Intelligent Systems, Robotics and Cybernetics

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A "Research⇨Development⇨Application" Organization

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Welcome to Sandia's Intelligent Systems & Robotics Center

Mobile Systems Range

Leveraging $150 Million DOE investment
In Facilities, Equipment, & Tech Base

Robotic Manufacturing Science & Engineering Laboratory

Technical Staff: ~41
8 PhD's; 22 MS; 6 BS
Number of Active Patents: 42

Heavy labs: 12
Light labs: 29
Total labs: 41

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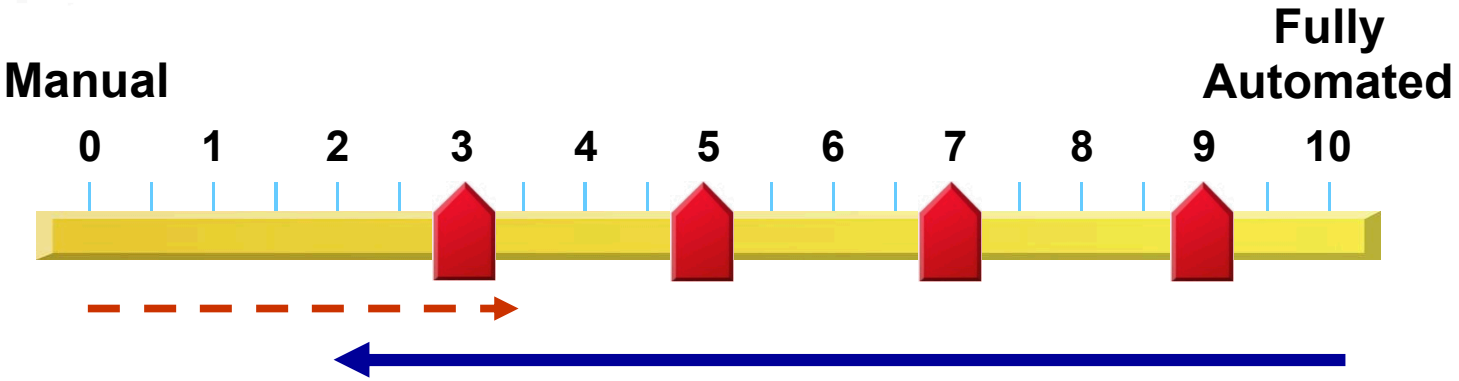
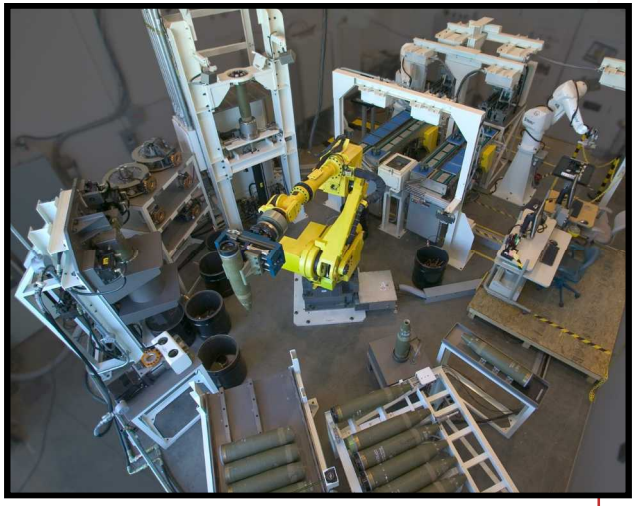
A Philosophical Approach To Robotics





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Levels of Autonomy Definition

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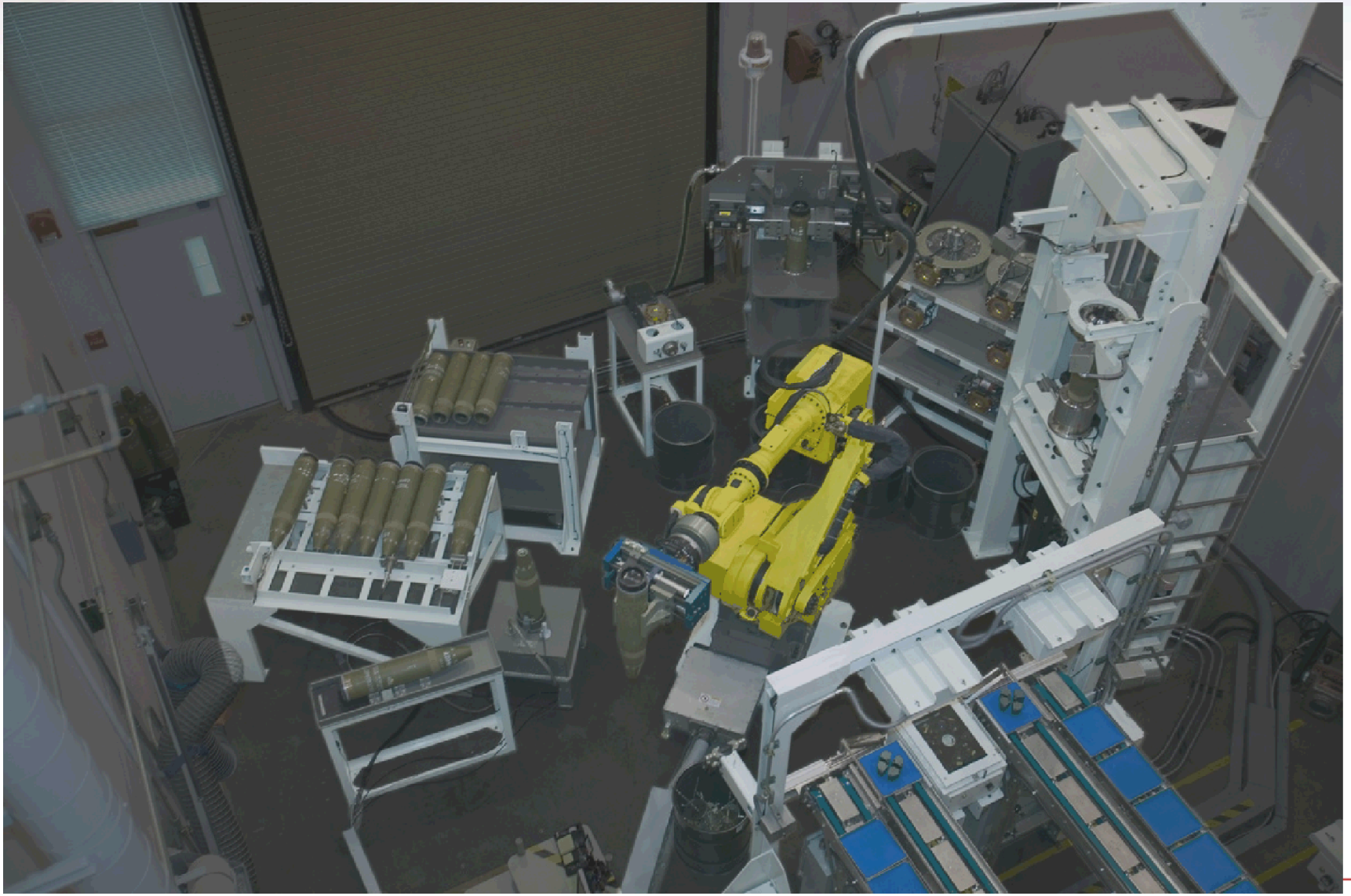
ADAM ICM Projectile Download Workcell



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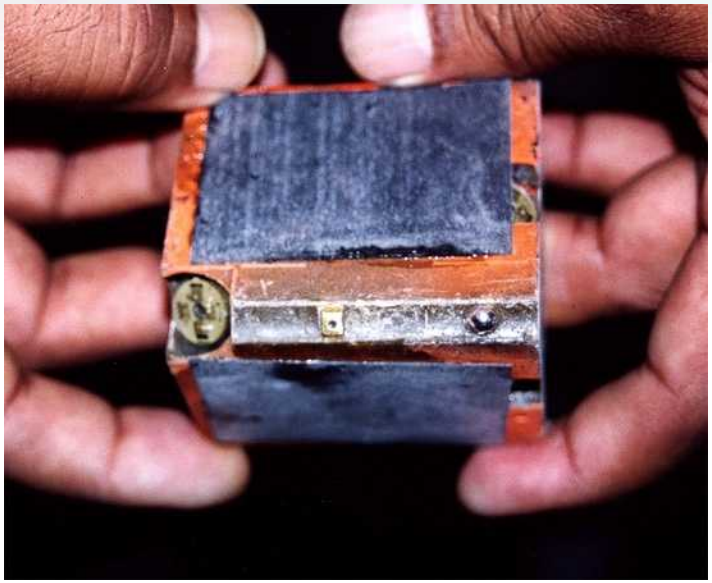
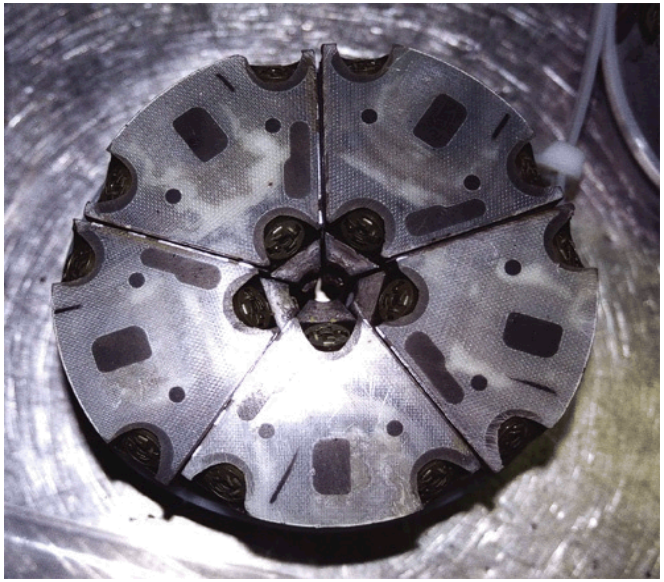
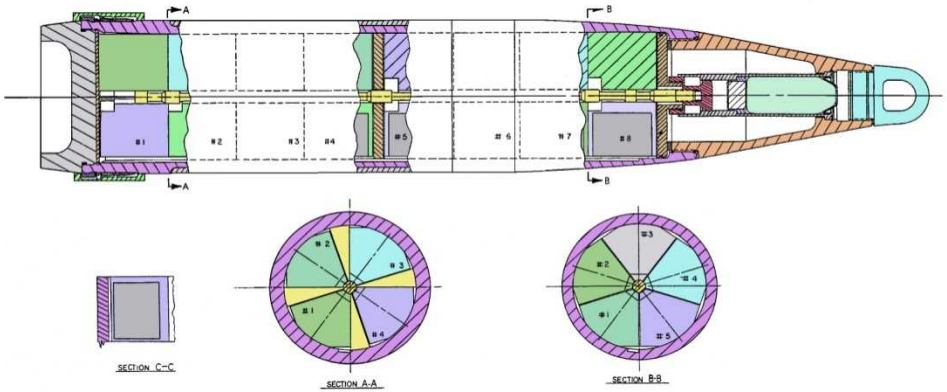
ADAM Mine and ICM Projectile







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D563 Download Workcell

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MLRS Warhead Download System

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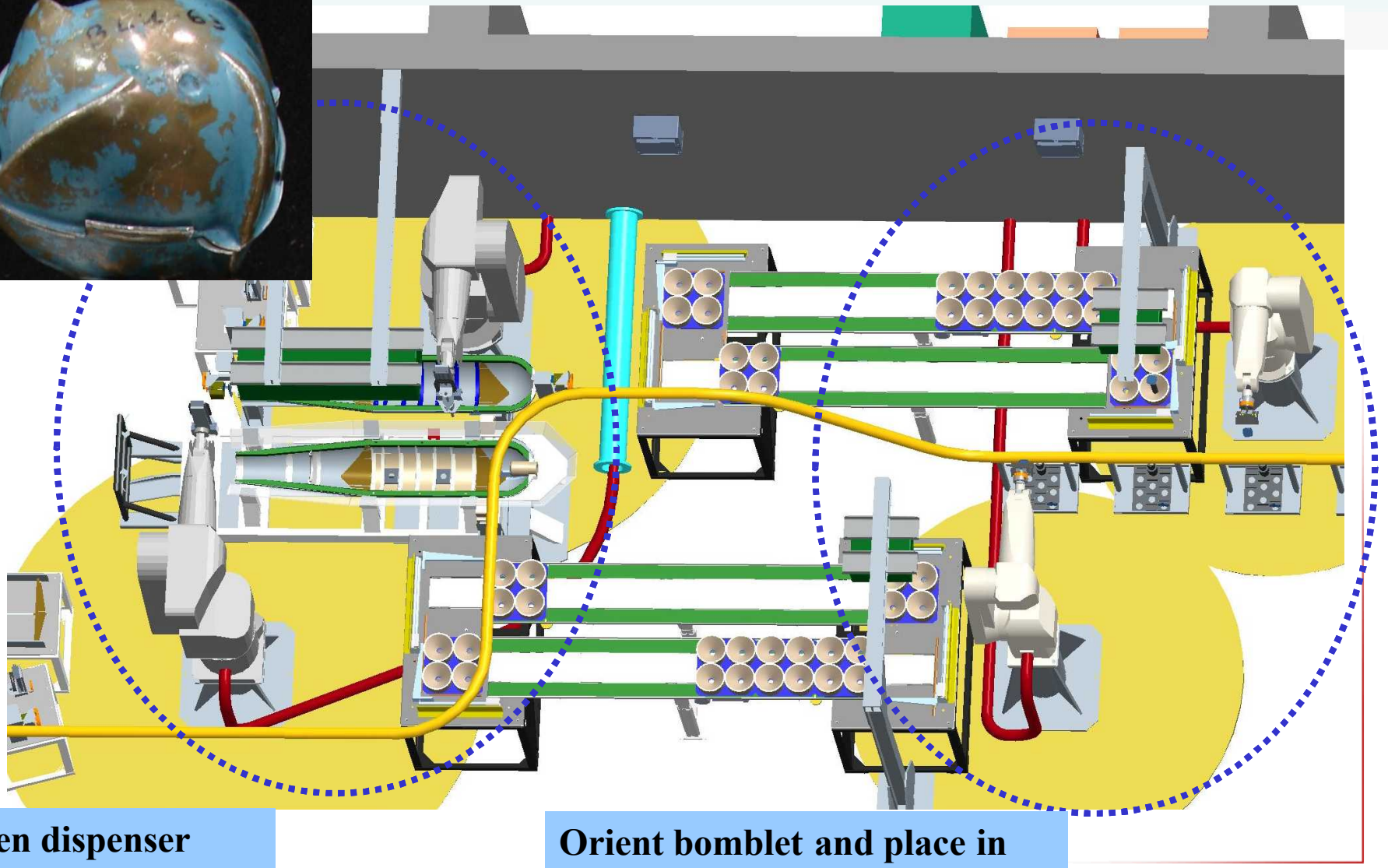
CBU Download Workcell



Open dispenser and unload

Orient bomblet and place in Fixture Separation Station

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Remote Ordnance Recovery and Disposal

- Sandia designed and developed remote vehicles have been used for excavating and removing munitions from pits and transporting them to destruction areas
- Operators control vehicles from a portable control room located up to 4 km away
- A single operator can command multiple vehicles
- Vehicles are driven to a location via teleoperation

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Remote Ordnance Recovery and Disposal

- Sandia robot manipulators can operate by teleoperation, telerobotic, or autonomous control
- Teleoperation can include technologies such as force reflection when operators need to “feel” end effector loads
- Sandia has developed control technologies to coordinate the motion of two or more arms working together to perform heavy payload or complicated manipulation tasks
- Sandia has integrated dexterous manipulators on many remote vehicle types

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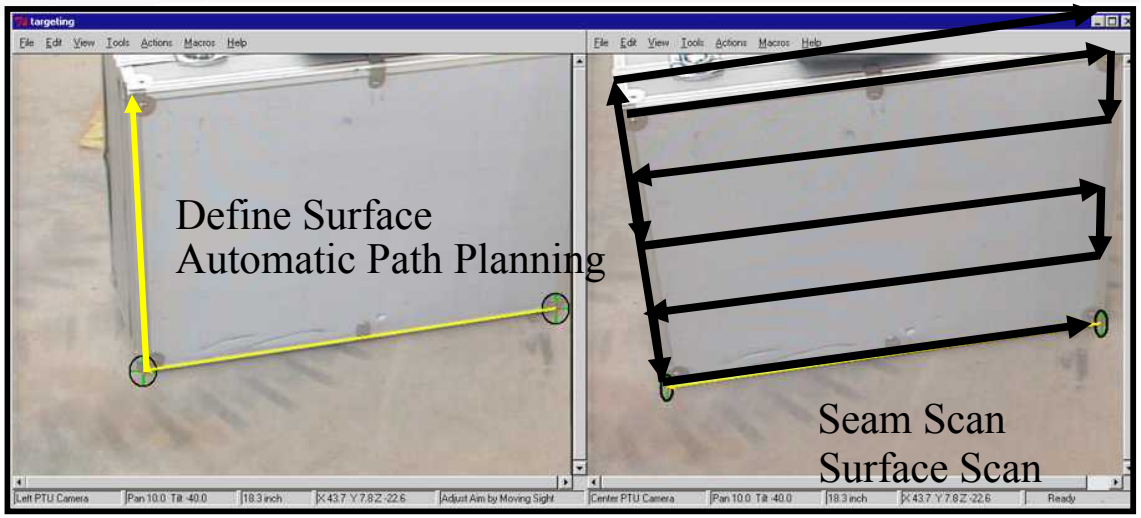
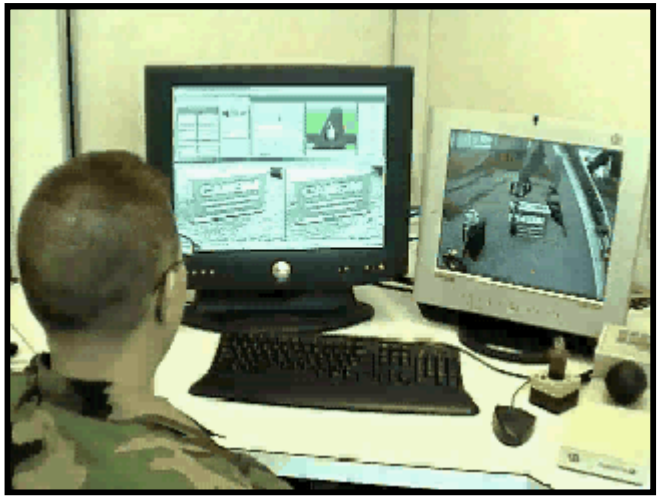
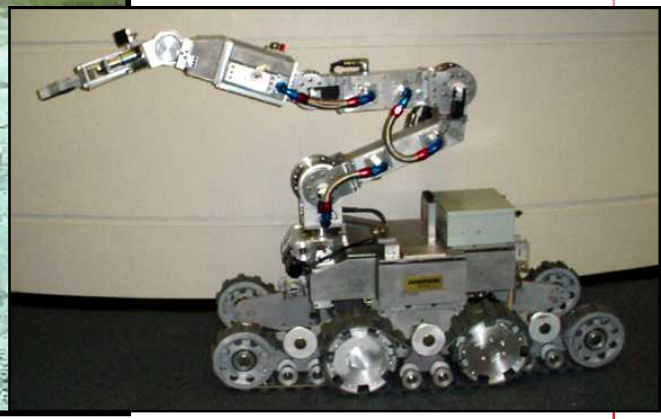
Automated Scanning Capabilities



- Detection
  - NBC/Explosive
- Decontamination
- Paint/coatings
- Fire fighting
- Damage control
- EOD





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UXO Retrieval Exercise

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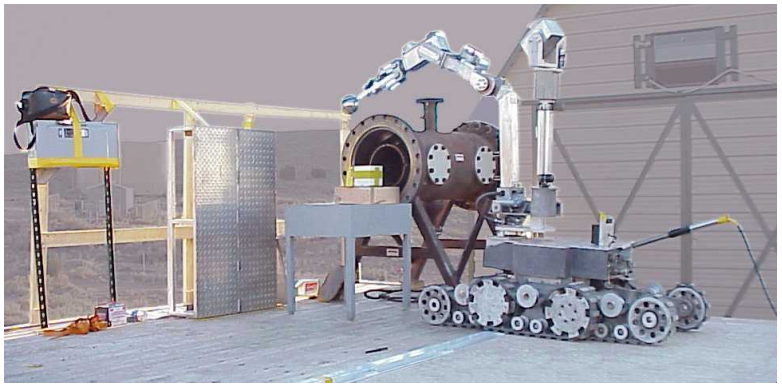
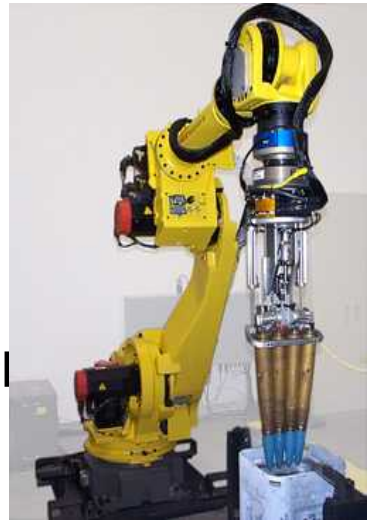
Enabling Technologies

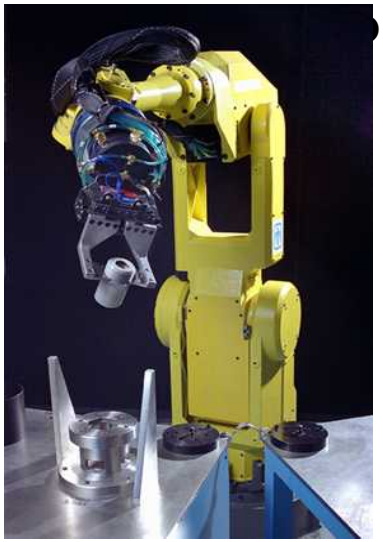
- **Enabling technologies will:**
  - **Increase the overall system safety and speed of operations**
  - **Allow the system to be operated in a teleoperation, telerobotic, or autonomous mode**
  - **Reduce operator fatigue and error by not requiring an operator to continuously manually drive the manipulator**
  - **Perform autonomous dexterous operations**
  - **Increase the speed of hardware and software integration**



Enabling Technologies - Dexterous Manipulation

- Dexterous manipulation combines enabling technologies such as force control, machine vision, etc. to perform complex tasks
- Dexterous manipulation will be required for:
  - Digging
  - Removing objects to expose munitions
  - Picking up and placing munitions into containers
  - Munition inspection and safing
  - Munition disassembly
  - Material handling to support neutralization processes





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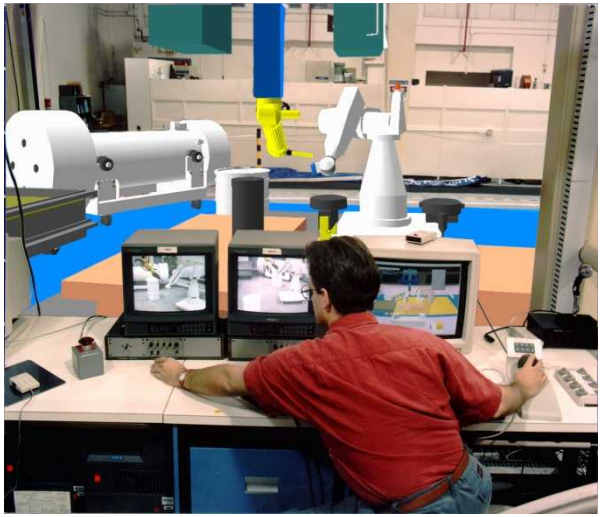
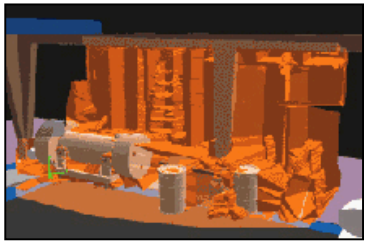
Enabling Technologies - Path Planning, Sensor and Model Based Control

- Automated path planning and programming automatically determines the robot motion to perform the commanded task
  - Path planners consider joint limits, singularities, obstacle avoidance, motion types
- Sensor and Model Based Control
  - Models are built from prior information or sensor input
    - CAD model information
    - Laser scanners, machine vision, force and proximity sensing
      - Geometric reasoning
  - Models plan motion
  - Motion can be previewed / approved
  - Sensors verify safe & successful motion execution
    - This includes collision detection





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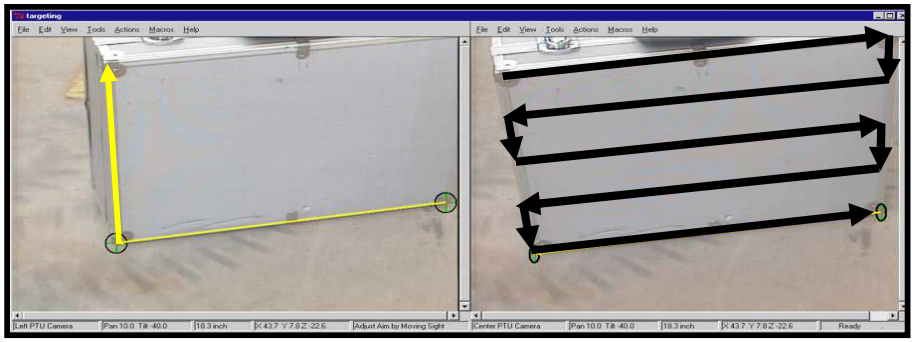
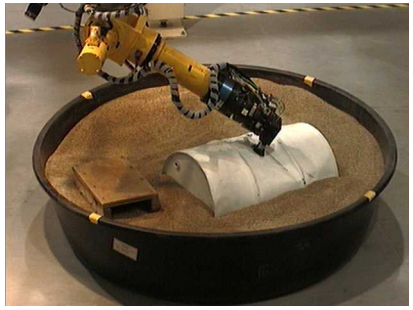
Enabling Technologies - Visual Targeting

- Visual targeting is an operator interface technology that provides operators an easy method for telling the robot where an object is located and the task to perform on the object
  - Visual targeting uses calibrated video images from the robotic vehicle to define the target object
  - The operator uses a mouse to position a set of cross hairs and select features on the video image. The operator then commands a task such as pick up object, cut object, push object, etc.





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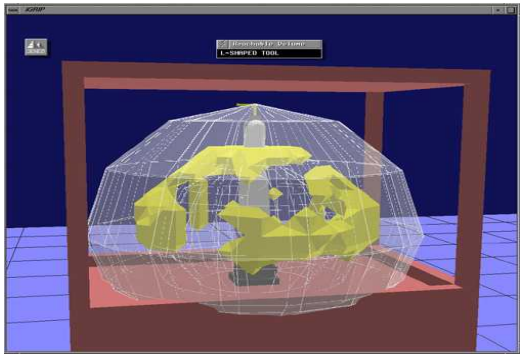
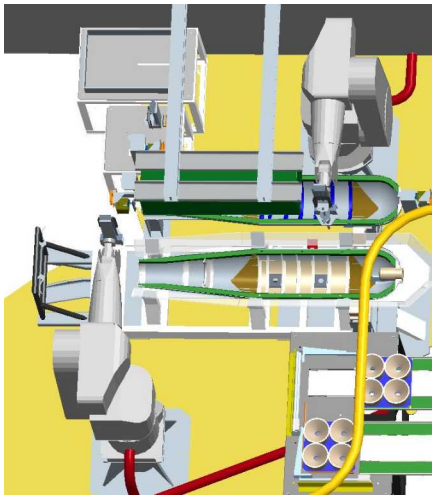
Enabling Technologies - Reachability Analysis

- This Sandia technology determines the working volume for an integrated system (vehicle, manipulator, and tooling) from a given location
  - Analysis based on manipulator joint lengths and motion limits, tool design, etc.
  - Exceptionally useful to evaluate system configuration and tooling design choices for systems with greater than five degrees of freedom
  - Useful for showing an operator the optimal location to position a vehicle so the robot can perform a desired set of tasks





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Our Core Competencies

- **Trade-offs between teleoperation and autonomy**
- **Non-contact sensing** and situational awareness
- Mission-specific and multi-mode mobility
- Micro-manipulation and micro-assembly
- Development of intelligent systems with microelectronic and MEMS devices
- **Modular robotic mobility, dexterity and controls**
- **Electrical, mechanical and software design**
- **Integration of high consequence robotic and automation systems**
- **Motion planning, path planning, navigation**
- Near human presence safety
- Improved user interfaces
- Geometric analysis and reasoning
- Decision support for planning, training and previewing
- Collective behavior science
- Cooperative automation
- Adaptive control and optimization
- Technology enabled military logistics
- Model and simulation-enhanced analysis

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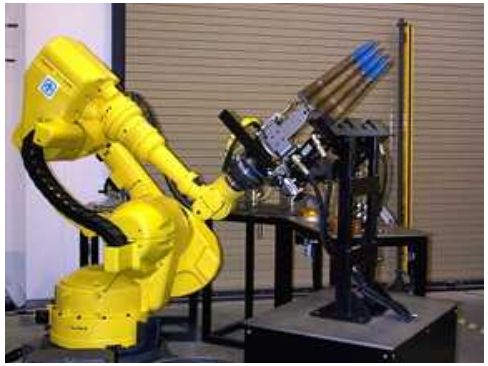
Services Sandia ISRC can Provide

- System selection and trade off studies
- Technology identification and evaluation
- Technologies and/or working systems for:
  - Removing chemical munitions from pits
  - Munition disassembly
  - Material handling
  - Delivering munitions into neutralization or other processes
- Engineering design and documentation support to obtain certifications for systems Sandia develops
- Technical support for delivered systems



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General Statement

- **Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.**

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