

Pioneer Robot System Testing and Training Status

Joseph N. Herndon
Robotics and Process Systems Division
Oak Ridge National Laboratory
865-574-7065
herndonjn@ornl.gov

Representing a Multi-Agency International Team

Presented at the ANS
9th Topical Meeting on Robotics and Remote Systems
March 6, 2001

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY



Pioneer...Inspection and Remote Operations Robot for Unstructured Environments



- **Mission Drivers:**

- investigate Shelter structural integrity through dimensional and physical inspection
- gather Shelter environmental data
- support unstructured remote work tasks within Shelter with manipulation and rad-hardened television

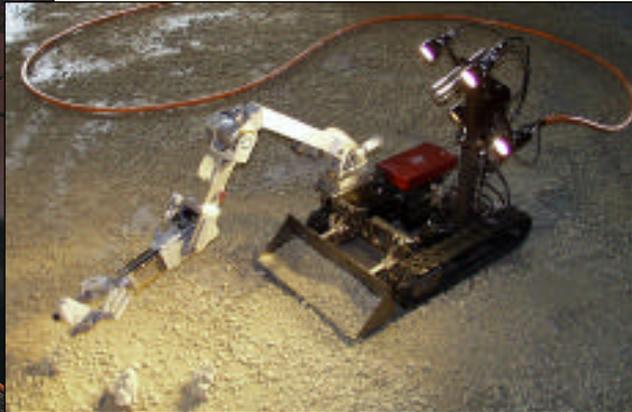
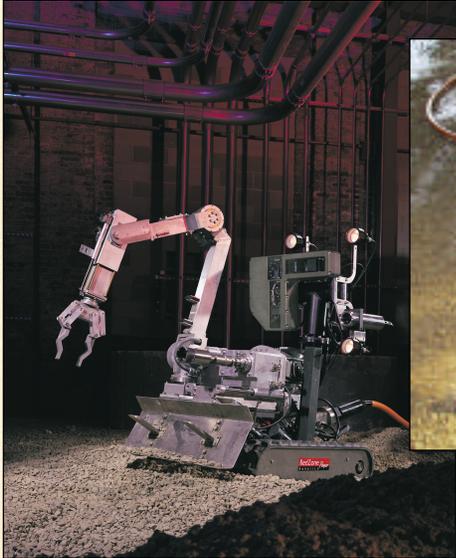
- **Mission-Driven Capabilities:**

- powerful mobility and rubble moving capability to negotiate the highly unstructured environment
- provide onboard manipulation dexterity for planned and unplanned tasks
- rad-hard viewing capability
- 3D map generation with photorealistic overlay
- concrete sampling
- measurement of radiation and other environmental data, tagging data to 3D maps

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY



Pioneer Robot Mobility/Manipulation Capabilities



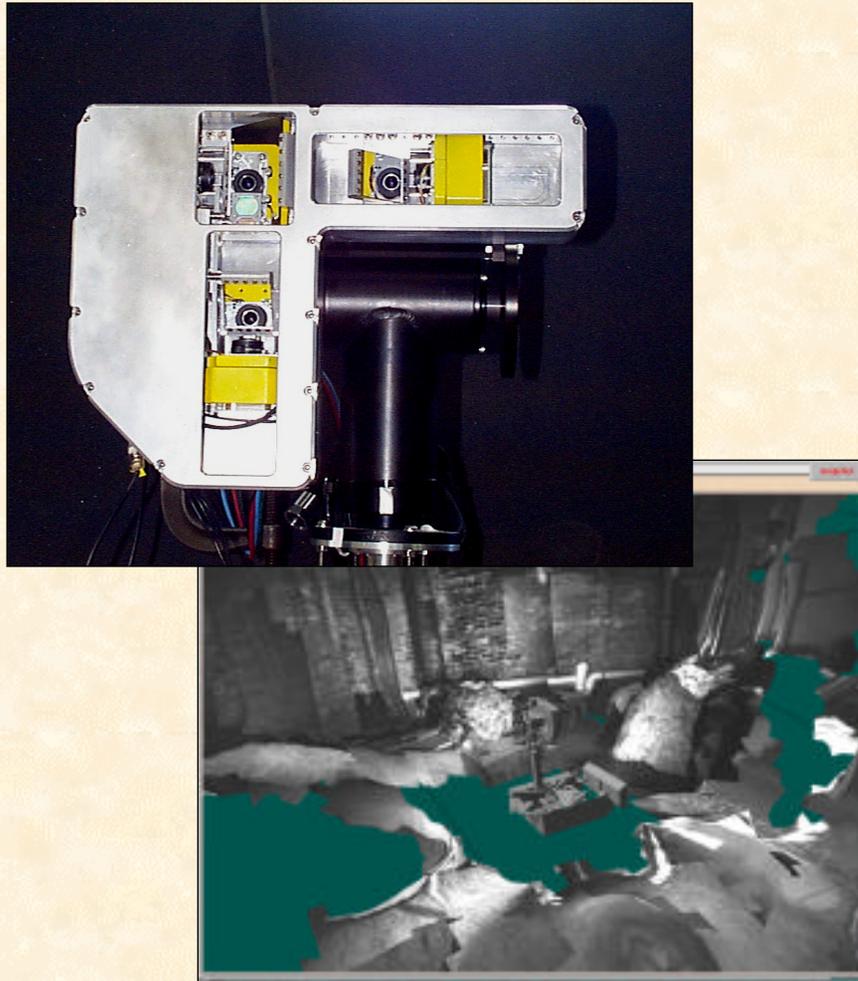
- tracked mobile platform with onboard manipulation
- teleoperated control with skid-steered mobility
- tether-based communications & power supply
- modular design for ease of transport
- radiation-hardened for application
- mission configurable by modular design

RedZone *Houdini* robot, successfully deployed for cleanup of waste storage tanks at ORNL, is the basis for the Pioneer platform

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

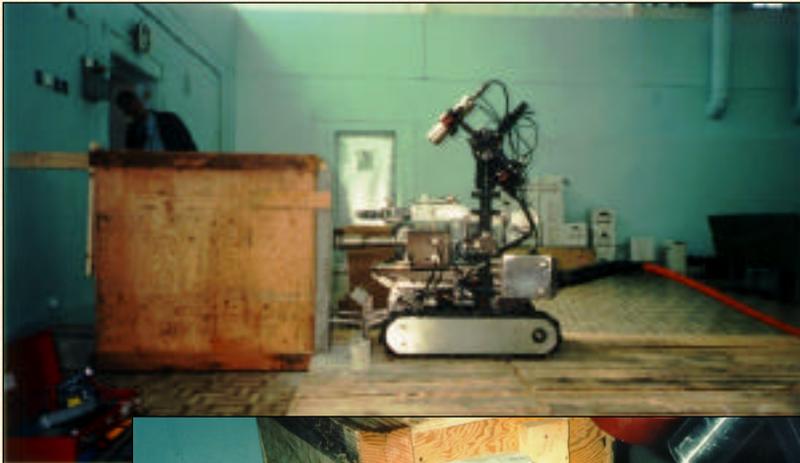

UT-BATTELLE

3D Mapping System ... Based on NASA Mars Pathfinder and CMU Artisan Technologies



- **Shelter structural and rubble measurements and mapping**
- **Spatial registration of collected environmental data**
- **Mission planning for...**
 - remote operator training
 - radiation exposure estimation
- **Radiation-hardened trinocular stereo vision**
- **Mesh matching & merging for surface modeling**
- **Color image engraving for photorealism**

Concrete Sampling Mission Module...Based on NASA Small Body Exploration and CMU/TMI Concrete Sampling Technologies



- **Concrete samples to assess Shelter structural integrity, including...**
 - stresses from accident-related displacements
 - embrittlement by radiation
 - degradation from aging in the “open” environment of Shelter
- **Closed servoloop drill control**
- **Force & torque sensing to infer substrate material properties during coring operations**
- **Failsafe operation with remote recovery from failure**

The Pioneer Robot System was Tested Onsite At Shelter Object During a Six Week Period in 1999

- Testing team consisted of US and Ukrainian Specialists
- Testing Program included:
 - system unpacking, transport, and assembly
 - Component- and system-level training and operations testing
 - full system training and operations testing
- Full-scale demonstrations
 - assess performance of typical Shelter-like remote operations
 - Shelter Object/ISTC Shelter operations crews
 - demonstration to senior government officials and Shelter PMU and Package contractors



OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY



Results of the Six-Week Pioneer Robot Cold Testing Program



- Pioneer was successfully assembled, operated, disassembled, and transported to simulated work sites
- All systems except concrete sampler successfully performed to design specifications
- Ukrainian specialists quickly became skilled Pioneer operators and completed training on theory, operations, and maintenance
- Cold Testing identified both the path forward and the potential challenges for future robotic operations in Shelter Object
 - extreme mobility constraints due to rubble and structural impediments limiting access to areas of interest => significant additional manual access creation work predicted by Shelter Object staff
 - very difficult tether management challenges in high radiation => great care in mobile operations
 - remote viewing limitations result in significant telepresence challenges => additional remote viewing
 - lack of control room and maintenance facility infrastructure at Shelter Object => infrastructure improvements

Moving Beyond Shelter Object...ChNPP Decommissioning and Emergency Response are the New Applications for Pioneer



- **Pioneer has been formally transferred to ChNPP ownership from US DOE**
 - support for ChNPP decommissioning
 - ChNPP and Ukraine-wide emergency response
- **Pioneer is fully operational and stationed at the ChNPP Emergency Management Center under the leadership of the Slavutych Laboratory for International Research and Technology**
- **A demonstration and testing program is preparing Pioneer and the operations crew to respond to needs during ChNPP Decommissioning and for nuclear plant emergency response**
- **ChNPP Decommissioning will take 5-7 years, with significant needs identified for robotics and for remote tooling**

Pioneer Resulted from a Multi-Agency International Collaborative Program



OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

- **US DOE and DOE Labs**
 - LLNL
 - PNNL
 - ORNL
- **NASA and NASA Labs**
 - CMU NREC
 - JPL
 - Ames
 - Univ. of Iowa
- **US Industry**
 - Redzone Robotics
 - Westinghouse Electric
- **Ukraine**
 - ChNPP and Shelter Object
 - ISTC Shelter
 - SLIRT