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7. Abstract

Tank Waste Remediation Systems functional requirements were reviewed. The Light Duty Utility Arm capabilities were considered as a means to support completion of these functional requirements. The recommendation is made to continue to develop the LDUA, integrating TWRS functional needs into the design to better support completion of TWRS mission needs.

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EXECUTIVE SUMMARY

The Light Duty Utility Arm is being developed in a joint effort by the Westinghouse Hanford Company, private industry, and several national laboratories. The project is sponsored by the U.S. Department of Energy, Office of Technology Development. This report investigates the potential application of the LDUA with respect to meeting the mission needs of the Tank Waste Remediation System (TWRS).

Light Duty Utility Arm capabilities were considered as a method to accomplish the indicated functional requirements of tank waste remediation. The LDUA was identified as a means of supporting many TWRS functions, some of which are significant milestones in the Hanford Site cleanup mission. An evaluation was not made to determine if the LDUA is the optimum alternative to meet the identified functional requirements. However, due to the large number of potential applications, it was assumed that the LDUA would be the preferred alternative for at least some requirements. Additionally, a key feature of the LDUA system is its ability to support many separate functions during a single tank entry. This enables the cost and risk associated with tank entry to be borne by several users, reducing the cost and risk to each individual user. This can also reduce the total number of separate tank entries required. The LDUA should be viewed as an alternate means of performing various TWRS support functions.

A recommendation is made to continue to integrate the TWRS functions and requirements into development of the LDUA. Additional considerations, such as safety, post-TWRS missions, and Hanford Site technology initiatives, are identified and discussed herein.

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TANK WASTE REMEDIATION SYSTEM LIGHT DUTY UTILITY ARM UTILIZATION STUDY REPORT

1.0 INTRODUCTION

The Tank Waste Remediation System (TWRS) mission is to store, treat, and ultimately dispose of Hanford Site tank waste in an environmentally sound, safe, and cost-effective manner. There are 149 single-shell tanks (SST) in the 200 Area tank farms. Major milestones necessary to move toward the final closure of these tanks include waste characterization, monitoring, and retrieval. The milestones are specifically defined and scheduled in the *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement (Ecology et al. 1994). Because of the hostile environment in the tanks, manned entry into the tanks is impossible. This has led to the recognition of robotics as a possible method of performing required operations in the tanks. Robotics technology has been used successfully in other industries, including the space program, nuclear fuels production, and the defense industry, where the operating environment precludes direct human contact.

1.1 BACKGROUND

Westinghouse Hanford Company (WHC), under sponsorship by the U.S. Department of Energy's (DOE) Office of Technology Development (EM-50), has been studying available robotics technology for use in the Hanford Site tank farms. An articulated robot arm system known as the Light Duty Utility Arm (LDUA), capable of deploying a variety of end effectors within the tanks using existing risers, is being developed by a vendor. The LDUA preliminary design has been approved, and a contract has been awarded to the vendor to supply a working model during the latter part of fiscal year 1995. Westinghouse Hanford Company, under the sponsorship of the DOE's Office of Waste Operations (EM-30), has commissioned this study to determine the ability of the LDUA to satisfy the functions and requirements of the TWRS mission. Primary focus is on the SSTs, but other operations were included as they were identified. These other areas include double-shell tanks (DST), miscellaneous underground storage tanks (MUST), strontium/cesium capsules, and cell operations.

1.2 PURPOSE AND SCOPE

This utilization study has been commissioned by WHC to investigate potential application of the LDUA with respect to meeting the mission needs of TWRS. The LDUA development is a joint effort involving WHC, Idaho National Engineering Laboratory (INEL), Oak Ridge National Laboratory (ORNL), Pacific Northwest Laboratory (PNL), Sandia National Laboratory (SNL), and Westinghouse Savannah River Company (WSRC). The scope of this report is limited to the LDUA system being developed for use in the Hanford Site tank farms. This report does not address the needs of project participants at the other facilities, which may operate under different constraints and with different interfaces.

2.0 SUMMARY OF RESULTS

In performing this utilization study, the strategy was to first identify the requirements of the TWRS program relating to in-tank operations. Then the capabilities of the LDUA were compared against those requirements. The LDUA is an alternative method of supporting many remediation tasks.

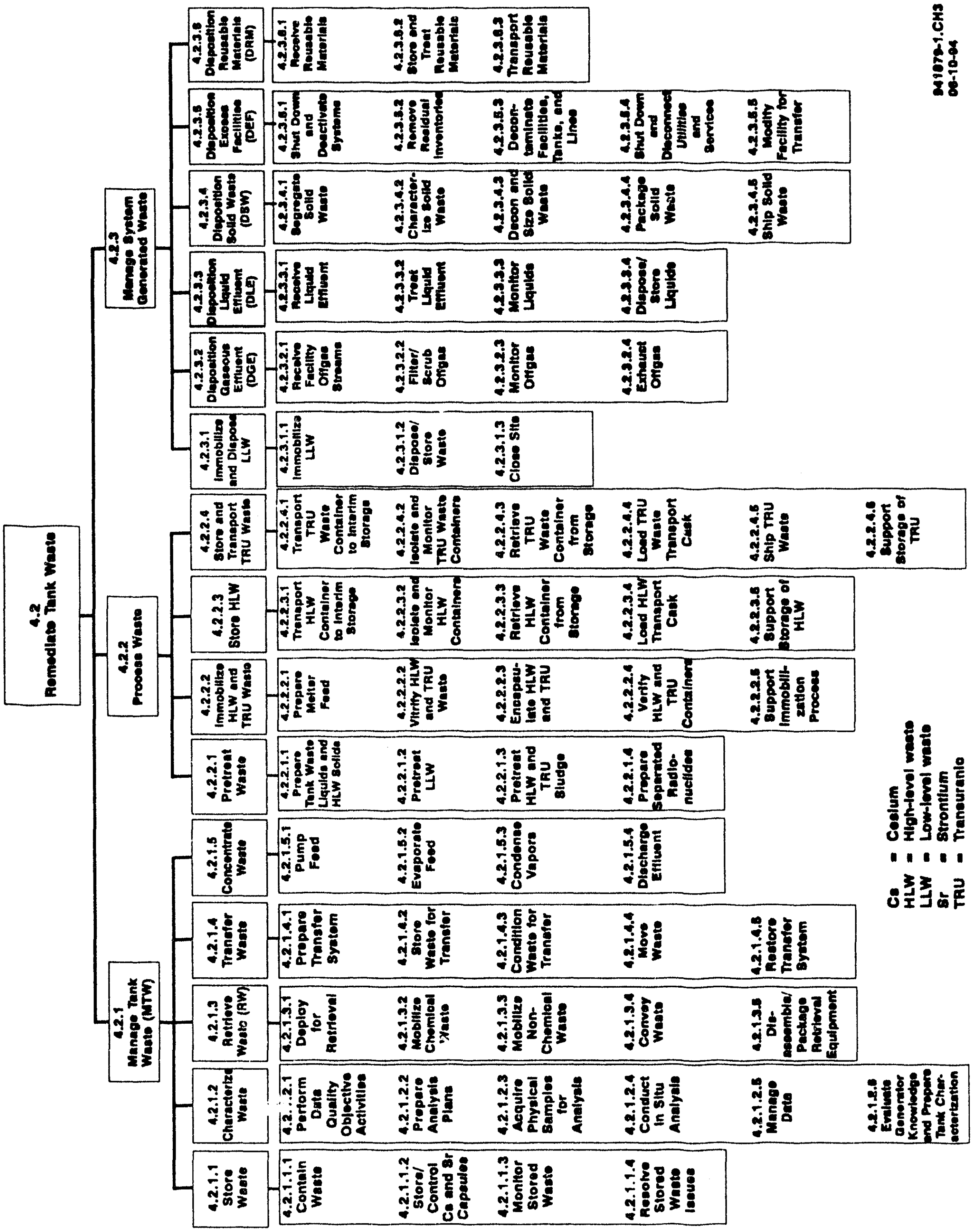
2.1 TANK WASTE REMEDIATION REQUIREMENTS

Tank waste remediation is a mission area of the Hanford Site cleanup plan outlined in the Tri-Party Agreement. The functional hierarchy for remediation is defined in DOE/RL-92-60, *TWRS Functions and Requirements (Draft)* (Grygiel 1994), part of which is reproduced in Figure 1. Tank farm cleanup is supported by functional block 4.2.1, Manage Tank Waste (MTW). The goal of MTW is to remove the waste from current storage and transfer it to a processing system to allow for closure of the SSTs. Specific functions that must be satisfied by the MTW system are described in depth in DOE/RL-92-60. These functions include the requirements to contain and monitor stored waste, resolve stored waste issues, acquire physical waste samples, conduct in situ analysis, and retrieve waste from the various underground tanks. Many of these requirements are associated with Tri-Party Agreement milestone deadlines. As an example, SST waste retrieval is to take place between December 2003 and September 2018. Technology required to meet certain milestones is not yet fully developed, as is the case for the design of SST retrieval technology (M-45-04).

It is anticipated that some of the MTW subfunctions, specifically waste storage, characterization, and retrieval (see Figure 1, blocks 4.2.1.1, 4.2.1.2, and 4.2.1.3, respectively) are interdependent. For example, waste must be characterized to determine its physical, chemical, and radiological properties before the commencement of retrieval. Additionally, waste must be stored in a safe and environmentally sound manner before and during the retrieval operation. It would then be desirable to develop technology capable of supporting several of these TWRS subfunctions on a single tank entry.

Because systems to perform these subfunctions have not yet been developed, the choice of an architecture is open. Selecting a design that will support multiple subfunctions is much more efficient than opting for separate systems to accomplish each subfunction. A number of studies evaluating various retrieval concepts have been performed during the last 25 years. Several of them have investigated or recommended the use of arm-based retrieval systems. The SSTs are 75 ft in diameter, and vary in volume from 500,000 to 1,000,000 gal. In order to retrieve the waste from the SSTs in the agreed to time frame in accordance with the Tri-Party Agreement, a high-volume retrieval system is required. Typically, an arm with sufficient payload to meet retrieval schedule requirements is lacking in dexterity and maneuverability, while arms with high dexterity or maneuverability lack sufficient strength to perform heavy retrieval tasks. For this reason, two recent studies have recommended the development of an auxiliary or service arm (Millsap et al. 1991; Thompson 1991). The LDUA is being developed to meet this need.

Figure 1. Function Hierarchy Diagram.



In addition to the SSTs, there are approximately 47 MUSTs, which vary in size and shape ranging from cylindrical, square, or "hot dog" shapes. Most of these tanks still require physical survey and characterization but are known to contain highly radioactive mixed waste in liquid, sludge, and solid form. The working position of the TWRS mission analysis calls for a tank-by-tank evaluation of the MUSTs to determine an appropriate course of action.

2.2 LDUA CAPABILITIES

As currently designed, the LDUA consists of a seven-jointed articulated arm with seven degrees of freedom (see Figure 2). The arm can support a maximum payload of 75-lb force at full extension and comes equipped with a force/moment sensor at the wrist for load monitoring. The arm has a maximum reach of 13.5 ft and can be deployed down a 12-in. or greater (using a reducing flange) diameter tank riser through the tank riser interface and confinement (TRIC) system. The TRIC also provides for structural support, radiological confinement and decontamination, and end effector changeout. The system is remotely operated from outside the tank farm fence via the Operations Control Center. For a more detailed description of system operation refer to WHC-S-0233, *Maintenance and Operations Specifications for the Light Duty Utility Arm (LDUA) Integrated System* (Brown 1994) and TTP RL421207, *Tank Riser Interface and Confinement (TRIC)* (Potter 1994).

The LDUA is not currently designed for deployment below the waste surface. However, the 13.5-ft reach gives the LDUA access to approximately 572 ft^2 of waste surface area per riser, with the potential for surface sampling. Out of a total area of approximately 4,417 ft^2 for 75-ft diameter tanks, this equates to roughly 13% of the total waste surface per riser (see Figure 3 for the operating envelope). Current technology allows access through most SST wastes but is limited to the waste surface immediately under the riser centerline. Combining the expanded surface area available to the LDUA with the waste depth penetration of current methods would yield a better understanding of tank waste heterogeneity. This is especially helpful in validating or refuting chemical models of the tank contents.

The range of tasks performed by the LDUA is defined predominantly by the end effectors. Currently, several photographic end effectors (stereoscopic video, high-resolution still photography) with pan, tilt, and zoom ability, utilizing 350-W floodlights for illumination, are available. These could support waste mapping and in-tank hardware (ITH) identification, liner integrity assessment, intrusion detection, and directing the placement of retrieval or characterization equipment. An end effector currently under development is a gripping-type manipulator hand. This could be used to directly place or move retrieval or monitoring equipment. Future end effectors identified include instrumentation for measuring tank parameters such as temperature, waste level and surface profiles, and radiation levels. Other tools include a nondestructive examination end effector for tank integrity assessment and a laser range finder for high-accuracy in-tank mapping. Equipment for vapor space, waste surface/near-surface analysis, and small-scale retrieval could be developed as well.

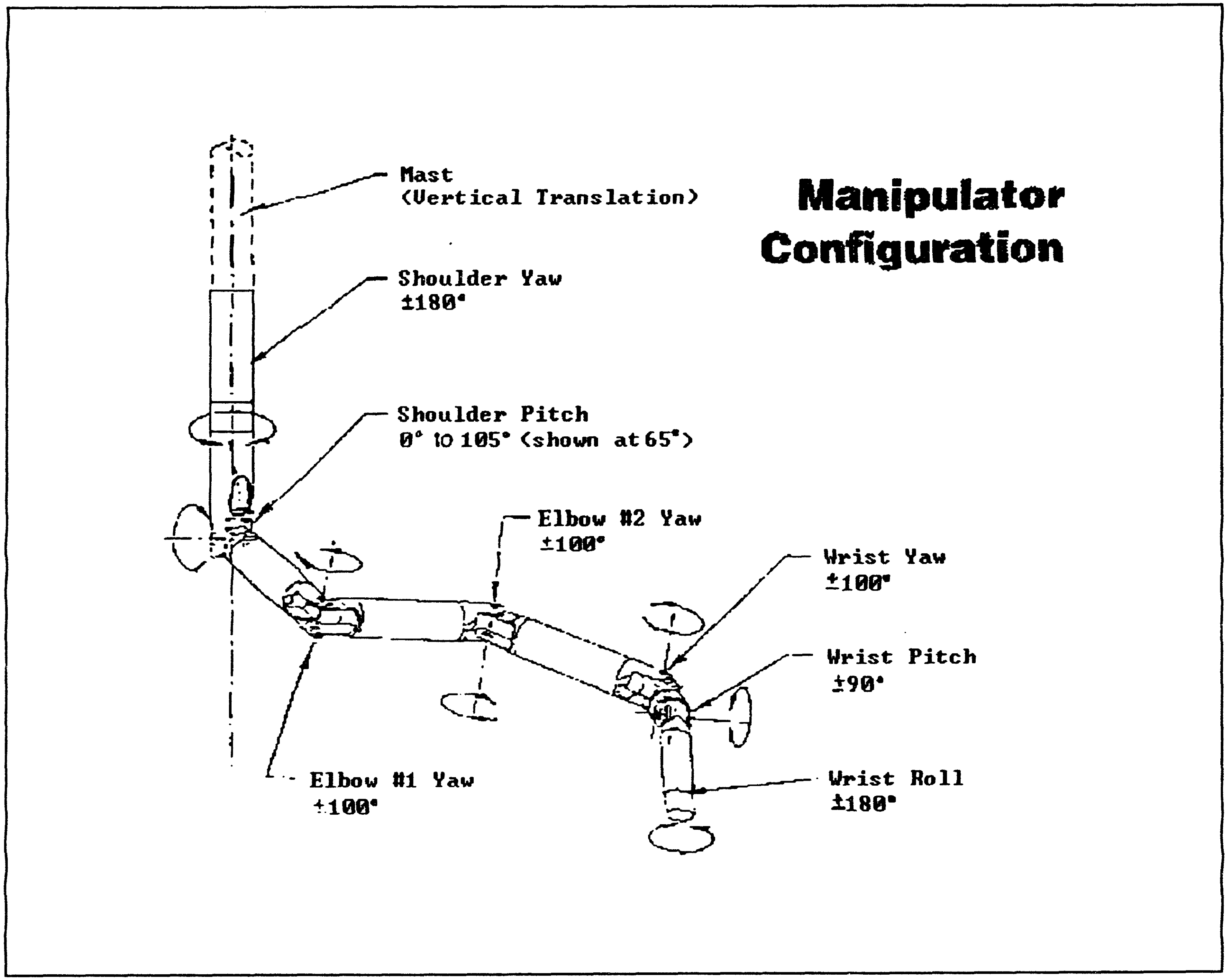
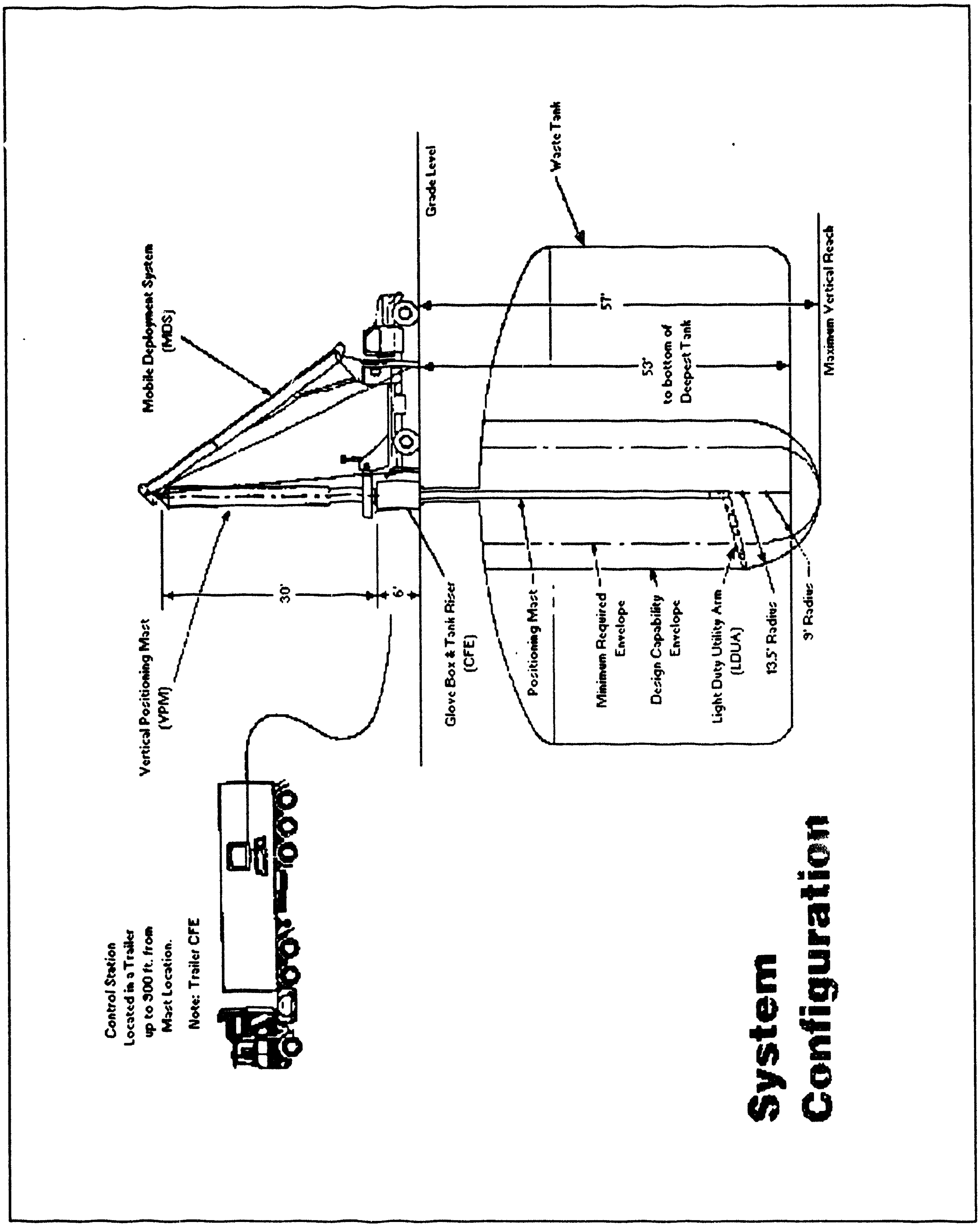


Figure 2. Manipulator Configuration.

Figure 3. System Configuration and Operating Envelope.



Another deployment concept calls for utilizing the LDUA as a general purpose tool for performing routine in-tank operations as well as responding to off-normal scenarios. Examples of routine tasks include assisting in the setup or takedown of sluicing, pumping, or sampling equipment. An example of an off-normal recovery task is attaching or guiding gear to aid in freeing equipment from in-tank obstructions.

2.3 MATCHING LDUA CAPABILITIES TO SPECIFIC TWRS FUNCTIONS

Table 1 shows the current and projected capabilities of the LDUA related to specific functional requirements of MTW. The first column of the table includes a broad description of the required TWRS tasks. The second column cites the function requirement or interfaces described in DOE/RL-92-60, *TWRS Functions and Requirements (Draft)* (Grygiel 1994). The third column describes the method or benefits of using the LDUA to perform the task. The final column shows the time period during which the function is planned to be performed. The time period is established in DOE/RL-92-60 and the Tri-Party Agreement.

The purpose of Table 2 is to present the LDUA as an alternate means of supporting the completion of various Tri-Party Agreement milestones concerning tank waste remediation. The first column is similar to column one in Table 1, without the amplifying comments. The second column is identical to the second column in Table 1. The third column lists the milestone by number and title, where applicable. The final column shows the time period or deadline specified by the milestone. It is not the intent of this report to identify the LDUA as the sole means of meeting the Tri-Party Agreement milestones cited. The LDUA should be viewed as an alternate means of performing various TWRS support functions.

3.0 DISCUSSION

3.1 LDUA MISSION

The LDUA development is being led by WHC under direction of the DOE's Office of Technology Development (EM-50), with support from INEL, ORNL, PNL, SNL, and WSRC. Each organization involved in the LDUA development may have different requirements for the system it ultimately employs, but in each there is a strong link between waste remediation and the LDUA. It is recommended that the final system be designed to support Hanford Site TWRS remediation efforts as much as possible.

The primary advantage of employing the LDUA system in Hanford Site tank farms is the synergism of performing multiple operations on a single tank entry. Current technology utilizes special-purpose equipment for many operations (such as push mode core sampling, photographing the waste tank interior, or obtaining liquid waste samples). Each of these evolutions requires tank entry and is performed individually, with associated permits, health physics support, and operations personnel. The LDUA is not designed to replace <u>all</u> of these functions; however, using the LDUA to perform those

Table 1. Light Duty Utility Arm Tank Waste Remediation System Support Functions. (sheet 1 of 3)

Function requirements and interfaces[a]		Function requirements and interfaces DOE/RL-92-60[b]	Benefits/method of achieving	Operational time span month/year
Survey of tanks before retrieval	• Information required to retrieve waste. • Complete closure of SSTs. • Data on tank's physical condition. • Develop SST retrieval technology.	4.2.1.3.1 I2 4.2.1.3 C5 4.2.1.3.1 04 4.2.1.3.2 I8 4.2.1.3.3 I6 4.2.1.3.4 I7 4.2.1.3.4 C1	• Visual tank inspection using stereoscopic camera end effector. • Waste surface mapping using laser range finder end effector • Radiation scanning, gross γ, spectra-graphic using radiac end effector.	04/97-09/18 09/18-09/24 04/97-09/18
Prepare tank for retrieval operations	• Information necessary to remove non-chemical waste.	4.2.1.3.3 I1	• Aid in the removal of obstacles, (i.e., tapes, lances, tc trees) by positioning tools and equipment using grabber end effector. • Aid in installation of new risers if required, using the same end effector.	04/97
Deploy retrieval equipment	• Operable retrieval system.	4.2.1.3.1 01	• Inspect, position, and assemble equipment in the tank using camera and grabber end effectors. • Support in recovery from off-normal events.	12/03-09/18
Monitor retrieval operation	• Identify additional retrieval needs during the operation.	4.2.1.3.2 01 4.2.1.3.3 01	• Visually verify retrieval system operation. • Repair/replace equipment as necessary.	12/03-09/18
Perform post-retrieval assessment	• Identify additional retrieval system needs.	4.2.1.3.4 01	• Evaluate retrieval effectiveness by: - Visual inspection - Topographical surveys • Residual waste characterization. • Residual waste "mop-up." • Determine effects of sluicing on tank structure.	12/03-09/18
Disassemble and package retrieval equipment	• Return retrieval equipment to ready condition.	4.2.1.3.5 I4	• Disassemble equipment in-tank. • Decontaminate on removal.	12/03-09/18
Evaluate shoreline corrosion	• Corrosion control constraint. • Information for characterization, retrieval, and safety. • Periodic assessment of integrity.	4.2.1.1.1 C19 4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	• Visual scan, removal of surface layers. • Investigate assumption that 75% of leaks occur at shoreline. This information can be used in determination of retrieval methods (i.e., whether or not to sluice) and may prove valuable as the DSTs age and begin to leak.	TBD
Tank stabilization	• Complete SST interim stabilization. • Interim stabilization of Watch List tanks.	4.2.1.1.1 C29 4.2.1.1.4 C24	• Evaluate leaking tanks before, during, and after pumping. Visual camera scan. • Identify and remove liquid from waste pools.	08/94-09/00 07/95-09/00

Table 1. Light Duty Utility Arm Tank Waste Remediation System Support Functions. (sheet 2 of 3)

Function requirements and interfaces[a]		Function requirements and interfaces DOE/RL-92-60[b]	Benefits/method of achieving	Operational time span month/year
Acquire undisturbed physical samples[c]	• SST characterization. • Tank characterization information.	4.2.1.2 C2 4.2.1.3 I5	• Deploy sampling end effectors off riser centerline, as opposed to current methods that are limited to the region immediately below the riser. This region becomes disturbed by repeated operations such as core drilling. The reach of the LDUA allows access to previously unreachable areas of the tank. • Increase characterization confidence, as photos of the tank contents indicate considerable surface heterogeneity. By obtaining limited samples within the 572-ft^2 area of the arm's reach, an indication of the chemical heterogeneity is possible.	09/95-09/99
Conduct in situ waste analysis[c]	• SST characterization. • Tank characterization information. • In situ analysis plan. • Reduce characterization cost and time.	4.2.1.2 C2 4.2.1.3 I5 4.2.1.2.4 I1 Goal 5.2[d]	• Deploy sensors for permanent installation, or analyze using end effectors equipped with sensors. This could provide immediate information on certain waste characteristics.	08/94-01/97 09/95-09/99 01/97
Conduct waste vapor analysis[c]	• SST characterization. • Tank characterization information.	4.2.1.2 C2-C5 4.2.1.3 I5	• Deploy sensors for permanent installation to allow for continuous monitoring in the tank, or analyze using end effectors equipped with sensors. This could be performed during a tank entry in support of a different function at essentially no extra cost.	08/94-01/97 09/95-09/99
Verify tank integrity	• Information for characterization, retrieval, and safety. • Periodic assessment of integrity for stored waste monitoring. • Information to support retrieval.	4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	• Weld and liner assessment by: - Nondestructive testing - Visual - Vacuum • Repair where practicable.	06/96-09/18
Detect intrusion into tanks	• Information for characterization, retrieval, and safety. • Periodic assessment of integrity. • Information to support retrieval.	4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	• Visual scan. • Sample/analyze influent.	TBD
Monitor stored waste	• Provide rapid identification of failed component and abnormal temperatures. • Requirements for monitoring, surveillance, and leak detection.	4.2.1.1.1 C17 4.2.1.1.3 C2-5 4.2.1.1.4 C3	• Deploy sensors for permanent installation to allow for continuous monitoring in the tank, or analyze using end effectors equipped with sensors. • Help provide emergency leak response by deploying equipment in tank.	03/95-09/18

Table 1. Light Duty Utility Arm Tank Waste Remediation System Support Functions. (sheet 3 of 3)

Function requirements and interfaces[a]		Function requirements and interfaces DOE/RL-92-60[b]	Benefits/method of achieving	Operational time span month/year
Install upgraded monitoring equipment	• TPA[e] milestone constraint. • Constraints to resolve stored waste issues.	4.2.1.1.3 C10 4.2.1.1.4 C6-8	• Direct placement in desired tank locations.	09/94-06/02
Synergism of multiple operations on a single tank entry	• Remote features to support exposure ALARA. • Minimize the potential for environmental releases. • Minimize secondary waste generation. • Cost effectiveness.	4.2.1.1.1 C25 4.2.1.1.1 C4	• Remote operability from outside fence. • Minimize the maintenance, permitting, and disposal of many unique systems.	All the time
DST operations	• Monitoring, surveillance, and leak detection.	4.2.1.1.3 C2	• Verify integrity. • Tank monitoring. • Apply lessons learned from SSTs.	09/95-09/99
MUST D&D	• Monitoring, surveillance, leak detection, and retrieval.	4.2.1.1.3 C2	• Monitor waste. • Employ lessons learned from SSTs. • Retrieval tool for MUSTs.	TBD
Demonstrate Hanford Site technology transfer initiative	• Make technology transfers available to the private sector. • Reduce major Hanford Site tank risks. • Use of BAT to reduce occupational radiation exposure.	Goal 5.3[d] Goal 1.2[d] 4.2.1.1.1 C37	• Develop ready service, multipurpose tool able to respond to a wide variety of contingencies. • Accomplish multiple tasks with a single system by changing out end effectors. This allows the execution of a variety of tasks on a single tank entry rather than repeated entries with the attendant cost in time, funds, and personnel exposure.	09/94 12/94-01/97

[a]Description of function requirements and interfaces identified in DOE/RL-92-60, TWRS Functions and Requirements (Draft), 1994, M. L. Grygiel, Westinghouse Hanford Company Richland, Washington.

[b]Functional inputs, outputs, and constraints identified in DOE/RL-92-60, TWRS Functions and Requirements (Draft), 1994, M. L. Grygiel, Westinghouse Hanford Company, Richland, Washington.

[c]Supplementary characterization in vapor space, waste surface, and near-surface only. The Light Duty Utility Arm is not capable of burrowing through several inches of hardened salt cake.

[d]Grumbly, T. P., 1994, Environmental Management Program Strategy and Goals (memorandum to all Environmental Management staff from EM-1, March 1), U.S. Department of Energy-Headquarters, Washington, D.C.

[e]Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

ALARA = As low as reasonably achievable
BAT = Best available technology
D&D = Decontamination and decommissioning
DST = Double-shell tank
MUST = Miscellaneous underground storage tank
SST = Single-shell tank
TBD = To be determined
TPA = Tri-Party Agreement

Table 2. Tri-Party Agreement Requirements for Tank Waste Remediation System Support Functions. (sheet 1 of 2)

Function	Function requirements and interfaces DOE/RL-92-60[a]	TPA Milestone Support[b]	Operational time span month/year
Survey of tanks before retrieval	4.2.1.3.1 I2 4.2.1.3 C5 4.2.1.3.1 04 4.2.1.3.2 I8 4.2.1.3.3 I6 4.2.1.3.4 I7 4.2.1.3.4 C1	M-45-04A Complete conceptual design for the initial SST retrieval system. M-45-00 Complete closure of SSTs.	04/97 09/24
Prepare tank for retrieval operations	4.2.1.3.3 I1	M-45-04A Complete conceptual design for the initial SST retrieval system.	04/97
Deploy retrieval equipment	4.2.1.3.1 01	M-45-05-T01 Initiate waste retrieval from one SST.	12/03
Monitor retrieval operation	4.2.1.3.2 01 4.2.1.3.3 01	M-45-04-T02 Complete design for the initial SST retrieval system. M-45-05 Retrieve waste from all remaining SSTs.	11/03 09/18
Perform post-retrieval assessment	4.2.1.3.4 01	Not specifically required by TPA. May be desirable to evaluate extent/effectiveness of retrieval method, as 99% waste removal is required.	TBD
Disassemble and package retrieval equipment	4.2.1.3.5 I4	Prepare equipment for entry into another tank.	TBD
Evaluate shoreline corrosion	4.2.1.1.1 C19 4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	Not specifically required by TPA. May be desirable from regulatory standpoint.	TBD
Tank stabilization	4.2.1.1.1 C29 4.2.1.1.4 C24	M-41-00 Complete SST interim stabilization. M-41-07 Complete safety studies and analysis on interim stabilization of remaining Watch List tanks.	08/94-09/00 12/94
Acquire undisturbed physical samples[c]	4.2.1.2 C2 4.2.1.3 I5	M-44-00 Issue tank characterization reports (TCR).	09/95-09/99
Conduct in situ waste analysis[c]	4.2.1.2 C2 4.2.1.3 I5 4.2.1.2.4 I1 Goal 5.2[d]	M-44-00 Issue TCRs. Performing in situ analysis of the tank waste may aid in TCR preparation, or may verify the validity of the TCRs if they are completed before LDUA deployment.	09/95-09/99 01/97
Conduct waste vapor analysis[c]	4.2.1.2 C2-C5 4.2.1.3 I5	M-40-10 Complete vapor space monitoring for all flammable gas generating tanks.	01/97

Table 2. Tri-Party Agreement Requirements for Tank Waste Remediation System Support Functions.
(sheet 2 of 2)

Function	Function requirements and interfaces DOE/RL-92-60[a]	TPA Milestone Support[b]	Operational time span month/year
Verify tank integrity	4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	Not specifically required by TPA. May be desirable from regulatory standpoint.	TBD
Detect intrusion into tanks	4.2.1.1.1 I4 4.2.1.1.3 C5 4.2.1.3 I2	Not specifically required by TPA. May be desirable from regulatory standpoint.	TBD
Monitor stored waste	4.2.1.1.1 C17 4.2.1.1.3 C2-5 4.2.1.1.4 C3	M-41-02 Prepare an improved SST emergency pumping capability.	03/95-09/18
Install upgraded monitoring equipment	4.2.1.1.3 C10 4.2.1.1.4 C6-8	M-40-02 Upgrade temperature monitoring capabilities in ferrocyanide tanks. M-43-04 Complete tank farm integrated instrumentation system upgrade.	09/94-04/95 01/97-06/02
Synergism of multiple operations on a single tank entry	4.2.1.1.1 C25 4.2.1.1.1 C4	Not specifically required by TPA. May be desirable to minimize cost and risk of repeated entries into the same tank.	All the time
DST operations	4.2.1.1.3 C2	M-44-00 TCRs for DSTs as well as for SSTs.	09/95-09/99
MUST D&D	4.2.1.1.3 C2	Not yet fully addressed in TPA.	TBD
Demonstrate Hanford Site technology transfer initiative	Goal 5.3[d] Goal 1.2[d] 4.2.1.1.1 C37	• Make 24 technologies available for transfer to the private sector by September 1994. • Significantly reduce the major risks posed by Hanford Site tanks by 1997.[d]	09/94 12/94-01/97

[a]Functional inputs, outputs, and constraints identified in DOE/RL-92-60, TWRS Functions and Requirements (Draft), 1994, M. L. Grygiel, Westinghouse Hanford Company, Richland, Washington.

[b]The Hanford Federal Facility Agreement and Consent Order, as amended, 1994, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington, does not specifically require the use of the LDUA. Milestones are shown to verify the operational time span cited.

[c]Supplementary characterization in vapor space, waste surface, and near-surface only. The Light Duty Utility Arm is not capable of burrowing through several inches of hardened salt cake.

[d]Grumbly, T. P., 1994, Environmental Management Program Strategy and Goals (memorandum to all Environmental Management sta[illegible]om EM-1, March 1), U.S. Department of Energy-Headquarters, Washington, D.C.

D&D = Decontamination and decommissioning
DST = Double-shell tank
LDUA = Light Duty Utility Arm
MUST = Miscellaneous underground storage tank
SST = Single-shell tank
TBD = To be determined
TPA = Tri-Party Agreement

functions identified in Table 1 will result in the sharing of the risks and costs of tank entry among several operations, thereby reducing the individual cost (in operating funds and personnel exposure) and risk borne by the performance of each individual task. This also can reduce the total number of separate tank entries required.

3.2 RECOMMENDATIONS

Efforts should be made to ensure that the LDUA capabilities are defined and understood by the various TWRS teams, involving tank farm operations, characterization, and retrieval representatives, in order to provide integrated systems. Savings in cost and time can be achieved by developing the LDUA as a tool capable of performing many functions on a single tank entry through the use of a variety of end effectors. End effectors should be developed to perform or enhance the performance of the following operations: determine waste physical characteristics, conduct waste surface mapping, verify tank liner integrity, conduct in situ waste and vapor space analysis, and aid in the installation and removal of in-tank hardware. By involving all stakeholders in the development of the end effectors, common features and components can be identified thus allowing for greater standardization of parts and maintenance support.

Following SST Farm closure, there are still many tasks required to complete the cleanup of the Hanford Site. Lessons learned from LDUA use in the SSTs can be directly applied to DST and MUST retrieval and closure, disposition of strontium and cesium capsules, and cleanup of other past practice units.

3.3 ADDITIONAL CONSIDERATIONS

Other design requirements beyond the technical issues raised by support of TWRS-specific functions were identified during this study. These tend to be more generic in nature, and thus do not necessarily fit into the TWRS functional hierarchy. The requirements include safety, environmental impact, schedule support, and cost effectiveness.

Public and Worker Health and Safety. The system's operation should result in no worker or member of the general public exceeding any exposure limit to radiation, radiological contamination, or hazardous material. All operation of the LDUA should maximize personnel maintaining exposure limits as low as reasonably achievable. System design and operation should prevent injury to operating personnel during all phases of normal operation and conceivable off-normal scenarios.

Environmental Impact. Adverse effects on the immediate environment during operation of the system should be minimized. Any discharge to the atmosphere or groundwater must be below any regulatory limits. In order to minimize leakage of tank waste to the environment, the LDUA must be able to operate in the tank farms without causing any damage to the tanks that would compromise tank integrity.

Schedule Support. The LDUA must have sufficient reliability and flexibility to support required operations according to the schedule outlined in WHC-EP-0392, *Tank Farms Restoration and Upgrades Program Plan* (Bigbee 1993); the Tri-Party Agreement (Ecology et al. 1994); and DOE/RL-92-60, *TWRS Functions and Requirements (Draft)* (Grygiel 1994). The LDUA must be able to operate in the tank farms without causing any damage to the tanks that would render the waste inaccessible, thus preventing timely waste retrieval.

Cost Effectiveness. The resources required to operate the LDUA (employee effort, procurement and maintenance, training) should be compared to alternate methods as part of an engineering/trade analysis.

Technology Initiative. U.S. Department of Energy Assistant Secretary Grumbly has set a goal of making 24 technologies available for transfer to the private sector by September 1994. Much of the LDUA technology already is coming from the private sector. It could eventually be completely privatized, although not by September 1994. The development, implementation, and privatization of the LDUA system for dealing with significant waste problems would clearly demonstrate WHC's initiative in, and commitment to, sponsoring and utilizing state of the art technology in the Hanford Site cleanup.

4.0 CONCLUSIONS

The LDUA should be viewed as an alternate means of performing various TWRS support functions. It is vital to integrate the functions and requirements of tank waste remediation into the LDUA final design and system operation. As the system is operated in the tank farms, it will be possible to further integrate the LDUA into the TWRS remediation technology.

Based on the LDUA's performance in supporting TWRS, its ability to support additional missions should be evaluated. These missions include DST operations; MUST retrieval, decontamination, and decommissioning; strontium and cesium capsule retrieval; and cell operations. The success of future technology used in the satisfactory completion of various Hanford Site cleanup tasks may depend on the ability of the LDUA to support those tasks, both during routine and off-normal events.

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7.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
BAT	best available technology
CFE	customer furnished equipment
Cs	cesium
D&D	decontamination and decommissioning
DEF	disposition excess facilities
DGE	disposition gaseous effluent
DLE	disposition liquid effluent
DOE	U.S. Department of Energy
DRM	disposition reusable materials
DST	double-shell tank
DSW	disposition solid waste
HLW	high-level waste
INEL	Idaho National Engineering Laboratory
ITH	in-tank hardware
LDUA	Light Duty Utility Arm
LLW	low-level waste
MTW	manage tank waste
MUST	miscellaneous underground storage tank
ORNL	Oak Ridge National Laboratory
PNL	Pacific Northwest Laboratory
RW	retrieve waste
SNL	Sandia National Laboratory
Sr	strontium
SST	single-shell tank
TBD	to be determined
TCR	tank characterization report
TPA	Tri-Party Agreement
TRIC	tank riser interface and confinement
TRU	transuranic
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
WSRC	Westinghouse Savannah River Company