DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

STUDENT SUMMER INTERNSHIP TECHNICAL REPORT-SUMMER 2009

June 1, 2009 to August 7, 2009

Compendium of Technology Providers, Experts, & University/Commercial Research Programs Applicable to D&D

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Prepared for:

U.S. Department of Energy
Office of Environmental Management
Under Grant No. DE-FG01-05EW07033

ABSTRACT

The deactivation and decommissioning (D&D) process and handling of contained hazardous/radioactive materials could be facilitated significantly with the use of remote and/or advanced technologies. Several robotic technologies are currently used in D&D; however, there is a lack of internal consolidated, single-source information on technology providers and experts that own technologies related to D&D and on the technology experts in this field. In addition, there are also several technologies developed by university/commercial research program that may be applied to D&D even though they were not originally developed for D&D applications. For either case, there is not an efficient, organized, up-to-date process to find these technologies. The assignment of this internship consists of developing a compendium that identifies this information into one source. Developing such tool will cut time invested in looking for the right technology to do the work. Before the assignment of this internship the Applied Research Center developed the *Gateway to Environmental Technologies (GET)* website, which consists of a compendium of technologies for Department of Energy-Office of Enviromental Management (DOE-EM). Besides the website, the Applied Research Center and the AEA Technology Engineering Services Inc., now called NuVision Engineering, developed a report called *ORNL Remote Operations for D&D Activities*. This data was very useful for the compendium, but new technology and updates on some of those technologies have been developed since them. The goal this compendium is to supply a number of technologies useful for the D&D tasks that contains all the necessary information for identifying a given technology and its developer. A total of 116 technologies from 37 different companies were gathered during the summer internship. Due to the vast number of technologies the DOE Fellows will continue this research at Florida International University's Applied Research Center.

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1. INTRODUCTION

This research work has been supported by the DOE/FIU Science & Technology Workforce Initiative, an innovative program developed by the U.S. Department of Energy's office of Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2009, DOE Fellow (Ramon Colon) spent ten weeks performing a summer internship at the Department of Energy's Office of Deactivation and Decommissioning and Facility Engineering (EM-23) under the supervision and mentoring of Mr. Andrew Szilagyi. This internship was organized by FIU-ARC and EM's Office of Human Capital (EM-41).

The purpose of the Office of Deactivation and Decommissioning and Facility Engineering is to reduce project technical risk and uncertainty through Technology Development and Deployment thus enabling the implementation of safe, cost-effective, efficient and timely deactivation and decommissioning (D&D) of facilities and their contents [1]. The D&D and handling of contained hazardous/radioactive materials could be facilitated significantly with the use of remote and/or advanced technologies including, but not limited to, robotic technologies. This means that the process will be done in a safer, faster and more cost-effective manner. Several robotic technologies are currently used in D&D; however, there is a lack of consolidated, single-source information on technology providers and experts that own technologies related to D&D and on the technology experts in this field. In addition, there are also several technologies developed by university/commercial research program that may be applied to D&D even though they were not originally developed for D&D applications. For either case, there is not an efficient, organized, up-to-date process to find these technologies. The main task of this internship was to identify the technology providers and experts that have developed and/or own D&D technologies, as well as university/commercial research program conducting cutting edge, innovative research on technologies applicable to D&D. All the information gathered was used to create this organized compendium.

The main purpose of developing this compendium is to facilitate the identification and use of available technologies to a specific need. To accomplish this, the compendium was designed to include an inventory of the technologies currently used or that could be used for D&D. Having an inventory of the current technologies and research available will help identify the areas in which future investments should be made.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE/FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2009, DOE Fellow (Ramon Colon) spent 10 weeks doing a summer internship at Office of Deactivation & Decommissioning and Facility Engineering (EM-23) at DOE Headquarters, located in Cloverleaf, MD under the supervision and guidance of Mr. Andrew Szilagyi. The intern's project was initiated on June 1st, 2009, and continued through August 8th, 2009, with the objective of creating a compendium of technology providers, experts, and university/commercial research programs that develops technology used in D&D tasks as well as technology that could be applied. A literature search was performed to find appropriate technologies for inclusion in the compendium. Sources included the Waste Management Symposium proceedings as well as technical reports from the DOE Information Bridge. As part of the research the Office of Deactivation & Decommissioning and Facility Engineering (EM-23) sent the intern to the Savannah River National Laboratory to observe the calibration of the Radball technology. Followed by, the scanning of the Radball technology in Duke University. Aside from the research, during these 10 weeks the intern participated on a prioritization workshop which helped understand the technology needs of the D&D contractors.

3. DESCRIPTION OF RESEARCH

3.1 CATEGORIZATION AND ORGANIZATION OF COMPEDIUM

The goal of this compendium is to supply a number of technologies useful for the D&D tasks. The compendium contains all the necessary information for identifying a given technology and its purpose as well as the company that developed it. The information was gathered and incorporated into an Excel tool. The Excel tool is composed of several parts. The first sheet contains all of the technologies arranged in categories. The second sheet contains the contact information of the developer of the technologies listed in Sheet 1. The last sheets consist of tabulated descriptions and pictures of all the technologies developed by each developer.

The compendium is meant to minimize the time needed to search for an appropriate technology. To accomplish this, several categories were incorporated in order to narrow the search to quickly find exactly what the user needs. The companies were categorized by their technologies and the technologies by the field in which they work. Within each field, the technologies were categorized by the type of technology, and finally by whether it can be applicable or is designed for D&D and whether it is currently commercially available or in development.

A technology listed as “Applicable, in Development” means that the technology is still in the research and development stage and was not originally designed for D&D purposes; however, with minor modifications, it can be used in a D&D task. A technology listed as “Applicable, Developed” is a technology that is commercially available, but it was not originally designed for D&D purposes. With minor modifications, this technology can be used in a D&D task. A technology listed as “D&D, in Development” is a technology that was designed for D&D but is still in the research and development stage. Finally, a technology listed as “D&D, Developed” is a technology designed for D&D and is currently commercially available and ready for use in D&D tasks. The architecture is shown in Figure 1.

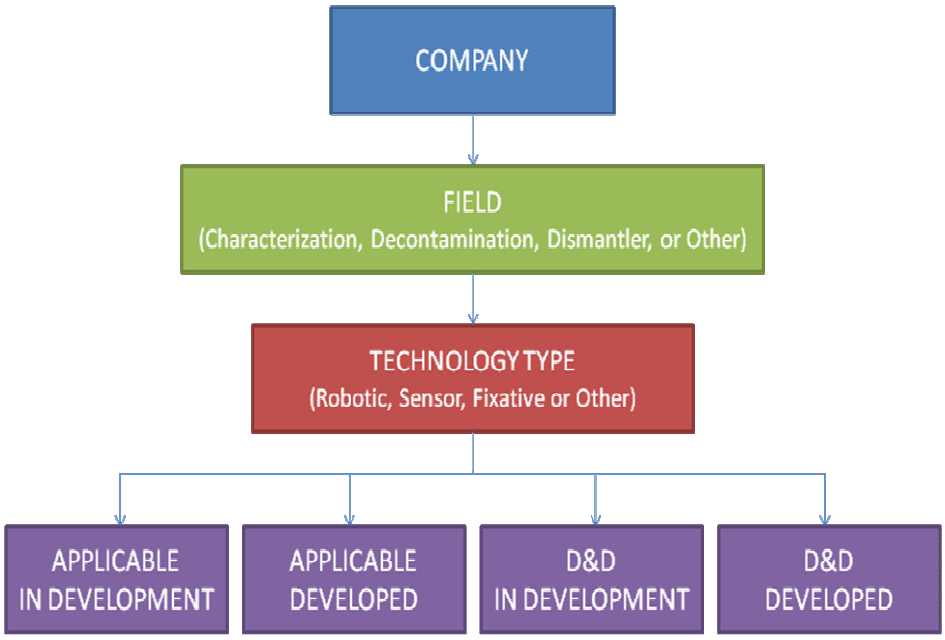


Figure 1: Flow of categorization.

In the contact information sheet, the user has the option of selecting the state or country for the technology company. This feature was included to support the desire of some sites to purchase locally. For example, the Y-12 in Oak Ridge makes 84% of their purchases in Tennessee. [2]

Finally, an individual Excel sheet has been created for each company. Each sheet contains brief technology descriptions, a list of key features, and a picture of the technologies developed by that company. The information gathered in these sheets comes directly from the technical papers, brochures, and other sources where the technology was found. This allows the user to see all the technologies developed by a given company.

A user manual for this compendium was developed with the purpose of helping new users navigate through it. The user manual explains how to search for a technology knowing the name of the technology or the desired characteristics. It also explains how to search for the contact information of the company, the description and picture of the technology. The user manual can be found in Appendix A.

3.2 PREVIOUS WORK

3.2.1 ORNL Remote Operations for D&D Activities

Florida International University's Applied Research Center (FIU-ARC) and NuVision Engineering, formerly known as AEA Technology Engineering Services Inc., collaborated in the development of the *ORNL Remote Operations for D&D Activities* [3] report. This report was prepared for DOE and consists of an assessment of buildings 3019A, 3019B, 3517, 3525, and the Oak Ridge Research Reactor. The assessment's view was toward understanding what D&D operations will require remotely operated technologies to complete the D&D. The assessment

was compared to typical D&D action and then compared to current and past technologies, at that point in time. This study helped identify the most challenging tasks to be undertaken at these facilities during the D&D. The study also identified the technology gaps which included:

- Technologies for sampling liquids left in various containers in the facilities.
- Adaptation of sensor technologies for remote deployment that have the ability to detect NOx, CO2, asbestos, PCB's, perchlorates, beryllium, and other hazardous substances.
- A single D&D workstation that incorporates tools for multiple common D&D tasks.
- Technologies for the application and removal of strippable coatings and other dry decontamination methods.
- Technologies for perchlorate neutralization and removal. It should be noted that work in this area has been done at ORNL, which could form the basis for follow-on work.

3.2.2 Gateway to Environmental Technologies (GET)

The *Gateway to Environmental Technologies (GET)* [4], which is currently supported by FIU-ARC, is a website with information on technologies available for EM tasks. This website contains 40 characterization technologies, 61 decontamination technologies, 41 dismantlement technologies, 6 waste management technologies and 11 worker health & safety technologies, for a total 159 technologies. In this website, the technologies can be searched by the field of work or by choosing the vendor. If the technologies are searched by field of work, the user selects between characterization, decontamination, dismantlement, waste management, or worker health & safety. If the technologies are searched by the vendor, all the technologies developed by that specific vendor are provided. Future developments for this system consist of updating the vendor's contact information in September of this year. Also, the GET system is scheduled to migrate into the D&D Knowledge Management Information Tool under the name of D&D Technology Solution.

It is important to clarify that this compendium is not meant to replace the GET system; instead, it will be used to add and improve the GET website with updated information.

4. END PRODUCT

The outcome of the research done during this internship was a compendium of 116 technologies developed by 37 companies. This report contains a print-out of all the tabulated information in the compendium's Search-Tool.

Table 1. Technologies and its Categories

Tech Name	Company	Field	Technology	D&D / Applicable	In Development / Developed
Air Angle Grinder	Areva	Tooling		D&D	Developed
Articulating Fiberscopes	GE Inspection Technologies	Tooling		D&D	Developed
Artisan Manipulator	NuVision Engineering	Dismantler	Robotic	D&D	Developed
BOA	Carnegie Mellon University	Decontamination	Robotic	D&D	Developed
BOA	Federal Energy Technology Center (FETC)	Decontamination	Robotic	D&D	Developed
Brokk 180	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 260	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 400	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 50	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 90	Brokk	Dismantler	Robotic	D&D	Developed
Bucket-250	Brokk	Tooling		D&D	Developed
Bucket-250	Brokk	Tooling		D&D	Developed
CC-260	Brokk	Tooling		D&D	Developed
CC-320	Brokk	Tooling		D&D	Developed
CC-420	Brokk	Tooling		D&D	Developed
CC-520	Brokk	Tooling		D&D	Developed
CC-560	Brokk	Tooling		D&D	Developed
CONAN Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
Concrete Grinder	Andrews Machinery Construction Supplies	Tooling		D&D	Developed
CORNER-CUTTER	Pentek, Inc	Tooling		D&D	Developed
Crystal Cam Push Camera	Inuktum Services LTD	Tooling		D&D	Developed
Crystal Cam®	Inuktum Services LTD	Tooling		D&D	Developed
Cybernetix Robotic Work Platform	Cybernetix	Dismantler	Robotic	D&D	Developed
Decisions in Motion	University of Regensburg	Dismantler	Robotic	Applicable	In Develop

DeconGel	Cellular Bioengineering Inc. (CBI)	Decontamination	Fixative	D&D	Developed
Dual Arm Work Platform Teleoperated Robotics System	Oak Ridge National Laboratory (ORNL)	Dismantler	Robotic	D&D	Developed
El-E	Healthcare Robotics Lab at Georgia Tech	Dismantler	Robotic	Applicable	Developed
Electrokinetic D&D	Lynntech Inc	Dismantler	Other	D&D	Developed
Everest Ca-Zoom 6.2 - PTZ100 Head	GE Inspection Technologies	Tooling		D&D	Developed
Everest Ca-Zoom 6.2 - PTZ140 Head	GE Inspection Technologies	Tooling		D&D	Developed
Everest Ca-Zoom 6.2 - PTZ70 Head	GE Inspection Technologies	Tooling		D&D	Developed
Exchanger: Handling Tool	Cybernetix	Tooling		D&D	Developed
G-30	Brokk	Tooling		D&D	Developed
Gamma Rover Crawler (Grover)	Mechanical Solutions Group (PNNL)	Characterization	Robotic	D&D	Developed
Gold Spikes	RMIT University	Characterization	Sensor	D&D	Developed
Gripper: Handling Tool	Cybernetix	Tooling		D&D	Developed
Grout	Carter Technologies Co	Decontamination	Fixative	D&D	Developed
Grout	Flour Fernald	Decontamination	Fixative	D&D	Developed
High Energy Nuclear/Ballistic IED RDD Shield	Demron-W	Protection	Other	Applicable	Developed
Hydrolic Dril (B-180)	Brokk	Tooling		D&D	Developed
Hydrolic Dril (B-90)	Brokk	Tooling		D&D	Developed
Internal Duct Characterization (TechID: 42)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	D&D	Developed
Kinshofer skopa (B-90)	Brokk	Tooling		D&D	Developed
Kinshofer skopa (B-180)	Brokk	Tooling		D&D	Developed
Little Robot	Standford University	Dismantler	Robotic	Applicable	In Develop
M3000	PaR System, Inc.	Dismantler	Robotic	D&D	Developed
M6000	PaR System, Inc.	Dismantler	Robotic	D&D	Developed
MAESTRO Advanced Hydraulic Manipulator	Cybernetix	Dismantler	Robotic	D&D	Developed
Mark V-A1 ANDROS (Andros 5)	Robotics and Remote Systems Section (SRNL)	Characterization	Robotic	Applicable	Developed

Microtracs™	Inuktum Services LTD	Tooling	Robotic	D&D	Developed
Mini Rigid Borescope	GE Inspection Technologies	Tooling		D&D	Developed
Mini-Flex Fiberscope	GE Inspection Technologies	Tooling		D&D	Developed
Minitracs™	Inuktum Services LTD	Tooling	Robotic	D&D	Developed
Mobile Automated Characterizaion System (MACS)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	D&D	Developed
Mobile Automated Characterizaion System (MACS)	Savannah River Technology Center (SRTC)	Characterization	Robotic	D&D	Developed
Molten Wax	Carter Technologies Co	Decontamination	Fixative	D&D	Developed
Molten Wax	Portage, Inc	Decontamination	Fixative	D&D	Developed
ORION 4R Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
ORION Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
Oxyacetylene Torch	Areva	Tooling		D&D	Developed
Perche: Underwater Pool Manipulator	Cybernetix	Dismantler	Robotic	D&D	Developed
Plama Arc Cutter	Areva	Tooling		D&D	Developed
Pneumatic Cut-off Tool	Areva	Tooling		D&D	Developed
Radball	National Nuclear Laboratory, UK	Characterization	Sensor	D&D	In Develop
Radscan 700 Gamma Scanner	BNFL Instruments	Characterization	Robotic	D&D	Developed
Raptor 150/300 Manipulator	NuVision Engineering	Dismantler	Robotic	D&D	Developed
Reactor Dismantler Manipulator (RDM)	Dounreay Site Restoration Ltd (DSRL)	Dismantler	Robotic	D&D	In Develop
Remote Characterization System (RCS)	DOE Robotics Technology Development Program (RTDP), PNNL	Characterization	Robotic	D&D	Developed
Remote Characterization System (RCS)	Idaho National Engineering and Enviromental Laboratory	Characterization	Robotic	D&D	Developed
Remote Characterization System (RCS)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	D&D	Developed
Remote Underwater Characterization System (RUCS)	Inuktum Services LTD	Characterization	Robotic	D&D	Developed
Rig Master Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
Responder	RedZone Robotics	Characterization	Robotic	Applicable	Developed
Robitc Ferret	Unversity of Sheffied	Characterization	Robotic	Applicable	In Develop

Robotically Deployed Laser Imaging	Robotics and Remote Systems Section (SRNL)	Characterization	Robotic	D&D	Developed
RODDIN: Crane-deployed work platform	Cybernetix	Dismantler	Robotic	D&D	Developed
ROMAIN 50/125: Master/Slave electric telemanipulator	Cybernetix	Dismantler	Robotic	D&D	Developed
Rotary Scan Borescope	GE Inspection Technologies	Tooling		D&D	Developed
ROTO-PEEN Scaler	Pentek, Inc	Tooling		D&D	Developed
Rovver 400	GE Inspection Technologies	Characterization	Robotic	D&D	Developed
Rovver 600	GE Inspection Technologies	Characterization	Robotic	D&D	Developed
Rovver 900	GE Inspection Technologies	Characterization	Robotic	D&D	Developed
RT-15	Brokk	Tooling		D&D	Developed
SB-152	Brokk	Tooling		D&D	Developed
SB-302 (B-180)	Brokk	Tooling		D&D	Developed
SB-302 (B-260)	Brokk	Tooling		D&D	Developed
SB-52	Brokk	Tooling		D&D	Developed
SB-552	Brokk	Tooling		D&D	Developed
SP-120 Camera	Inuktum Services LTD	Tooling		D&D	In Develop
Spectrum 150 Camera	Inuktum Services LTD	Tooling		D&D	Developed
Spectrum 45 Camera	Inuktum Services LTD	Tooling		D&D	Developed
Spectrum 90 Camera	Inuktum Services LTD	Tooling		D&D	Developed
Squirrel-1	Pentek, Inc	Tooling		D&D	Developed
Swing Prism Borescope	GE Inspection Technologies	Tooling		D&D	Developed
TITAN 4 Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
TITAN T and TITAN T-Gamma Manipulator	Schilling Robotics Headquarters	Dismantler	Robotic	D&D	Developed
TMTC: Electrical Manipulator Arm	Cybernetix	Dismantler	Robotic	D&D	Developed
TPE: Inspection Tool	Cybernetix	Tooling		D&D	Developed
UHPT-C Tool: Clean Up & Decontamination Tool	Cybernetix	Tooling		D&D	Developed
UHPT-L Tool: Clean Up & Decontamination Tool	Cybernetix	Tooling		D&D	Developed
UHPT-S Tool: Clean Up & Decontamination Tool	Cybernetix	Tooling		D&D	Developed

Uman (Umass Mobile Manipulator)	University of Massachusetts Amherst	Others	Robotic	Applicable	In Develop
Versatrax 100	Inuktum Services LTD	Characterization	Robotic	D&D	Developed
Versatrax 150	Inuktum Services LTD	Characterization	Robotic	D&D	Developed
Versatrax 300 VLR	Inuktum Services LTD	Characterization	Robotic	D&D	Developed
Waste Treatment Sponge	NuVision Engineering	Decontamination	Robotic	D&D	Developed
Wireless Power Harvesting	Nokia Research Centre, UK	Others	Charger	Applicable	In Develop
WU & PC Tools: Water jet and plasma cutting tool	Cybernetix	Tooling		D&D	Developed
Modified Brokk Demolition Machine (OST Tech ID 2938)	Oak Ridge National Laboratory (ORNL)	Dismantler	Robotic	D&D	Developed
Compact Remote Operator Console (OST Tech ID 2180)	Oak Ridge National Laboratory (ORNL)	Dismantler	Robotic	D&D	Developed
Telerobotic Manipulation System (OST Tech ID 2181)	Oak Ridge National Laboratory (ORNL)	Decontamination	Robotic	D&D	Developed
Remotely Operated Vehicle (ROV) System for Horizontal Tanks (Tech ID 2086)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	Applicable	Developed
Remotely Operated Vehicle (ROV) System for Horizontal Tanks Operator Panel (Tech ID 2086)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	Applicable	Developed
Heavy Waste Retrieval System (Tech ID 2194)	Oak Ridge National Laboratory (ORNL)	Decontamination	Robotic	Applicable	Developed
Tank Riser Pit Decontamination System (Tech ID 2195)	Oak Ridge National Laboratory (ORNL)	Other	Robotic	Applicable	Developed
Sampling End-Effector for West Valley Tanks (Tech ID 2941)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	Applicable	Developed
Remote Technologies for High-Level Waste Tank Component Maintenance and Disposal (Tech ID 2943)	Oak Ridge National Laboratory (ORNL)	Decontamination	Other	Applicable	Developed

Remote Underwater Characterization System (Tech ID 2151)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	D&D	Developed
Canyon Disposition Initiative Remote Characterization System (Tech ID 2178)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	D&D	Developed
Mobile Automated Characterizaion System (MACS)	Oak Ridge National Laboratory (ORNL)	Characterization	Robotic	Applicable	Developed
Red Zone Sonar	RedZone Robotics	Characterization	Sensor	Applicable	Developed
Red Zone 3D Laser	RedZone Robotics	Characterization	Sensor	Applicable	Developed
Inertial Measurement Unit (IMU)	RedZone Robotics	Characterization	Sensor	Applicable	Developed
H2S Gas Analyzer & Temperature	RedZone Robotics	Characterization	Sensor	Applicable	Developed
CCTV Pipe Inspection	RedZone Robotics	Characterization	Sensor	Applicable	Developed
Mini Crystal Cam	Inuktum Services LTD	Tooling	Other	D&D	Developed

Table 2. Companies Contact Information

Company Name	POC	Physical Address	Phone Number	Fax Number	Email
Andrews Machinery Construction Supplies		1757 1st Ave. S, Seattle, WA 98134-1403	(206) 622-1121	(206) 622-3742	
BNFL Instruments	David Heath	BNFL Instruments, Inc. 4001 Office Court Drive, #800 Santa Fe, NM 87507	(505) 424-6660		
Carter Technologies Co	ErnieE. Carter	9702 Garden Row Drive, Sugar Land, TX 77478 USA	281-495-2603	281-495-0540	cartertech@prodigy.net
Cellular Bioengineering Inc. (CBI)	Michael Chun	1946 Young Street, Suite #288 Honolulu, Hawaii 96826	(808) 949-2208 Ext 146	(808) 949-2209	mchun@tecongel.com
Cybernetix (HQ-France)		Technopôle de Château-Gombert - BP 94 - 13382 MARSEILLE Cedex 13 - FRANCE	33 (0)4 91 21 77 00		nucleaire@cybernetix.fr
Demron-W	Dan Edward	PO Box 14-4254 Coral Gables, FL 33114	(866) 733-6766	(866) 533-6766	dedward@radshield.com
Pacific Northwest National Laboratory	Sharon A. Bailey	Energy Science & Technology Directorate PNNL P.O. Box 999, K5-08 Richland, WA 99352	(509) 375-2243	(509) 375-3614	sharon.bailey@pnl.gov
Dounreay Site Restoration Ltd (DSRL)	Jared Fraser	Dounreay, Thurso, Caithness, Scotland, KW14 7TZ	01847 802121	01847 802697	jared.fraser@dounreay.com
Fluor Fernald	P.J. Pettit	2923 Ashwood Dr. Loveland, OH 45140 USA			
Fluor Fernald (Media Relations)	Dave Hinaman	P.O. Box 538704 Cincinnati, Ohio 45253-8704	513.648.4899		
Areva		3315 Old Forest Rd Lynchburg, VA 24501-2912	(434) 832-3000	(434) 832-3663	
GE Inspection Technologies	Bob Anderson	GE Inspection Technologies 721 Visions Drive,Skaneateles, NY 13152	(804) 379-5645	(804) 379-5676	E bob.anderson@ge.com
Healthcare Robotics Lab at Georgia Tech	Charlie Kemp	Health Systems Institute, 2nd Floor Georgia Institute of Technology 828 West Peachtree Street, NW 2nd Floor Atlanta, GA 30332-0477	(404) 226-3301	(404) 385-7452	charlie.kemp@hsi.gatech.edu

Idaho National Engineering and Enviromental Laboratory					
Inuktum Services LTD	Milton Morris	23083 Highway 190 E Robert, LA 70455 United States of America	(985) 662-0755		milton.morris@inuktunusa.com
Lynntech Inc	Dr. Adrian Denvir	Lynntech Inc 7610 Eastmark Drive College Station, TX 77840	(214) 357-0800		adrian.denvir@lynntech.com
National Labs and Industry (Not Specified)					
National Nuclear Laboratory (NNL)	Christopher John Holmes	National Nuclear Laboratory, H260 Hinton House, Risley, Warrington, WA3 6AS, UK	+44(0)1925 834639		chris.holmes@nnl.co.uk
Nokia Research Centre					
NuVision Engineering (NVE)	Hank Kaczowka	2403 Sidney Street, Suite 700, Pittsburgh, PA 15203	(412) 586-1993	(412) 586-1811	kaczowka@nuvisioneng.com
Oak Ridge National Laboratory (ORNL)	Mark W Noakes	R&D Staff, Robotics and Energetic Systems Engineering Science and Technology Division ORNL Box 2008, Bldg 7601, MS6305 Oak Ridge, TN 37831-6305	(865) 574-5695	(865) 574-4624	noakesmw@ornl.gov
PaR System, Inc.					
Pentek, Inc					
Portage, Inc	B.D. Welty	1075 South Utah Avenue, Idaho Falls, ID 83402 USA			
RedZone Robotics		RedZone Robotics 484 West Seventh Avenue Homestead, Pa. 15120	(412) 476-8980	(412) 476-8981	
Royal Melbourne Institute of Technology University (RMIT)	Suresh Bhargava	RMIT University Building: 3, Level: 1, Room: 2 GPO Box 2476V Melbourne, Victoria 3001 Australia	(613) 9925 3691		suresh.bhargava@rmit.edu.au
Robotics and Remote Systems Section (SRNL)	Robert Fogle	Savannah River National Laboratory, BLDG 723-A, Aiken, SC 29808			robert.fogle@srnl.doe.gov
Savannah River Technology Center (SRTC)					

Schilling Robotics Headquarters					
Brokk (Nuclear & Military Sales)	Tony Marlow	1 Coral Bell Court, Santa Fe, NM 87508	(505) 699-8923		tony@brokkinc.com
Standford University	Andrew Ng	Computer Science Department, Stanford University Room 156, Gates Building Stanford, CA 94305-9010	(650) 725-2593	(650) 725-1449	ang@cs.stanford.edu
University of Massachusetts Amherst	Dov Katz		(413) 461-6187		katz@nsm.umass.edu
University of Regensburg	Mark Greenlee	Universität Regensburg Institut für Experimentelle Psychologie 93040 Regensburg Deutschland	0941-943-3281		mark.greenlee@psychologie.uni-regensburg.de
Unversity of Sheffied	Dr. Tony Dodd	University of Sheffield, Department of Automatic Control and Systems Engineering, S1 3JD	0114 222 5636		T.J.Dodd@sheffield.ac.uk
Carnegie Mellon University	Hagen Schempf	Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213	(412) 268-6884		hagen@frc2.frc.ri.cmu.edu.
Federal Energy Technology Center (FETC)	Vijendra Kothari	FETC, 3610 Collins Ferry Road, Morgantown, WV 26507-8880	(304) 285-4579		vkotha@fetc.doe.gov
Applied Research Center	Jose Varona	Applied Research Center - Florida International University 10555 W Flagler St Suite 2100 Miami FL 33174	(305) 348-6653	305-348-1852	varonaj@fiu.edu

Table 3. Brokk's Technology

Technology Name	Brief Description (Directly from Vendor)	Picture
Brokk 50	The smallest demolition robot in the Brokk family is Brokk 50. Originally introduced to strip down tiles in old bathrooms, Brokk 50 is able to pass through 60 cm wide doorways and is therefore the perfect machine wherever narrow openings have to be considered. It can be transported in a standard passenger elevator or even climb up and down ordinary stairways. The low weight of Brokk 50 enables it to be used in most normal buildings, even on weak floor structures. Its small dimensions also allow it to operate in very confined spaces, such as bathrooms of only 3 sq m floor area. **Key Features:** Weight: 470 kg (1036 lbs) Width min: 590 mm (23.2 in) Height min: 940 mm (37 in) Motor output: 5,5 kW Recommended max weight attachment: 70 kg (154 lbs)	
Brokk 90	Brokk 90 is one of the most versatile machines available on the market for demolition in confined spaces. It incorporates the best features of previous Brokk models and all the experience gained by Brokk operators and owners and fills the gap between our smallest Brokk 50 and the next size, Brokk 180. **Key Features:** Weight: 980 kg (2161 lbs) Width min: 780 mm (30.7 in) Height min: 1210 mm (47.6 in) Motor output: 11 kW Recommended max weight attachment: 150 kg (331 lbs)	

Brokk 180	The popular Brokk 180 is our medium range demolition robot. This flexible, all-round machine is suitable for many different demolition tasks in construction demolition but also in the cement, process and nuclear industries. Small size and great strength is a winning combination. Despite its low weight, Brokk 180 can be equipped with a breaker with a hitting power of as much as 410 joules. Breakers and concrete crushers are the most commonly used accessories, but bucket, grapple, steel shears and scabbler are also available. **Key Features:** Weight: 1930 kg (4255 lbs) Width min: 800 mm (31.5 in) Height min: 1392 mm (54.8 in) Motor output: 18,5 kW Recommended max weight attachment: 270 kg (595 lbs)	
Brokk 260	Our most wanted model is back in a new package, updated to a new high level to cope with even greater demands within the demolition industry. The Brokk 260 is a perfect all-round machine and the basic concept was developed in the mid 1970s. A powerful combination of reliable technology and continuous development are the basis of the precursor Brokk 250´s success around the world! The Brokk 260 covers up the gap between Brokk 180 and Brokk 400 since it has great capacity and remarkable hitting power. The machine is, however, small enough to work in tight spaces! The Brokk 260 is designed for different kind of demolition work in the construction industry but can be used equally well in the cement- and process industry. The machine is 1,8 ton lighter than the bigger Brokk 400 and enables strong attachments for example the Atlas Copco hydraulic breaker SB 302 and the Darda crusher CC520. The combination of light weight and the capacity to carry heavy tools makes the machine very efficient! **Key Features:** Weight: 3050 kg (6724 lbs) Width min: 1200 mm (47.2 in) Height min: 1530 mm (60.2 in) Motor output: 22 kW Recommended max weight attachment: 395 kg (871 lbs)	

Brokk 400	The Brokk 400 is the largest machine in the Brokk range and the most powerful demolition robot available on the market today. As with all Brokk machines, the capacity in relation to size and weight is unsurpassed. The Brokk 400 weighs 4800kg without attachment and can handle tools of up to 600 kilos in weight. Compare these figures with the weight of a conventional excavator equipped with the same type of breaker! The difference is that a Brokk machine is designed and built specifically for demolition purposes, thus optimized for this particular kind of job; it does it better than any other equipment available. **Key Features:** Weight: 4800 kg (10582 lbs) Width min: 1500 mm (59.1 in) Height min: 1722 mm (67.8 in) Motor output: 30 kW Recommended max weight attachment: 600 kg (1323 lbs)	
SB-52	Attachment for Brokk 50	
G-30	Attachment for Brokk 50	

RT-15	Attachment for Brokk 50	
CC-260	Attachment for Brokk 50	
SB-152	Attachment for Brokk 90	

Kinshofer skopa	Attachment for Brokk 90	
CC-320	Attachment for Brokk 90	
Hydrolic Dril	Attachment for Brokk 90	

SB-302	Attachment for Brokk 180	
Kinshofer skopa	Attachment for Brokk 180	
CC-420	Attachment for Brokk 180	

Hydrolic Dril	Attachment for Brokk 180	
SB-302	Attachment for Brokk 260	
CC-520	Attachment for Brokk 260	

Bucket-250	Attachment for Brokk 260	
SB-552	Attachment for Brook 400	
CC-560	Attachment for Brook 400	

Bucket-250	Attachment for Brook 400	

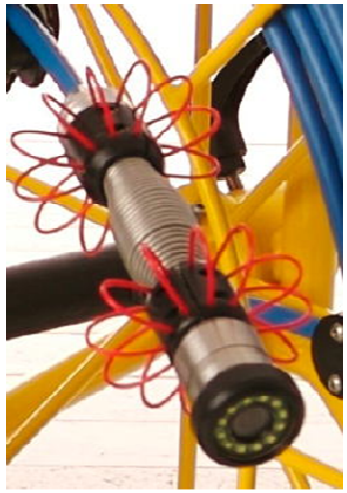
Table 4. Cellular Bioengineering Inc

Technology Name	Brief Description (Directly from Vendor)	Picture
Cellular Bioengineering Inc. (CBI)	DeconGel™ 1120/1121 is recommended for decontamination of radioisotopes as well as particulates, heavy metals, water-soluble and insoluble organic compounds (including tritiated compounds). The hydrogel coating can be applied to horizontal, vertical and inverted surfaces and can be applied to most surfaces including bare, coated and painted concrete, aluminum, steel, lead, rubber, plexiglass, herculite, wood, porcelain, tile grout and vinyl, ceramic and linoleum floor tiles. When dry, the product locks the contaminants into a polymer matrix. The film containing the encapsulated contamination can then be peeled and disposed of according to appropriate local, state and federal regulations.	

Table 5. Inuktun Technology

Technology Name	Brief Description (Directly from Vendor)	Picture
Minitracs™	Precision machined and incorporating high quality components, each Minitrac™ unit is fitted with a sealed, oil-filled, geared drive-train capable of submerged operation to a depth of 30 m / 100 ft. **Key Features:** Depth Rating: 30 m / 100 ft Speed: 10m / 32 ft per minute Pull Rating: 32 kg / 50 lb per track DIMENSIONS Height 100 mm / 4 in Width: 90 mm / 3.5 in Length: 380 mm / 15 in	
Microtracs™	By design, Microtracs™ units are small and rugged, providing the user with access to confined spaces and harsh environments. When operated in pairs the system is easily steerable, even in piping and ductwork. In a tripod assembly (Versatrax Vertical Crawler), the Microtrac™ units can travel vertically in a 20 to 30 cm (8 to 12 in) diameter pipe. **Key Features:** Depth Rating: 30 m / 100 ft Speed: 9 m / 30 ft per minute Pull Rating: 6.5 kg / 15 lb per track DIMENSIONS Height: 60 mm / 2.25 in Width: 50 mm / 2 in Length: 170 mm / 7 in	
Versatrax 100™	The Versatrax 100™ is a miniature crawler system capable of internal inspection within extremely small pipe sizes from a minimum internal diameter of 4 in / 10 cm. Despite its compact size, this system has the power to penetrate up to 600 ft / 180 m of pipe and overcome obstacles and offset joints. **Key Features:** Pipe diameter: min 4 in / 10 cm Depth rating: 100 ft / 30 m Tether cable: 600 ft / 180 m Speed: Up to 32 ft / 10 m per minute Payload: 24 lb / 10.8 kg Camera: Color, pan, tilt, color rear auxiliary Option: 7 in Monitor with built-in DVR	

Versatrax 150™	The Versatrax 150™ is a modular, long range internal pipe inspection system capable of operation within a variety of pipe sizes from a minimum internal diameter of 150 mm / 6 in. **Key Features:** Pipe diameter: min 6 in / 150 cm Depth rating: 100 ft / 30 m Tether cable: 500 ft / 160 m (up to 1500 ft / 457 m optional) Multi Conductor, Abrasion Resistant Rilsan Speed: Up to 30 ft / 9 m per minute Payload: 200 lb / 92 kg Camera: Color, pan, tilt, zoom, color rear auxiliary Option: 7 in Monitor with built-in DVR	
Versatrax 300VLR™	The solution to long-range pipe inspection challenges: inspect more than a mile of pipe in a single run. The Versatrax 300™ is compatible with piping of 300 mm / 12 inch internal diameter and greater. **Key Features:** Pipe diameter: min 12 inches / 300 mm Depth rating: 100 ft / 30 m Tether cable: 6500 ft / 1981 m Speed: 0 – 30 ft / 0- 9 m per minute Payload: 184 kg / 400 lb Camera: Color, pan, tilt, zoom, color rear auxiliary	

Crystal Cam® Push Camera	The low-cost Crystal Cam® Push Camera is a unique, high-performance color video camera system that is designed for lateral and mainline pipe push inspections. This compact, lightweight readily affordable camera system has built-in LED lighting and a high resolution; the low lux camera is highly effective in low light environments. The camera head is completely encased in transparent epoxy, making it virtually indestructible with a lightweight portable tether reel for turn-key pipe inspection applications. **Key Features:** Diameter: 44.5 mm / 1.75 in Push Camera Assembly Length: 32 cm / 12.5 in Depth Rating: 300 m / 1000 ft Min. Pipe Diameter 50 mm/ 2 in **Camera:** Type: ¼ in Color CCD Resolution: 400 TV lines Sensitivity: 1.0 lux Lights: 12 LEDs Variable intensity Option: 7 in Monitor with built-in DVR	
Crystal Cam®	The low-cost Crystal Cam® camera, designed and developed by Inuktun, is a unique, high-performance micro video camera that is compact, lightweight and readily affordable. With built-in LED lighting and a high resolution, the low lux camera, the Crystal Cam® is highly effective in low light environments. The camera head is completely encased in transparent epoxy making it virtually indestructible operating in the most confined spaces, hazardous areas and to depths of 300 m / 1000 ft. **Key Features:** Diameter: 1.5 in / 37.5 mm Length: 2 in / 50 mm Depth Rating: 1000 ft / 300 m **Camera:** Type: ¼ in Color CCD Resolution: 400 TV lines Sensitivity: 1.0 lux Lights: LEDs Up to 50,000 hours Variable intensity Option: 7 in Monitor with built-in DVR	

Spectrum 45™ Camera	The Spectrum 45™ PT Camera is extremely compact and powerful, providing the perfect solution to a wide range of inspection challenges unique to every industry. **Key Features:** Diameter: 1.75 in / 45 mm Length: 4.1 in / 104 mm (plus connector) Depth Rating: 100 ft / 30 m **Camera:** Type: Color ¼ in CMOS Resolution: 420 TV lines (vertical) Sensitivity: 1.0 lux Lights: Variable intensity Option: 7 in Monitor with built-in DVR	
Spectrum 90™ Camera	The amphibious Spectrum 90™ Pan, tilt and zoom camera is the perfect solution to a wide range of inspection challenges. **Key Features:** Diameter: 3.5 in / 90 mm Length: 11 in / 280 mm Plus connector Depth Rating: 100 ft / 30 m (1000 ft / 300 m is available as an option) **Camera:** Type: Color 1/4 EX VIEW CCD Resolution: 460 + TV lines Zoom: 40:1 (10 X Optical; 4 X Digital) Sensitivity: < 1.5 lux Lights: Variable intensity Option: 7 in Monitor with built-in DVR	

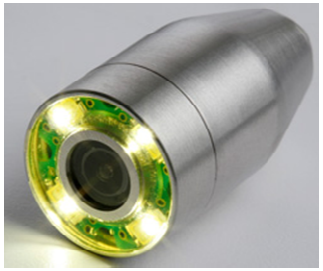
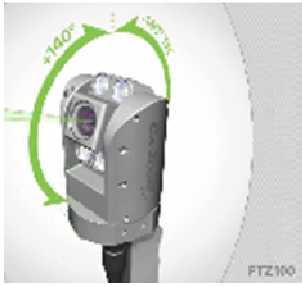
Spectrum 150 Camera	The amphibious Spectrum 150™ pan, tilt and zoom camera carries unique features designed with end users in mind. The 360° continuous pan and 360° tilt reduces the need for repositioning the camera. Plus, with its 432 X zoom, you can see further than is possible with most of the other cameras on the market. The Spectrum 150™ makes inspection easier and quicker. **Key Features:** Diameter: 6 in / 150 mm Length: 15 in / 286 mm Depth Rating: 100 ft / 30 m **Camera:** Resolution: 460 + TV lines Zoom: 432:1 (36 X Optical; 12 X Digital) Lights: Variable intensity Option: 7 in Monitor with built-in DVR	
SP-120 Camera	In Develop. It consist of a HD Imager.	No Picture Available Yet
Mini Crystal Cam	At only a 7/8 in (22 mm) diameter, the Mini Crystal Cam allows inspection in extremely small pipes and confined spaces. The high quality color camera offers excellent image quality and has built-in LED lighting. Combining an external stainless steel housing and internal potted electronics makes the camera extremely durable and ideal for operation in the most extreme conditions. With a depth rating of 1,000 feet (300 metres), the Mini Crystal Cam can go almost anywhere you need it. **Key Features:** Diameter: 0.875 in / 22 mm Length: 2 in / 50 mm Minimum Pipe Diameter: 1 in / 25 mm Depth Rating: 1000 ft / 300 m **Camera:** Type: ¼ in Color CMOS Resolution: 420 TV lines Sensitivity: 1.0 lux Lights: LEDs Up to 50,000 hours Variable intensity	

Table 6. GE Technology Inspection's Technology

Technology Name	Brief Description (Directly from Vendor)	Picture
Everest Ca-Zoom 6.2 - PTZ70 Head	The Everest Ca-Zoom® 6.2 system is the world's most advanced industrial pan-tilt-zoom camera system. The system features still image or full-motion video capture, CompactFlash® removable storage media, comparison measurement and PC remote control and re-measurement software. The PTZ70 camera head can be deployed through 76 mm (3.0 inch) diameter openings and features a high-performance 10x optical and 4x digital zoom capability, eight high-powered LED lighting, and advanced camera setup features with our exclusive iVIEW™ image management platform.	
Everest Ca-Zoom 6.2 - PTZ100 Head	The Everest Ca-Zoom® 6.2 system is the world's most advanced industrial pan-tilt-zoom camera system. The system features still image or full-motion video capture, CompactFlash® removable storage media, an available laser measurement system, and PC remote control and re-measurement software. The PTZ100 camera head can be deployed through 100 mm (4.00 inch) diameter openings, and features a high-performance 10x-optical and 4x-digital zoom capability, high-powered LED lighting, and advanced camera setup features with our exclusive iVIEW™ image management platform.	
Everest Ca-Zoom 6.2 - PTZ140 Head	The Everest Ca-Zoom® 6.2 system is the world's most advanced industrial pan-tilt-zoom camera system. The system features still image or full-motion video capture, CompactFlash® removable storage media, an available laser measurement system and PC remote control and re-measurement software. The PTZ140 camera head can be deployed through 140 mm (5.5 inch) diameter openings and features a high-performance 36x-optical and 12x-digital zoom capability, high-powered halogen lighting, and advanced camera setup features with our exclusive iVIEW™ image management platform.	

Rovver 400	A compact yet powerful inspection tool, the ROVVER® 400 robotic crawler is valued around the world for its rugged versatility. The ROVVER 400 features a unique modular design and lighting for maximum adaptability. The system also provides full-directional viewing in 100mm (4 inch) or greater horizontal pipeline with its pan-and-tilt or forward-viewing video camera. Both cameras have remote adjustable focus for a clear view at all times. The ROVVER crawler features a remote pendant to control focus and lighting and to steer the crawler when obstacles, such as debris or offsets, are present. **Key Features:** Length: 247 mm (9.7 in.) with axial camera, 339 mm (13.4 in.) with pan-and-tilt camera Width: 94 mm (3.7 in.) Height: 80 mm (3.2 in.) Weight: 4.5 kg (9.9 lbs.)	
Rovver 600	The ROVVER® 600 robotic crawler is the most portable and versatile inspection crawler on the market today. It is ideal for many applications due to its modular design and ability to inspect inside pipes with diameters ranging from 150 mm (6 in.) to 900 mm (36 in.). As the smallest crawler in its class, the ROVVER 600 can pass through restricted pipe, large offsets and protruding pipe taps. The ROVVER crawler features a remote pendant to control focus and lighting and to steer the crawler when obstacles, such as debris or offsets, are present. **Key Features:** Length: 282 mm (11.1 in.) with axial camera, 374 mm (14.7 in.) with pan-and-tilt camera Width: 118 mm (4.6 in.) Height: 90 mm (3.5 in.) Weight: 8kg (17.6 lbs.)	
Rovver 900	When you need an adjustable viewing height range and the power to inspect rough terrain, the ROVVER® 900 system is the inspection crawler to use. For optimum, large-diameter, 225 mm to 1500 mm (9 in. to 60 in.) pipe inspection, the ROVVER 900 features a pendant-controlled lift platform that adjusts the camera height from 150 mm to 300 mm (6 in. to 12 in.). The camera can stay centered in the pipe for optimum magnification and undistorted inspection in any viewing direction. This all-wheel-drive, rugged crawler is high-powered to move easily over debris and around multiple elbows. The remotely-operated clutch can release the wheels, allowing the operator to pull the crawler back in a free-wheeling operation. **Key Features:** Length: 488 mm (19.2 in.) with axial camera, 582 mm (22.9 in.) with pan-and-tilt camera Width: 200 mm (7.9 in.) Height: 150 mm (5.9 in.) Weight: 25 kg (55 lbs.)	

Articulating Fiberscopes	GE Inspection Technologies provides high-resolution articulating flexible fiberscopes, featuring densely-packed, 7-micron diameter imaging fibers to reveal more detail than other scopes, in diameters as small as 2.4 mm. **Key Features:** Lengths: 0.7 to 2.7 m (2.3 to 8.8 ft.) Diameters: 2.4, 3.3, 4.0, 5.0, 6.0, 8.4, 13.5 mm Direction-of-View: 0º and/or 90º Field-of-View: 45º and 60º	
Mini-Flex Fiberscope	High-resolution Mini-Flex fiberscopes from GE Inspection Technologies feature densely-packed, 7-micron diameter imaging fibers to reveal more detail than other scopes for extremely small access applications, in diameters as small as 0.5 mm. **Key Features:** Lengths: 0.25 to 2.0 m (0.83 to 6.6 ft. Diameters: 0.5, 1.0, 1.5, 2.0 mm Direction-of-View: 0º Field-of-View: 55º and 70º	
Rotary Scan Borescope	Rotary Scan borescopes, by GE Inspection Technologies, feature an optional integral zoom and allow 360° rotational viewing without moving the body of the scope. Rotary Scan rigid borescopes are available in 4 mm, 5 mm, 6 mm, 8 mm and 10 mm diameters and include a variety of directions and fields-of-views. **Key Features:** Lengths: 14 to 158 cm (5.5 to 62 in.) Diameters: 4.0, 5.0, 6.0, 8.0, 10.0 mm Direction-of-View: 0º, 45º, 70º, 90º, 110º Field-of-View: 35º, 56º/60º, 70º and 90º Benefits: 360º circumferential inspection without moving scope body	

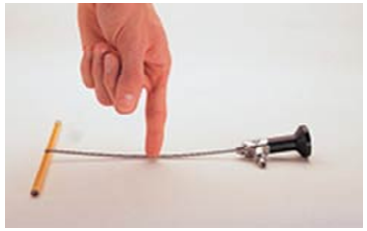
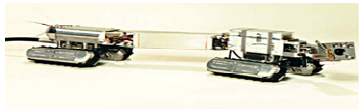
Swing Prism Borescope	Swing Prism rigid borescopes, by GE Inspection Technologies, can fulfill the function of two or three separate conventional borescopes. The direction-of-view is adjustable from 55° to 115° and scans an object's entire length. A zoom feature magnifies the entire image, unlike conventional zoom features that simply narrow the field-of-view. Additionally, the rotating barrel allows 360° viewing without moving the body of the scope. Swing Prism borescopes are available in 6, 8 and 10 mm diameters. **Key Features:** Lengths: 25 to 69 cm (10 to 27 in.) Diameters: 6.0, 8.0, 10.0 mm Direction-of-View: 55º - 115º Adjustable Field-of-View: 35º and 50º Benefits: Variable direction-of-view does the job of multiple scopes	
Mini Rigid Borescope	Mini Rigid borescopes, by GE Inspection Technologies, are uniquely constructed to better tolerate accidental bending than conventional small-diameter borescopes—without compromising image quality. A patented, short rod-lens optical system provides outstanding brightness and depth-of-field from 1mm to infinity, as well as exceptional bending tolerance. Mini Rigid borescopes are available in 1.7, 1.9 and 2.7mm diameters and lengths from 6cm to 26cm. **Key Features:** Lengths: 6 to 26 cm (2.4 to 10 in.) Diameters: 1.7, 1.9, 2.7 mm Direction-of-View: 0º, 30º, 70º (90º available with Mirror Tube) Field-of-View: 65º and 80º Benefits: Unique short rod-lens design offers exceptional clarity and reduces breakage	

Table 7. NuVision Technology

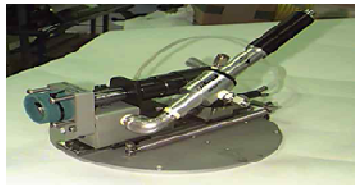
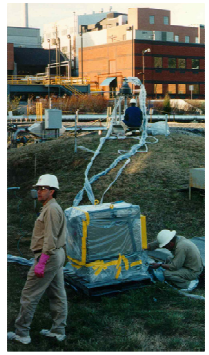
Technology Name	Brief Description (Directly from Vendor)	Picture
Artisan Manipulator	NuVision Engineering's ARTISANTM telerobotic heavy-duty hydraulic manipulators and control systems are specifically for hazardous environment/material handling applications. The ARTISAN™ is a robust, reliable, modular workhorse that can be easily maintained and operated. It has achieved very high levels of availability even in the most demanding of applications, with over 100,000 operating hours of service at 97% reliability in harsh and radioactive environments.	
Raptor 150/300 Manipulator	The RAPTOR® is designed for deployment on all-terrain, unmanned ground vehicles (UGVs), robotic combat support systems (RCSS) and all-purpose robotic transport systems (ARTS), as well as other heavy-duty equipment such as excavators or in fixed mount applications. In addition to being rugged, reliable and robust, Raptors provide the user with the capability to operate in extremely hazardous environments from a safe distance, thereby minimizing risk to the operator.	
Waste Treatment Sponge	The NuVision Engineering system uses grit incorporated into a soft (sponge like) media. As the media particles are blasted out of a nozzle using compressed air, they hit the substrate, flatten out and decontaminate the surface with the abrasive grit. The soft media matrix then closes around the contaminant, trapping it in the sponge matrix and thereby reducing the potential for airborne contaminants.	

Table 8. Oak Ridge National Laboratory's Technology

Technology Name	Brief Description (Directly from Provider)	Picture
Internal Duct Characterization System (Tech ID 42)	The Internal Duct Characterization System (IDCS) consists of a control station, a reel-mounted tether for data communication, video and power, and the duct crawling vehicle. The IDCS vehicle can travel over 200 feet in round ducts 6 inches in diameter and larger and in rectangular ducts 6 inches square and larger. The vehicle visually inspects the interior condition of ducts using a high-resolution color video camera and has an integrated radiation sensor to detect significant levels of radioactivity. The entire vehicle is made from stainless steel and is designed to be decontaminated. The IDCS system also provides limited contaminant sampling and decontamination capabilities.	
Remote Underwater Characterization System (Tech ID 2151)	The Remote Underwater Characterization System (RUCS) is based on a small, commercially-available submersible vehicle. The submersible vehicle itself is approximately 12 inches long, 9 inches wide and 6 inches tall. The small size of the vehicle allows it to operate in areas where access is tight or where maneuvering room is limited. The system is very inexpensive when compared to others of similar capability. The vehicle has underwater lights, a front color camera, and a rear black and white camera. It is operated over a 125-feet neutrally buoyant tether and is capable of operating at depths up to 100 feet. The Robotics Crosscutting Program (Rbx) has added an on-board compass, a depth sensor and a gamma radiation detector. An 'auto-depth' control feature has also been implemented to allow the vehicle to 'hover' at a user-selected depth.	
Canyon Disposition Initiative Remote Characterization System (Tech ID 2178)	The Canyon Disposition Initiative (CDI) Remote Characterization System is a robotic characterization platform for use in the 221-U facility (U-Plant) at Hanford. It is designed for fully remote collection of characterization data such as gross gamma readings, video and smear samples. The photo shows the system deployed in the U-Plant railroad tunnel.	

Modified Brokk Demolition Machine (OST Tech ID 2938)	The Modified BROKK Demolition Machine with Remote Console combines a commercially available BROKK demolition system with the Compact Remote Operator Console (TMS ID 2180) to extend the applicability of the BROKK system to projects that require removal of the operator from the work area due to exposure to radiological, chemical or industrial hazards. The Robotics Crosscutting Program has developed modifications to a BROKK to provide remote viewing and tool control capabilities. The modified BROKK has been integrated with the Compact Remote Operator Console to provide a true remotely operated low-cost D&D system applicable to a wide range of small D&D demolition tasks across the DOE complex.	
Compact Remote Operator Console (OST Tech ID 2180)	The compact remote operator console provides an economical solution to remote systems control in a portable and modular fashion. It is based on a single box meant to be wheeled in through a standard size personnel entry door, opened up and folded out rapidly into a working system. Weight, power, consumption, ease and speed of setup are emphasized. Remote viewing and graphical user interface are provided via flat panel screens arranged as a video cylinder in front of the operator. A control chair is the central focal point, using side consoles for remote viewing and peripheral control inputs. High-level control provided for the remote system is supplied via a separate control box.	
Telerobotic Manipulation System (OST Tech ID 2181)	The Telerobotic Manipulation System was established as a project within the Rbx D&D product line as a new start in FY 1999. From Rbx interactions with the Tanks Focus Area, there is a similar near-term need for a remote system to perform decontamination of pits associated with underground storage tanks at Hanford. The Rbx D&D activity was merged with the Rbx Tank Waste Retrieval (TWR) project for development of a prototype system. The Rbx D&D product line will assist in concept development and may provide operator console and telerobotic controls technologies for use in the prototype. The long-term target for D&D deployment of a system is within the Canyon Disposition Initiative for D&D of the canyon process cells.	

Remotely Operated Vehicle (ROV) System for Horizontal Tanks (Tech ID 2086)	Many waste characterization and retrieval tasks can be performed remotely using a mobile vehicle system with on-board manipulator, cameras and lights. The Robotics Crosscutting Program (Rbx) is developing a general purpose, remotely operated work platform capable of deployment through 18-inch risers for operation in horizontal waste storage tanks. The system will also include a waste dislodging and conveyance system, a tank riser interface and a containment system. The base vehicle is an adaptation of the Scarab IIA vehicle built by ROV Technologies for reactor maintenance. The resulting system is known as the Scarab III.	
Remotely Operated Vehicle (ROV) System for Horizontal Tanks Operator Panel (Tech ID 2086)	Remotely Operated Vehicle (ROV) Operator Panel	
Heavy Waste Retrieval System (Tech ID 2194)	The Tank's Focus Area and the Robotics Crosscutting Program are developing a system for removing waste heels remaining in large underground waste storage tanks like those found at Oak Ridge, Savannah River, and Hanford. This system could be deployed following bulk sludge retrieval and would be designed to remove essentially all visible sludge. This system operates in conjunction with the Modified Light-Duty Utility Arm, Houdini and Confined Slucing System at Oak Ridge National Laboratory. The heavy waste retrieval system provides a process tank for adding supernate to the output of the Confined Slucing End Effector to maintain acceptable minimum waste flow.	

Tank Riser Pit Decontamination System (Tech ID 2195)	The Tank's Focus Area and the Robotics Crosscutting Program are developing a system for preparing riser pits for reuse. There are about 600 of these riser pits at Hanford on the single-shell tanks. These pits contain numerous contaminated pipes and tools that must be removed as well as accumulated sludge waste in the bottom of the pits. Radiation exposures can be as high as 50 rads/hr. Since the cost of installing new risers is estimated at millions of dollars for each, it is highly attractive to reuse existing risers. This joint project was a new start in FY 1999. Requirements were defined, and a design concept was developed in FY 1999. By the end of FY 2000, a field deployable system will be in procurement. A similar requirement is needed for deactivation and dismantlement of pit facilities across the DOE. This system will be defined for ease of mobility from tank to tank.	
Sampling End-Effector for West Valley Tanks (Tech ID 2941)	The West Valley Demonstration Project has been removing sludge successfully using mixer pumps for several years, but has reached the point where most of what remains is a, difficult to access, heel. The Robotics Crosscut Program is developing a grab sampling end-effector that will allow representative samples of the remaining waste heel to be collected in Tanks 8D-1 and 8D-2. This end-effector will be designed for deployment by the mast tool delivery system and will also include provisions for subsequent transport of the sample to the lab for analysis.	
Remote Technologies for High-Level Waste Tank Component Maintenance and Disposal (Tech ID 2943)	Much of the equipment associated with high-level waste tank processing equipment is long-length and highly contaminated. When this equipment requires maintenance or decontamination and disposal, remote technologies are needed to reduce worker exposures and increase operating efficiencies. Existing and upcoming technologies will be tested and assessed. Based upon the results, a suite of components will be selected and integrated into a long-length component deactivation and decommissioning system.	

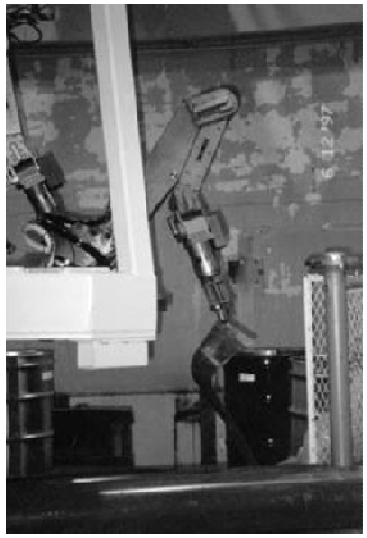
Dual Arm Work Platform Teleoperated Robotics System	The Dual Arm Work Platform (DAWP) system was used to perform mechanical dismantlement of the radioactive reactor and bio-shield structures. The DAWP manipulated standard, commercially available tools (i.e., circular saws, jackhammers, etc.) using two Schilling Titan III hydraulic, teleoperated manipulator arms that were controlled from a remote location. At the CP-5 reactor facility, the two arms were mounted to a steel work platform (DAWP) designed to hold the associated tooling, utilities, and cameras supporting the operation of the manipulator arms and providing a sturdy base for lifting the assembly into the reactor assembly using the facility's polar crane. Once positioned the system segmented, dismantled and moved the radioactive material to a transfer canister. Operators would use the DAWP in conjunction with Rosie, a tethered, teleoperated robotic system to off-load radioactive materials to a lower radiation dose staging area for final manual packaging into appropriate disposal/transport containers. Aluminum, lead, boral and graphite low level radioactive waste was size reduced by the DAWP and handled in this manner throughout this demonstration.	
Mobile Automated Characterizaion System (MACS)	The Mobile Automated characterization System (MACS) has been developed by Oak Ridge National Laboratory and the Savannah River Technology Center for the U.S. Department of Energy's Robotics Technology Development Program. MACS are a commercially available, battery-powered, autonomous robot base supplemented by a laser positioning system and a scintillation detector array. MACS can detect alpha and beta contamination, and moves over floors at a speed of one inch per second. MACS was designed to automate the collection, storage and analysis of large, open floor areas, relieving the HP personnel of this portion of the floor characterization task. MACS does not require a dedicated full time operator and can be set up by the normal HP staff to survey the open areas while other techniques are used on the more constrained areas. MACS is designed for unattended operation and has safety and operational monitoring functions, which will safely shut the system down if any difficulties are encountered.	

Table 9. Pacific Northeast National Laboratory's Technology

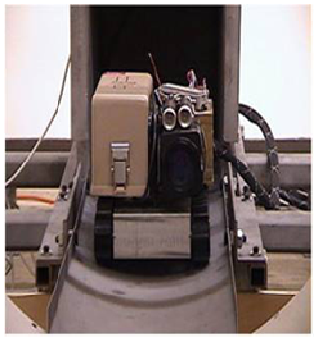
Technology Name	Brief Description (Directly from Provider)	Picture
Gamma Rover Crawler (Grover)	The Gamma-Rover is a remotely-operated, mini-tracked crawler that has been assembled to obtain visual characterization and dose profiling data in contaminated ventilation ducting that exhausts air from hot cells. It is an electrically powered, dual-tracked crawler equipped with gamma radiation sensors and video cameras. The deployment platform is made of 1-inch steel to provide radiation shielding. Gamma Rover is a skid-steered vehicle, whereby turning is accomplished by having one track move forward while the other track moves backward or remains stationary. The crawler has been designed to drive and automatically track in round duct. However, to provide an indication of stability, a whiteline dangle meter is provided in the forward directed camera; if the vehicle should tilt, this line moves to either the lower right or lower left. A hand-held pendant has rocker switches for vehicle/camera control and a master on/off switch. A second pendant provides controls for a wincbhether drive.	

Table 10. RMIT's Technology

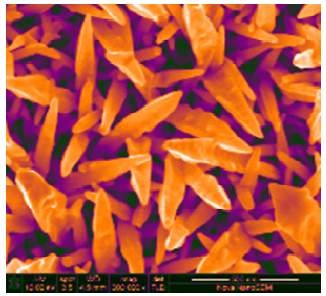
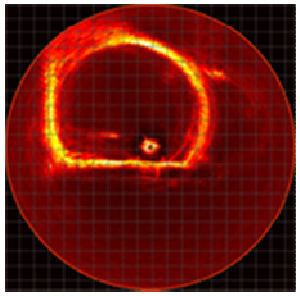
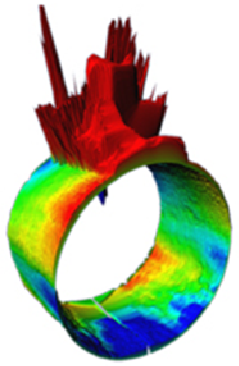
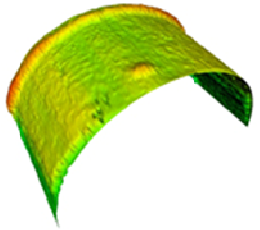
Technology Name	Brief Description (Directly from Vendor)	Picture
Gold Nanostructure Spikes	The mercury sensor developed by RMIT's Industrial Chemistry Group uses tiny flecks of gold that are nano-engineered to make them irresistible to mercury molecules.	

Table 11. RedZone's Technology

Technology Name	Brief Description (Directly from Vendor)	Picture
Red Zone Sonar	Provides location and volume of sediment and debris by measuring the inside pipe diameter and comparing to the as-built diameter. **Features:** Operates at multiple frequencies from 650 KHz to 2 MHz within pipes that are 36 inches to 21 feet in diameter Accurate in fully- or partially-submerged conditions Generates precise pipe cross-sections via dwell scan Used for Sonar report	
Red Zone 3D Laser	Measures pipe inside diameter with great precision (above water line). **Features:** Unique spinning configuration Generates 3D color images of pipe inside surface Used for 3D Laser report	Picture not Available
Inertial Measurement Unit (IMU)	Measures location of robot in 3D space (pitch, roll & yaw). **Features:** Accelerometers and gyroscopes Location and movement used by other sensors	

H2S Gas Analyzer & Temperature	H2S Gas Analyzer & Temperature Measures hydrogen sulfide gas - H2S and temperature. **Features:** Measures H2S concentration to 1 ppm Also measures temperature to 1 degree Used for H2S Gas report	Picture not Available
CCTV Pipe Inspection	Measures visual defects. **Features:** 24 frames per second video capture 0.6 Mega-pixels per frame Coded to PACP or WRC standards Used for CCTV report	
Responder	The Responder™ robotic platform is targeted for critical wastewater infrastructure, primarily large diameter pipe. Weighing 650 pounds and with a 3.5HP hydraulic engine, it can travel more than 1 mile through challenging conditions to inspect sewer pipe unreachable by traditional crawlers. RedZone uses the Responder routinely for 84" pipe and has successfully inspected 21 foot diameter pipe with accurate results. **Specifications:** Deployment length: 6,600 feet Maximum depth: 500 feet Max speed: 30 feet / sec Up to 8 axes of motion Load cell for monitoring umbilical tension Skid steer independent track operation	

5. CONCLUSIONS AND FUTURE WORK

As a result of this research a total of 116 technologies were found, categorized, and organized into the compendium. Out of this 116 technologies, 31 can be applied in the field of characterization, 9 can be applied in the field of decontamination, 26 in the dismantling field, and 50 technologies are considered tools.

At this point the compendium can be used but is not completed. There are more technologies that could be identified and incorporated, but not in the ten weeks period of this internship. Therefore, the research will be continued by the DOE Fellow upon his return to FIU-ARC. All additional research will be subsequently incorporated into a revision of the Excel tool.

Since this compendium has technologies that the GET system does not have, and vice versa, there is a potential for joining the compendium database with the GET system. This will happen while the GET system merges into the Knowledge Management Information Tool (KM-IT) system. In order to incorporate the data into the KM-IT system the compendium data has to be reviewed, and reformatted to meet the KM-IT's format. Additional work will be done to improve the KM-IT system such as categorizing technology demonstration videos supplied by the DOE, and the continuation of the research on new technology. It is recommended to develop a new list of D&D experts. This list will include the DOE-EM personnel, DOE contractors, academia and site personnel that are considered experts in the field of D&D.

6. REFERENCES

[1] U.S. Department of Energy, *Deactivation and Decommissioning (D&D) Multi-Year Program Plan FY2009 – 2011*

[2] Y-12 National Security Complex, "This is Y-12," Video Documentary.

[3] AEA Technology Engineering Services, Inc., "*ORNL Remote Operations for D&D Activities Final Report*," March 2007.

[4] Applied Research Center, Gateway to Environmental Technologies database, http://www.dandd.org/default.aspx, Florida International University. .

Appendix A. Compendium Manual

This compendium can be used in Microsoft Excel 2007 and previous editions. For simplicity, the manual will teach how to use the compendium with only the first 23 lines of the compendium as illustrations. Anytime that the user wants to go back to all the available technologies, the user will need to check the "(Select All)" box in all the customized filters.

Search Technology

The simplest search in this compendium is with a known name. With a known name, simply click on the filter arrow in the "Tech Name" column and click the desired technology name. Note: The technology will be in alphabetical order in the filter. In Figure 2, the user has selected the technology name Brokk 400. After selecting the desired technology, click on the OK button. This will display the categorization of that specific technology, as seen in Table 12.

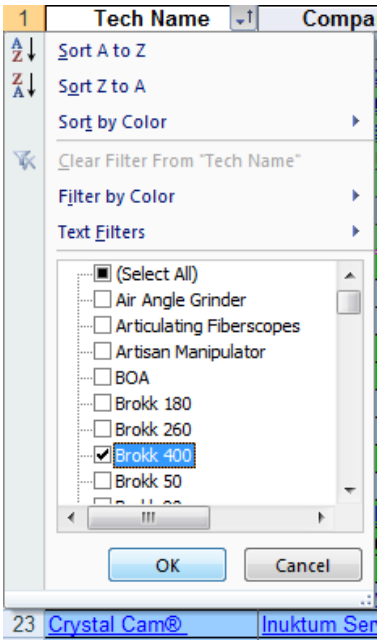


Figure 2: Searching compendium by technology name.

Table 12. Display of Technology Searching by Technology Name

Tech Name	Company	Field	Technology	D&D / Applicable	In Develop / Developed
Brokk 400	Brokk	Dismantler	Robotic	D&D	Developed

Another option to find a specific technology is through the company. Click on the filter arrow of the "Company" column, to select the desired company, as shown in Figure 3. Once the desired company is selected, click on the OK button, and all the technologies developed by that given technology will be displayed (Table 13).

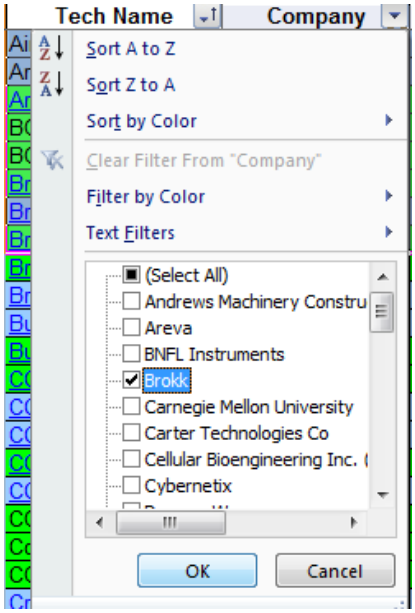


Figure 3: Searching compendium by company name.

Table 13. Display of Technologies Searching by Company

Tech Name	Company	Field	Technology	D&D / Applicable	In Develop / Developed
Brokk 180	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 260	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 400	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 50	Brokk	Dismantler	Robotic	D&D	Developed
Brokk 90	Brokk	Dismantler	Robotic	D&D	Developed
Bucket-250	Brokk	Tooling		D&D	Developed
Bucket-250	Brokk	Tooling		D&D	Developed
CC-260	Brokk	Tooling		D&D	Developed
CC-320	Brokk	Tooling		D&D	Developed
CC-420	Brokk	Tooling		D&D	Developed
CC-520	Brokk	Tooling		D&D	Developed
CC-560	Brokk	Tooling		D&D	Developed
G-30	Brokk	Tooling		D&D	Developed
Hydrolic Dril (B-180)	Brokk	Tooling		D&D	Developed
Hydrolic Dril (B-90)	Brokk	Tooling		D&D	Developed
Kinshofer skopa (B-90)	Brokk	Tooling		D&D	Developed
Kinshofer skopa (B-180)	Brokk	Tooling		D&D	Developed
RT-15	Brokk	Tooling		D&D	Developed
SB-152	Brokk	Tooling		D&D	Developed
SB-302 (B-180)	Brokk	Tooling		D&D	Developed
SB-302 (B-260)	Brokk	Tooling		D&D	Developed
SB-52	Brokk	Tooling		D&D	Developed
SB-552	Brokk	Tooling		D&D	Developed

If no specific technology or company is known, the technology can be found by identifying the field of work needed followed by the technology type, whether or not the technology was made for D&D purposes, and whether it has been developed or is in development. By selecting the categories available the user can narrow down the results.

Company's Contact Information

After obtaining the technology needed from the compendium, the company name can be clicked to obtain the company's contact information, which will include the point of contact (POC), a physical address, the phone number, the fax number and the email, if supplied by the vendor.

Technology's Description and Picture

In order to obtain a brief description and key features provided by the supplier of the technology, simply click on the name of the technology and the Excel Sheet will bring up the sheet on which that technology is displayed, as well as all the other technologies developed by the same company. As an example, by selecting the technology "Brokk 50" the information shown in Table 14 will be displayed.

Table 14. Display of Description and Picture of Technology

Technology Name	Brief Description (Directly from Vendor)	Picture
Brokk Machinery		
Brokk 50	The smallest demolition robot in the Brokk family is Brokk 50. Originally introduced to strip down tiles in old bathrooms, Brokk 50 is able to pass through 60 cm wide doorways and is therefore the perfect machine wherever narrow openings have to be considered. It can be transported in a standard passenger elevator or even climb up and down ordinary stairways. The low weight of Brokk 50 enables it to be used in most normal buildings, even on weak floor structures. Its small dimensions also allow it to operate in very confined spaces, such as bathrooms of only 3 sq m floor area. **Key Features:** Weight: 470 kg (1036 lbs) Width min: 590 mm (23.2 in) Height min: 940 mm (37 in) Motor output: 5,5 kW Recommended max weight attachment: 70 kg (154 lbs)