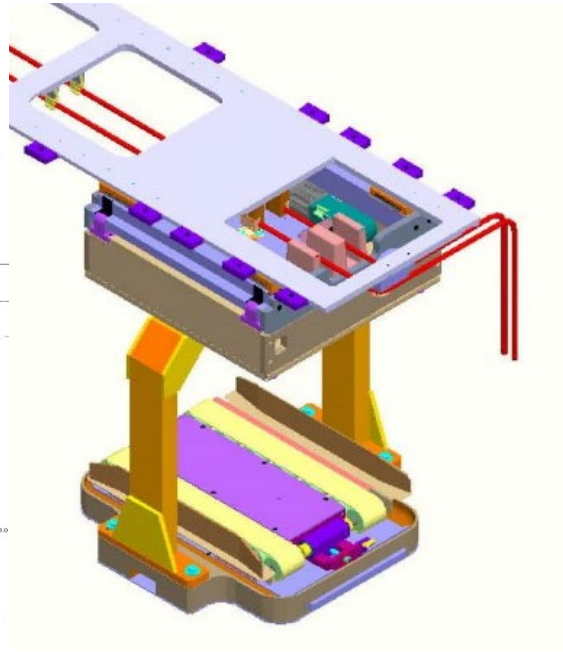
Automation and Robotics Applications at LANL

- Material Handling witih Gloveboxes
  - Hazardous materials with limited human access
  - Material Transport systems/Manipulators
  - Automated and teleoperated systems
- Machine Tending
  - Automating processes to improve accuracy and throughput
  - Support for enhanced production goals and timelines
- Beamline Positioning
  - Custom parallel system for positioning experiments within LANL accelerators

Prior LANL Robotics Work – Glovebox Material Transport Systems

- Extensive experience in this area
- Design ideas have evolved over time
- Try to keep most complexity outside of the glovebox environment
- Have worked on systems in extremely high radiation environments

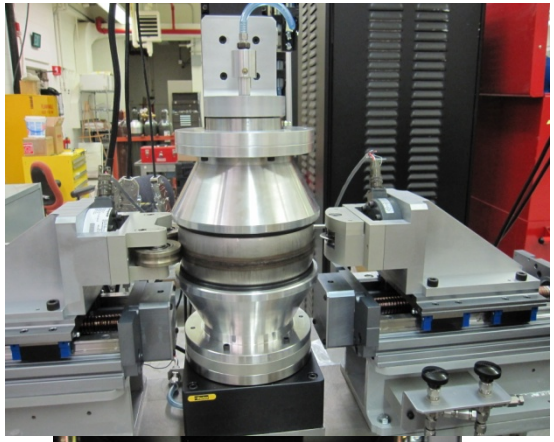




Hot cell train and SSFL systems are shown. Other systems include ARIES, ER, LAMPS, etc.

Prior Robotics Work – ARIES Pit Cutter

- Linear slides, motors, rotary table on common base weldment.
- Control system based on the Aerotech Ndrive HPE20 Digital Amplifier and A3200 software.
- Four axes (3 linear and 1 rotary); each axis is controlled by one Ndrive.
- Drives and the computer linked using a high speed FireWire network. The FireWire network facilitates coordinated motion using multiple axes.
- The Aerotech A3200 software provides an interface for manual operation of axes as well as automated programming using standard CNC programming languages

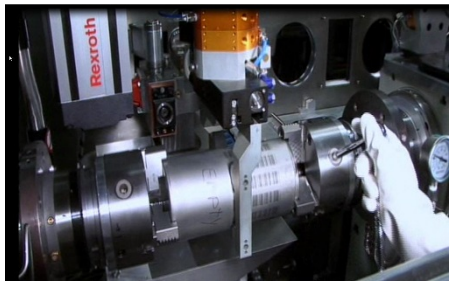


Prior Robotics Work Manipulators and Mobile Platforms

- Robotic Lathe – A precision CNC lathe integrated with a custom 5 axis gantry robot
- CVD Robot – Assist in cleaning out Pu-contaminated spherical containment vessels
- Radiography – Six axis sample positioning, improved throughput
- Pu Manufacturing – Robotic pit assembly
- RoboRCT – Routine contamination monitoring / vault inspection
- Component disassembly – Material reduction

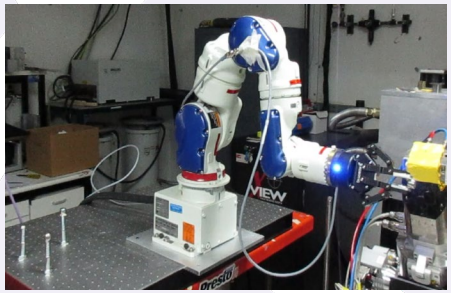
RoboRCT

Material Reduction

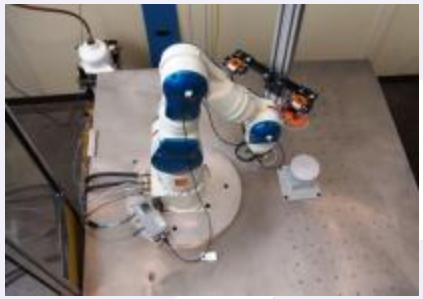


Robotic Lathe

CVD



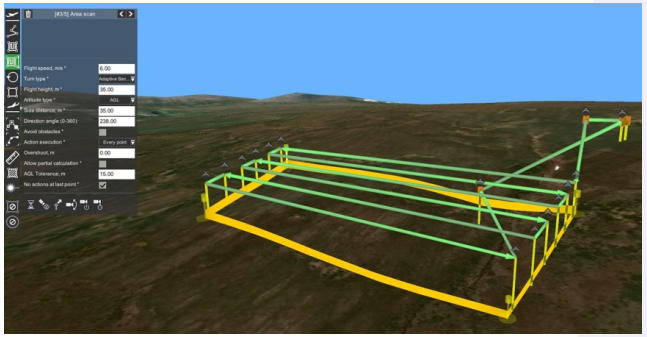
Radiography



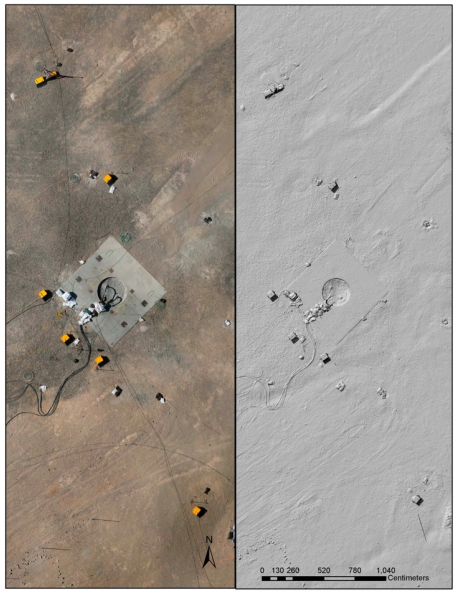
Robotic Assembly

Unmanned Aerial Vehicles – NA-22 Source Physics
PI: Emily Schultz-Fellenz

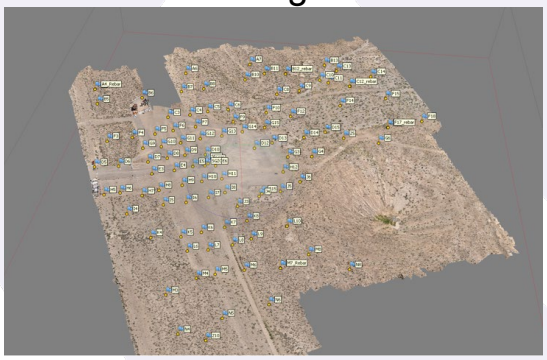
Unmanned aerial vehicle + sensors



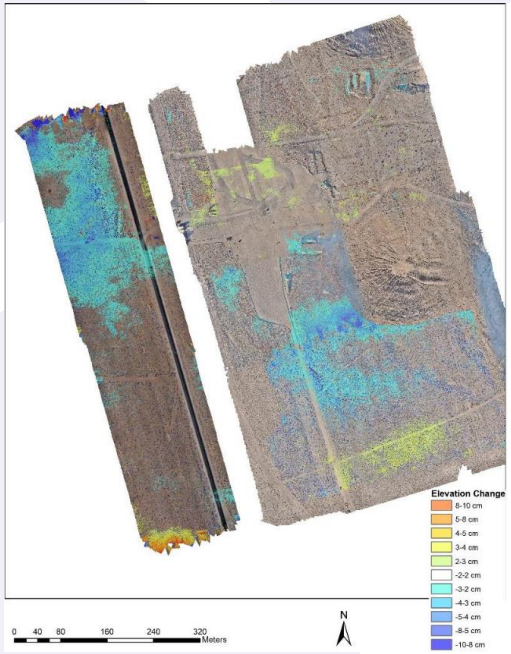
Semi-autonomous mission planning



Orthoimage (L) and DEM (R) of surface ground zero



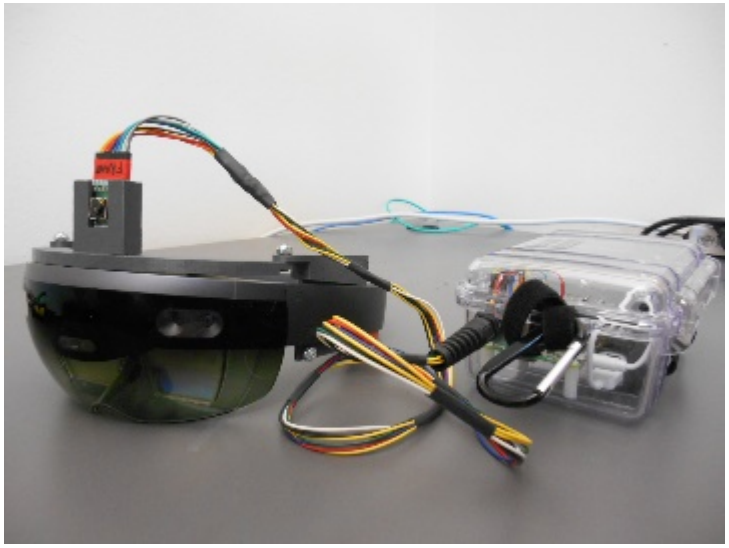
Data alignment with surveyed control

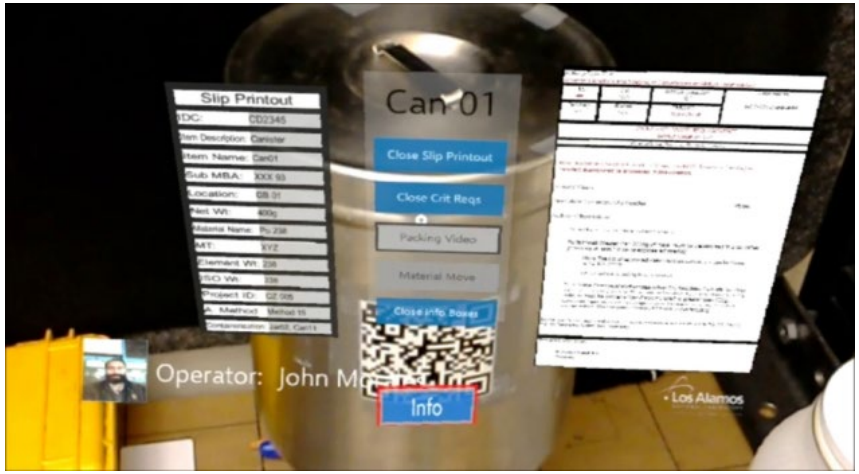


Robotic operations and analyses can detect surface changes at cm scales from an underground conventional explosion in alluvium

Augmented Reality for LANL Mission Applications
PI: David Mascareñas

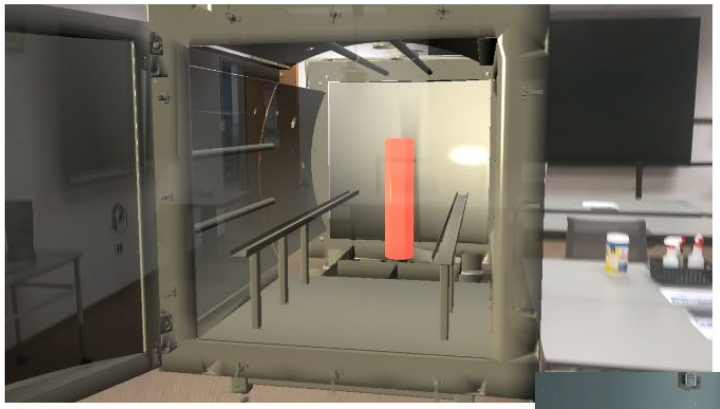
- Nuclear Detector Alignment
- Infrastructure Inspection
- Robotic Control
- Hologram Interaction



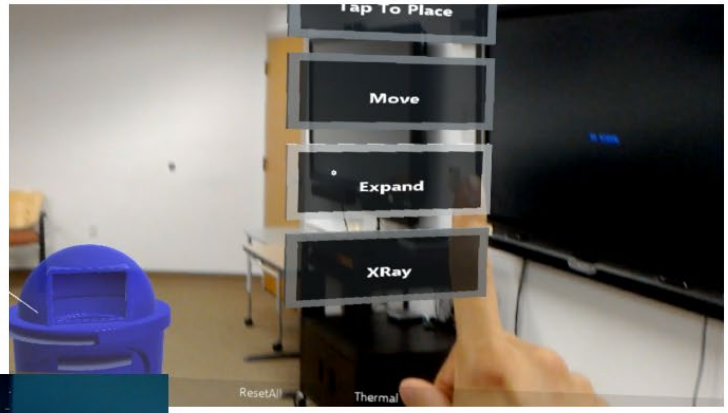


Augmented Reality – Hologram Interaction

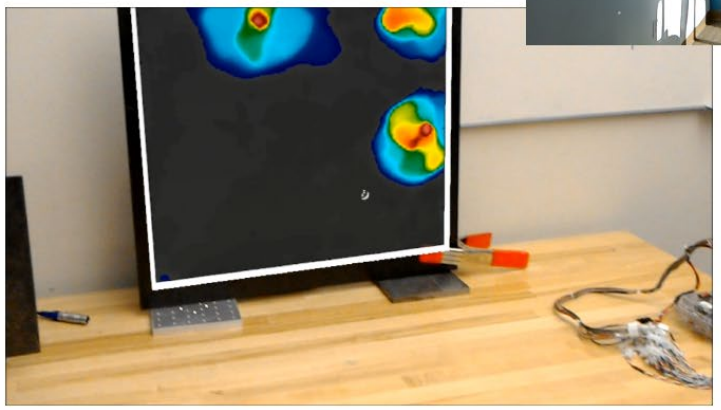
Microreactor Program, MAGNET Visualization



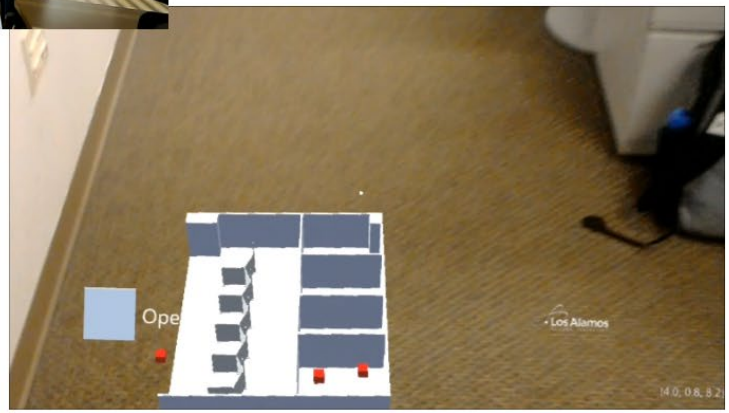
IED Training Simulation



Data Visualization



Indoor Localization

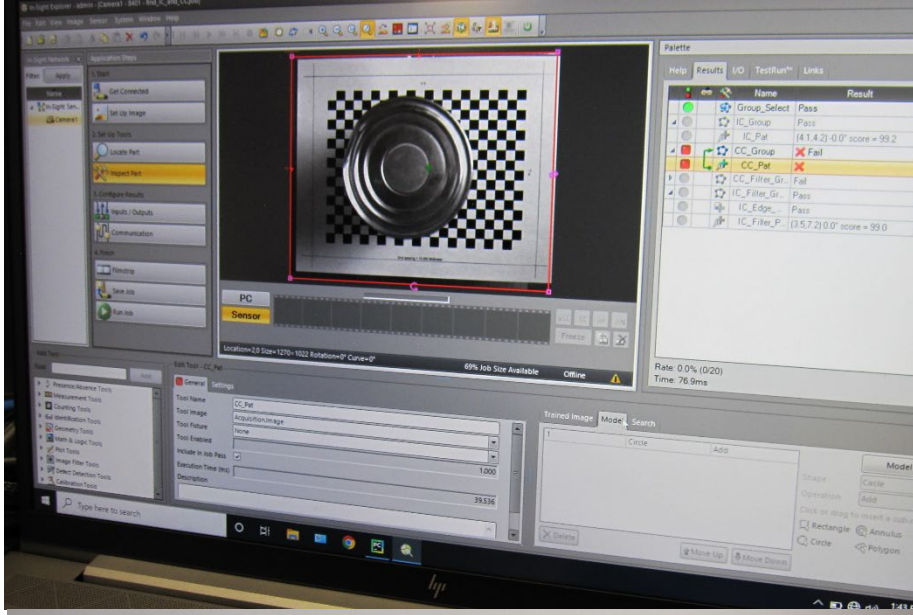


Workcells – RIPS/Robotic Packaging

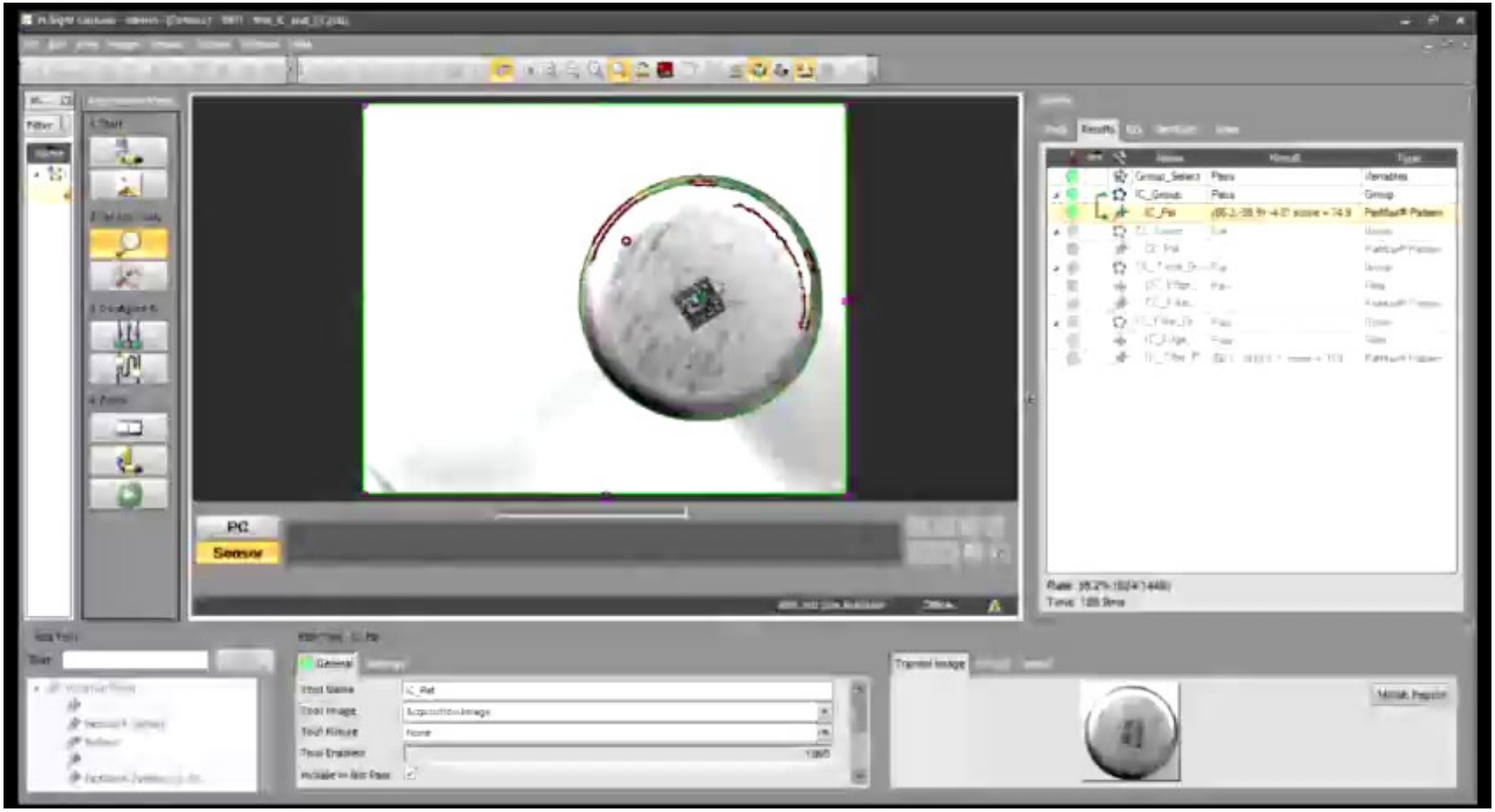
- Robot-centered workcell automating convenience can repackaging and decontamination
  - Upgrade of prior Fanuc LRMate 100iD system developed in partnership with SNL
  - Yaskawa Motoman YRC1000Micro w/ OnRobot RG6 two-finger Gripper
  - Integrated vision system for can identification
- Multiple processing station interfaces
  - Loading from glovebox transport system
  - Welding system
  - Custom Electrodecontamination system

RIPS Vision

- Fixed camera mounted within glovebox to identify location of convenience cans for robot pick-and-place
  - Cognex In-sight 8401M camera with motosight software package
  - Ease fixturing requirements and improve reliability of robot work cell by enabling robot to adjust positioning to alternate can position
  - Ensure robot does not interact with unwanted parts

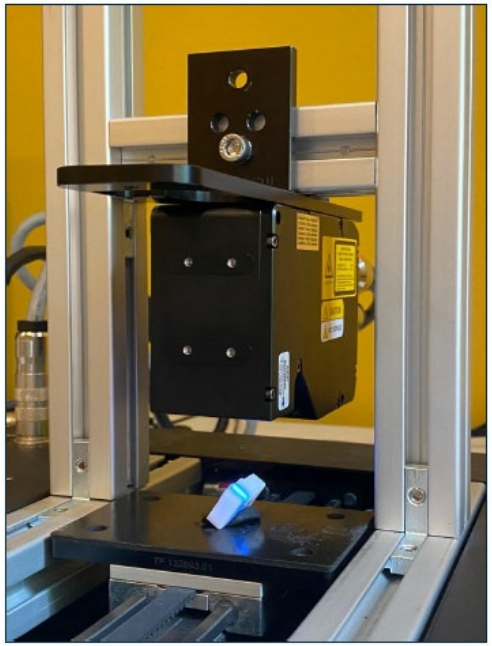


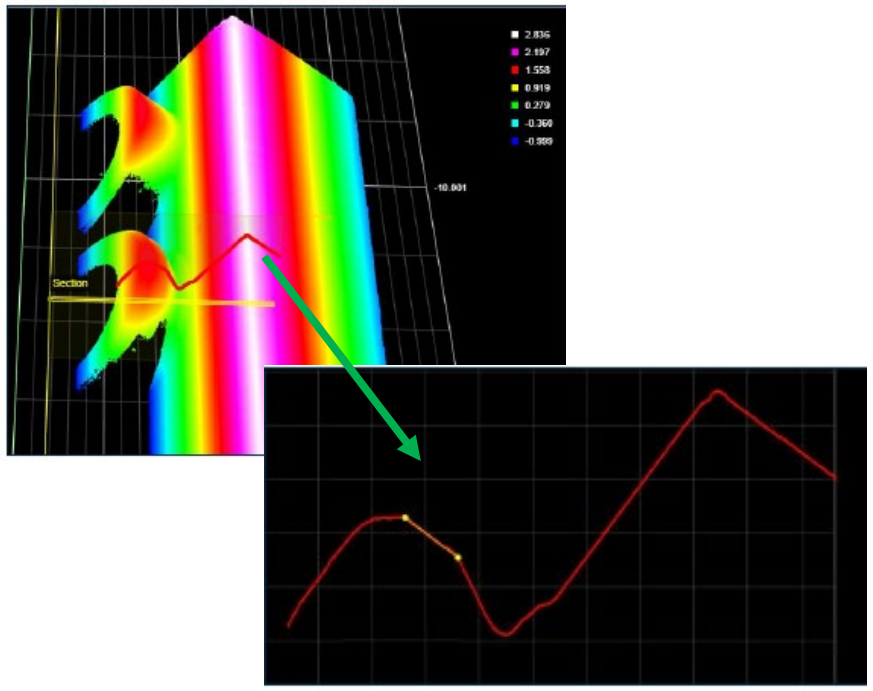
Can Identification Demonstration Video



Workcells – Component Production in AM Process

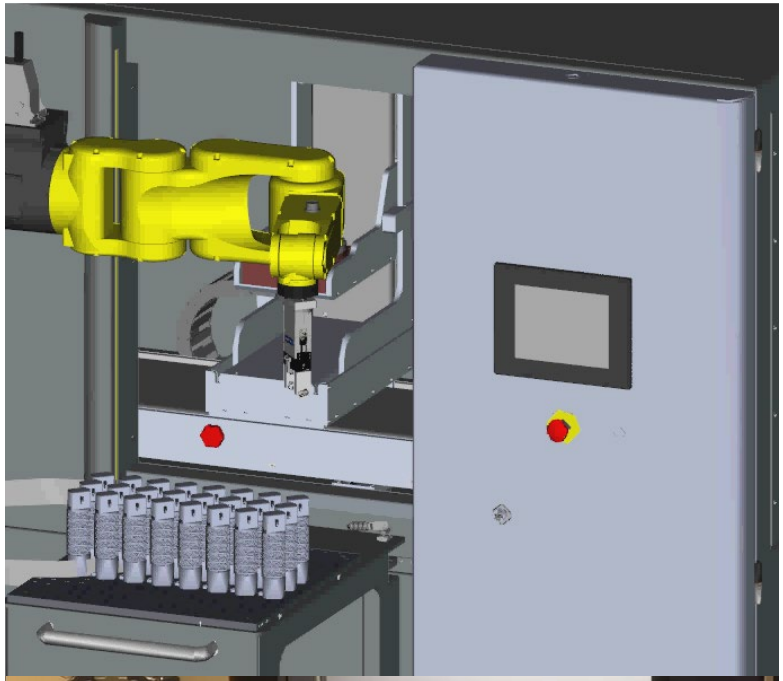
- Update production process by incorporating machine tending robot with additive manufacturing and inspection processes
- LMI Laser profile scanner mounted to gantry platform to increase throughput vs. current CMM process

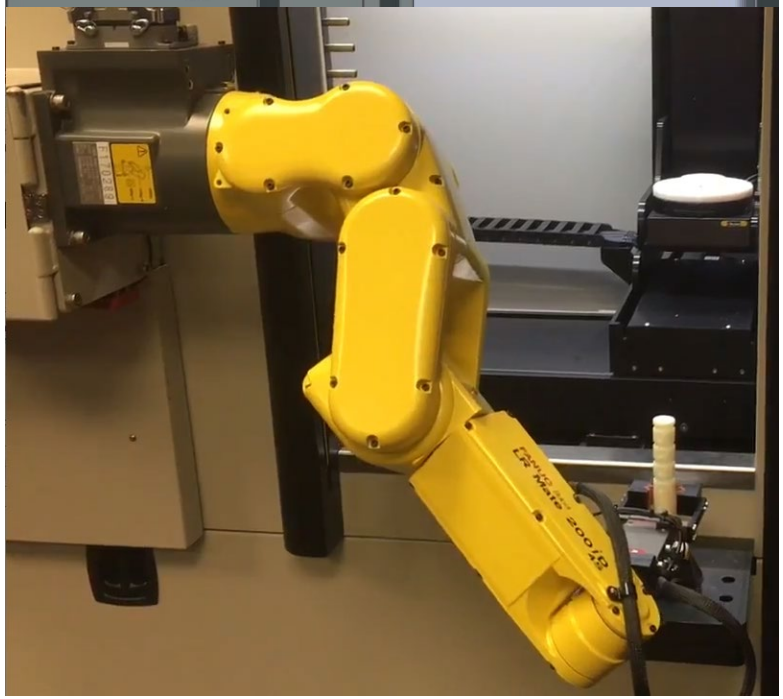




Workcells – CT Part Inspection

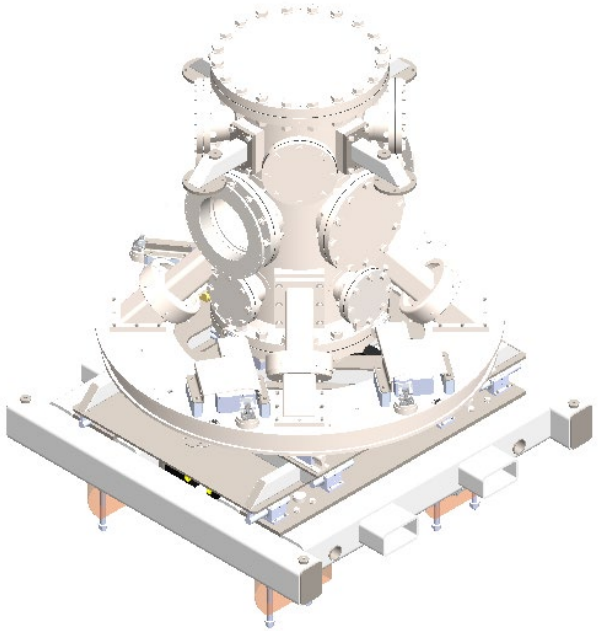
- Fanuc Robot LRMate 200iD mounted to North Star Industrial CT Scanner
- Labor-intensive QA inspection for parts
- Direct interface between robot and scanner allows batch processing of parts
- Custom Gripper finger design maintains required part orientation during grasping
  - Integrated IR sensor ensures proper interface between gripper and part.

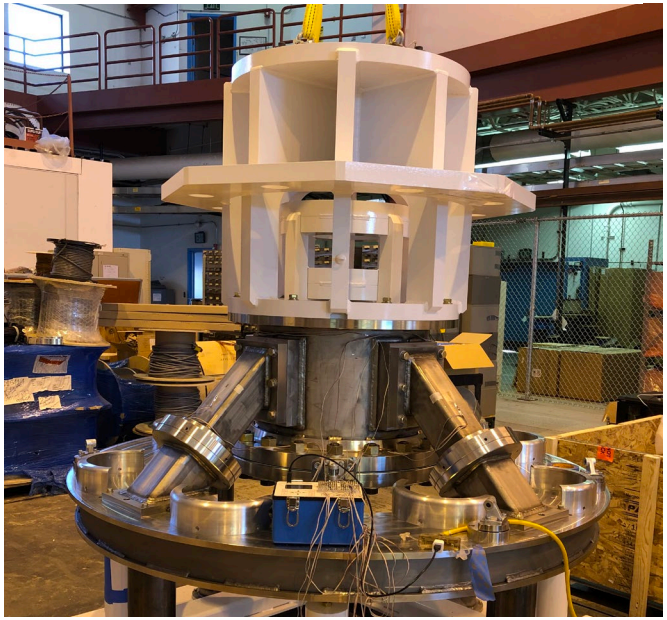




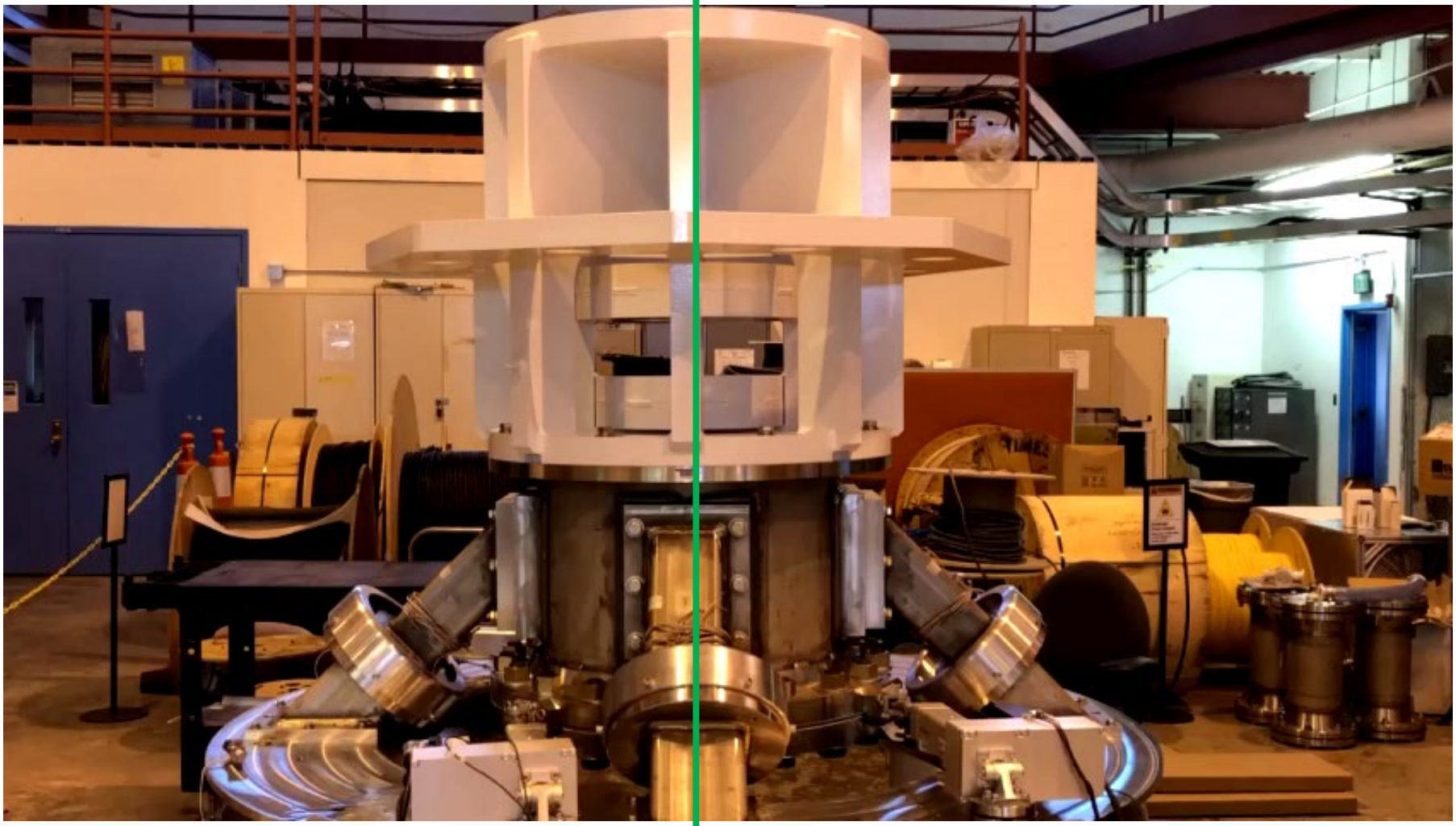
Custom Beamline Positioning System

- Positioning of ~4500-lb vessel with 6DOF inside pRad beamline at LANSCE
  - 1mm linear positioning
  - 0.1° rotational requirement
- Custom parallel 3DOF rotational system using spherical Teflon pads on steel feet to rotate vessel about fixed geometric center
  - Specialized kinematic model developed to translate rotations into actuators for IK control
  - Operational prototype fabricated and developed to demonstrate performance



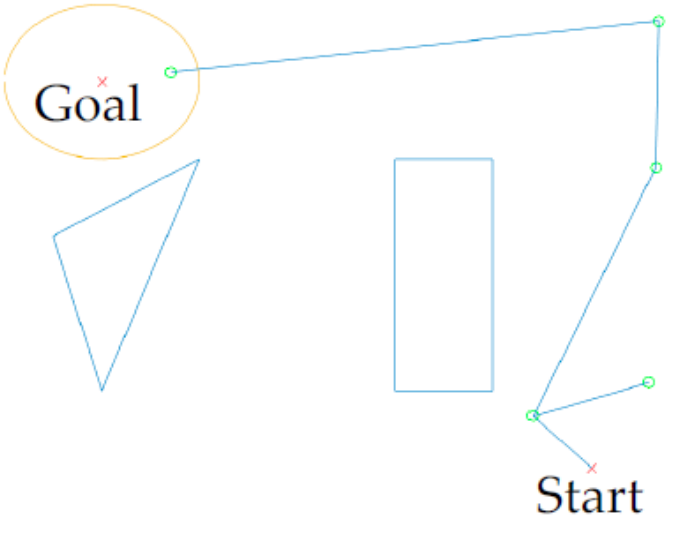


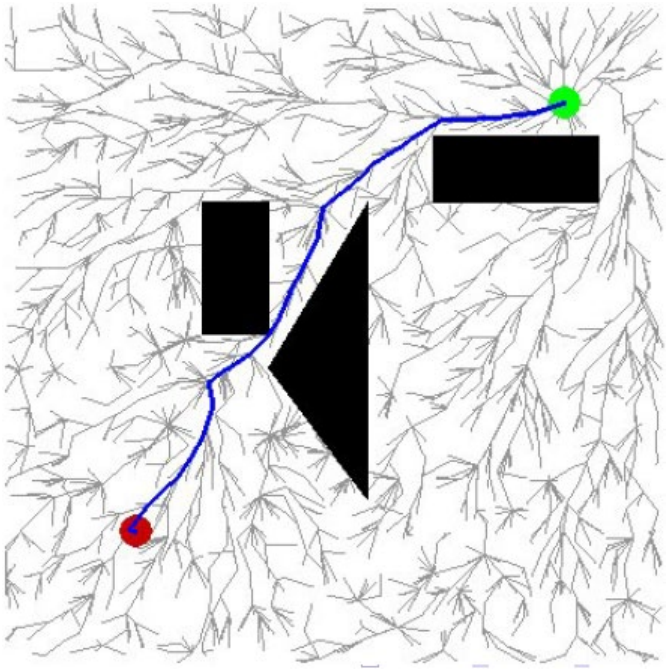
Parallel Positioning Demonstration Video



Research – Motion Planning

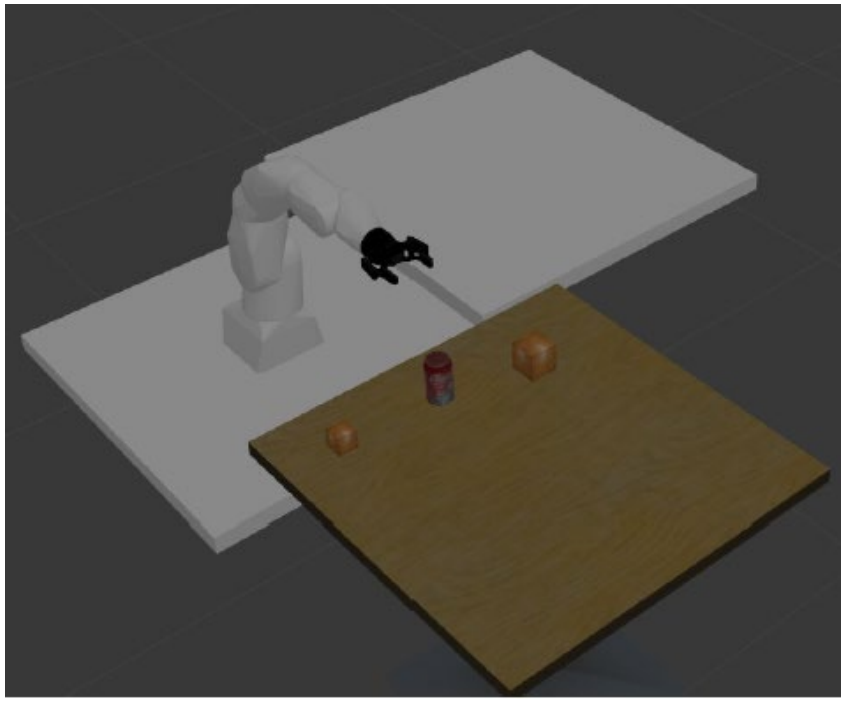
- Manipulator Path Planning
  - Performed in partnership with UCSD
  - RRT path planning for obstacle avoidance in dynamic environments
  - Predictive Path Planning to account for unknown and dynamic obstacle locations
    - Update to Predictive Moving Goal Tree path planning algorithm
  - Potential applications for robot operations within constrained glovebox environments
  - Probabilistic model to maximize distance from potential obstacles/minimize probability of collision
  - Application of machine learning/neural networks to improve ability of algorithm to output optimally safe paths

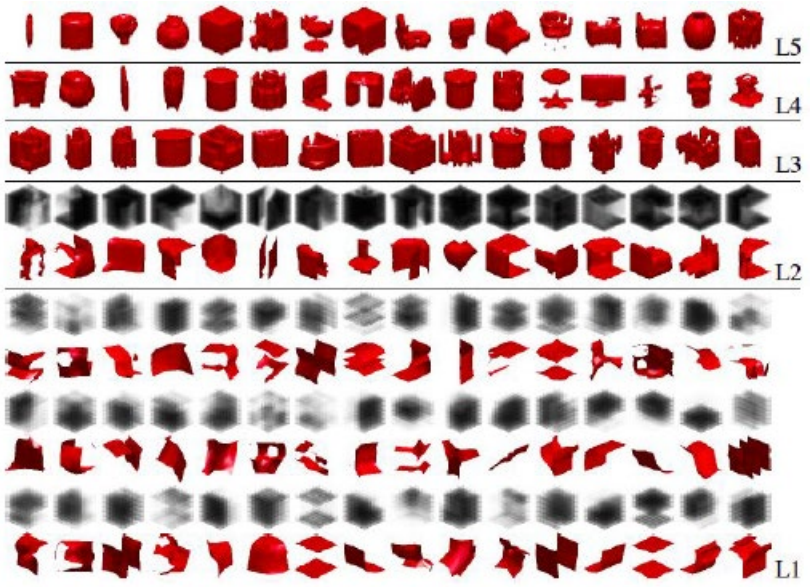




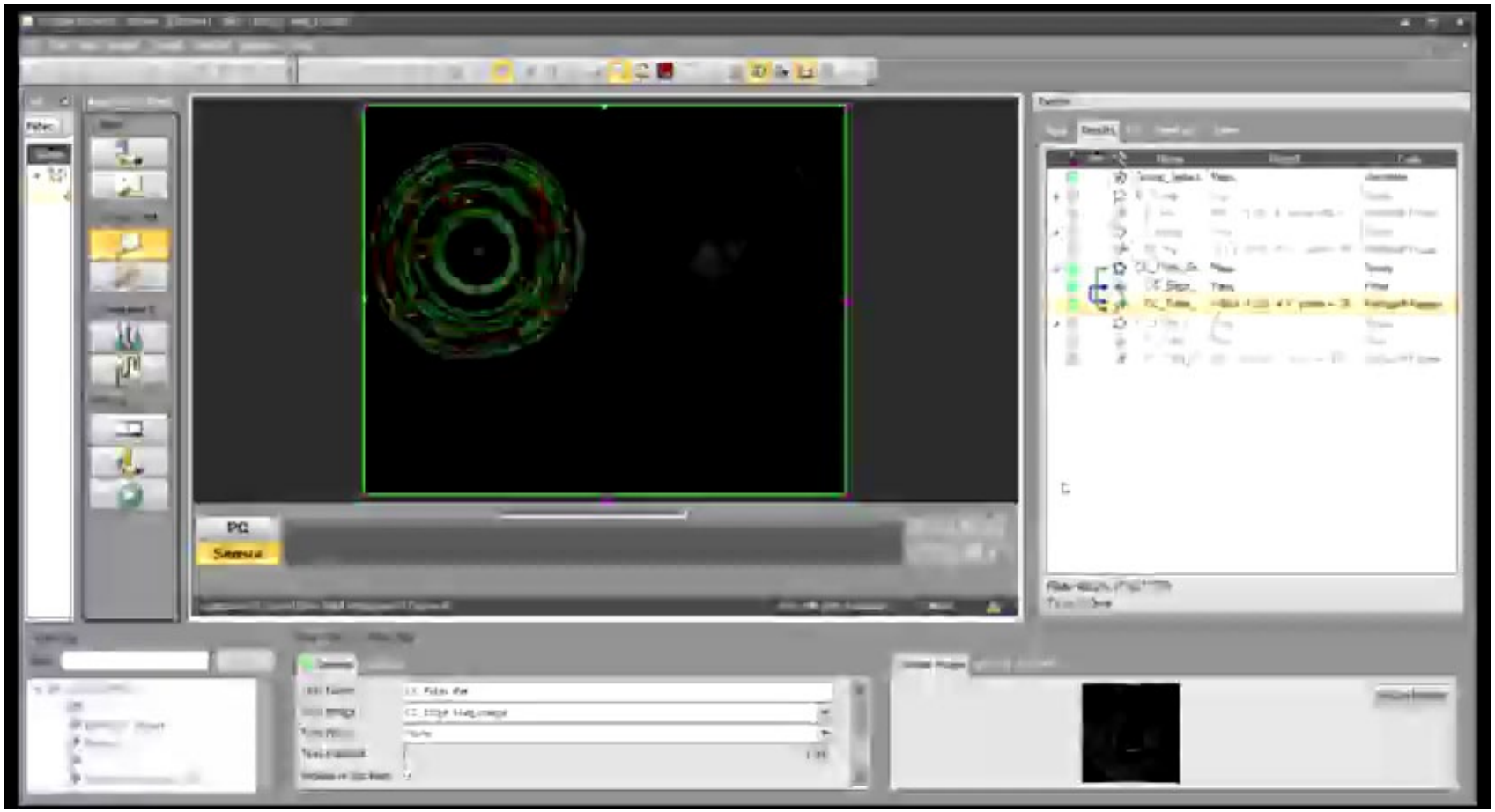
Research – Camera Object Identification

- Independent and end-effector mounted camera systems used to generate point clouds
  - Compared input from vision systems to known object geometries to identify objects within workspace of manipulators
  - Enhance performance via machine learning to train camera identification over time.





Object Identification Filter Demonstration Video

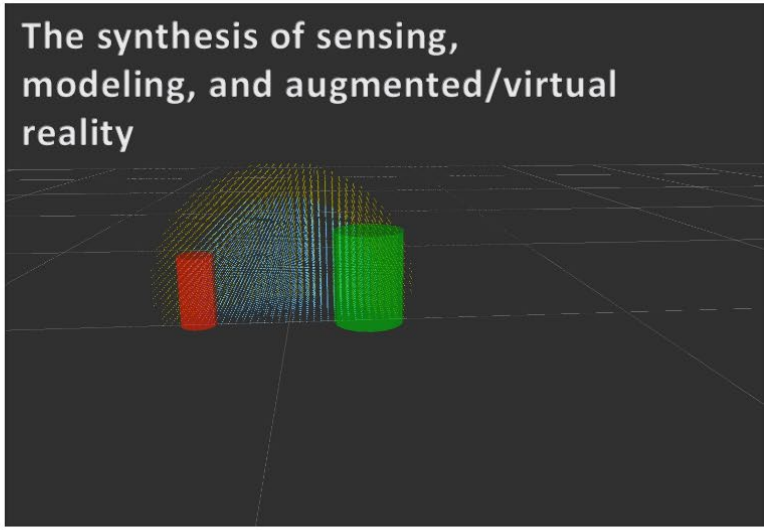


Future Research – General Robotics

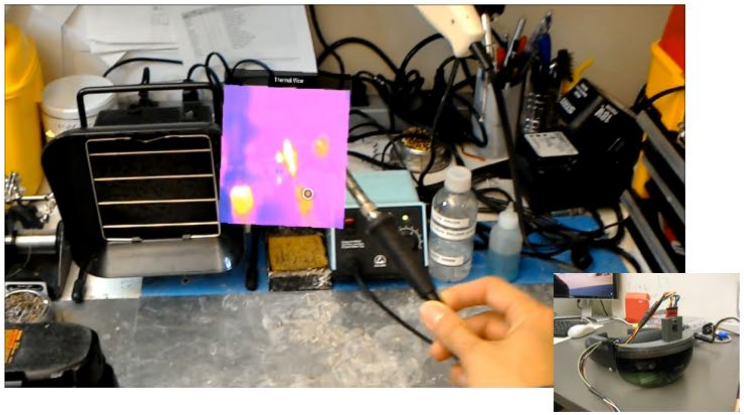
- Application of research within simulation environments to real-world environments
  - Novel path planning algorithms
  - Integrating custom algorithms onto available control software for commercial manipulators
  - Including machine learning/neural networks to for highly dynamic environments with large uncertainties in object locations
- Further integration of vision systems within manipulator path planning algorithms to allow for more uncontrolled automation environments
- Continued development of custom automation systems to address unique processes involved with Pu production and disposal at LANL.

Augmented Reality Future Researh

User interface improvements



Sensor integration



MCNP

Challenges

- Development of new processes to address large ramp-up in laboratory production goals
  - Limited scalability of existing processes with high labor requirements means that robots and other automation are highly in demand
  - Limited ability to alter processes due to environmental/space concerns of glovebox operation prevents the use of many COTS systems and increases engineering effort in development of custom system.
- Design constraints inherent with limited accessibility environments
  - Limited capacity to access robots operating in gloveboxes/radiation areas requires longer life cycle/systems with lower maintenance requirements.
  - Smaller footprint/lower payload systems required for operation in highly constrained environments.
  - Greater safety concerns due to the nature of material being handled raise requirements to certify systems for unattended operation
- Security concerns with increased use of vision systems for nuclear material processing

Acknowledgments

- All of the following scientists and engineers contributed to this presentation
  - Troy Harden, LANL, AMPP-DO
  - Emily Schultz-Fellenz, LANL, EES-14
  - David Mascarenas, LANL, NSEC
  - Beth Boardman, LANL, E-3
    - Javier Ruiz, LANL
    - Robert Schloen, LANL
    - Paul Lathrop, UCSD
  - Greg Port, LANL, E-3