INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0482

Excel Automatic Locking Scaffold

Deactivation and Decommissioning
Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

September 1999

INNOVATIVE TECHNOLOGY
Summary Report

Excel Automatic Locking Scaffold

OST Reference #2320

Deactivation and Decommissioning
Focus Area

Demonstrated at
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://OST.em.doe.gov under "Publications."

TABLE OF CONTENTS

SECTION 1
SUMMARY

Introduction

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology sponsors large-scale demonstration and deployment projects (LSDDPs). At these LSDDPs, developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The Idaho National Engineering and Environmental Laboratory (INEEL) LSDDP generated a list of need statements defining specific needs or problems where improved technologies could be incorporated into ongoing D&D tasks. Although not addressed explicitly, the use of scaffolds is needed in several of the listed needs, including characterization, demolition, and asbestos abatement. In these areas, scaffold towers are used to access areas that are not accessible using mechanical methods such as manlifts or mechanical platforms. In addition, the work requires more mobility than what can be achieved using ladders. Because of the wide use of scaffold on D&D projects, a need exists for a safer to use, faster to set up, and overall cheaper scaffold system.

This demonstration investigated the feasibility of using the Excel Automatic Locking Scaffold (innovative technology) to access areas where tube and clamp scaffold (baseline) is currently being used on D&D activities. Benefits expected from using the innovative technology include:

- Decreased exposure to radiation, chemical, and/or physical hazards during scaffold erection and dismantlement
- Increased safety
- Easier use
- Shorten D&D Schedule
- Reduced cost of operation.
- Excel Scaffold is compatible with tube and clamp scaffold.

This report compares the cost and performance of the tube and clamp scaffold to the cost and performance of the Excel Automatic Locking Scaffold.

Technology Summary

Baseline Technology

D&D projects use scaffold under a variety of working conditions including characterization, decontamination, and dismantlement. Most D&D projects at the INEEL use the baseline scaffold to manually access elevated areas where mechanical lifting devices cannot be used, and where a ladder will not provide enough mobility. Typically, at least one carpenter, who may be assisted by laborers, sets up the scaffold. These workers must be trained to use the scaffold and to work in various hazardous environments, including elevated areas (above 6 feet), confined spaces, radiation areas, and environments that may contain hazardous gases, asbestos, or other potential airborne hazards.

A qualified and competent person must inspect and tag each scaffold once it is erected to ensure that it is set up properly and that it meets predetermined safety criteria as listed in INEEL's Management Control Procedure (MCP) 2712, Scaffolding. The scaffold must also be inspected prior to a new shift using the scaffold. In this demonstration, scaffold was used to access pipes, ductwork, and boiler tanks insulated with asbestos-containing material (ACM). Figure 1 shows a baseline scaffold used during this D&D asbestos removal project.

Figure 1. Baseline Tube and Clamp Scaffold

Innovative Technology

The innovative technology is an improved, positive-locking, modular scaffold that eliminates staging shortcomings using a design developed by experienced carpenters. Since commencing production, the Excel design has proven itself capable of dramatically lowering total scaffold labor expenditures and reducing critical path time for maintenance work activities in a variety of industrial applications. Excel was designed and engineered to be constructed using the same requirements specified by Occupational Safety and Health Administration (OSHA) and California Occupational Safety Health Program, the Federal Occupational Safety and Health Administration (CAL/OSHA), that have been historically used with tube and clamp and other scaffold systems. The Excel Automatic Locking Scaffold is compatible with tube and clamp scaffold and can be used in conjunction with the tube and clamp scaffold when necessary.

The innovative technology utilizes a patented positive locking trigger mechanism that locks the horizontal bearers and other attachments to the vertical legs (Figure 2). The trigger mechanism attaches to cups on the vertical legs, spaced at 5.75-in intervals. Horizontal and vertical pipes are designed to be compatible with standard 1.90-in OD tube and clamp material. Vertical legs range from 1-ft to 10-ft. Horizontal bearers range in length for 1-ft to 10-ft. Diagonal braces range from 4-ft to 10-ft. The system also can supply various pre-manufactured components such as ladders, spring-loaded swing gates, floor hatches, trusses, trolleys, chainfall, cantilever attachments, lifting attachments, stairs, casters, screw jacks, and various other components (Figure 3). Scaffold users must be familiar with Federal, State, and Local regulations governing scaffold construction and use. Only qualified and competent users should erect, modify, or dismantle the scaffold.

Figure 2. Excels Trigger Release Mechanism

Figure 3. Excel Automatic Locking Scaffold

The technology was demonstrated in February, March, and April of 1999 at the INEEL Security Training Facility (STF), currently under D&D action; see Figure 4. This facility was selected based on the need for scaffold to access pipes, air ducts, and boilers throughout the facility that were insulated with asbestos-containing-material (ACM). The STF facility was originally built in 1963 as a support facility for the Experimental Organic Cooled Reactor (EOCR). Construction was scheduled for completion in 1963 but a similar reactor in Canada was made operational to obtain the needed information. The project at EOCR was canceled at about ninety percent completion and work was halted in September 1962.

Starting in 1983, the EOCR was converted to the Security Training Facility (STF). The STF was used for security exercises until 1998. The STF facility is undergoing D&D to remove the facility and restore the area to natural conditions. Many of the pipes, air ducts, and boilers associated with the heating and cooling system are insulated with ACM insulation. This ACM must be removed prior to demolition of the remainder of the facility. Scaffold is needed to access some of the pipes, air ducts, and boilers in the facility to support the asbestos removal.

Prior to INEEL procuring the scaffold, an Excel representative visited the site to provide an estimate the amount of scaffold needed for the project. When the scaffold arrived, the representative returned for a day to train the individuals involved in the scaffold set-up. The vendor provided these services at no added cost to the INEEL, a service routinely provided to the customers at no added cost.

The Excel Automatic Locking Scaffold was evaluated against the baseline technology in the areas of safety, timesavings, ease of use, and cost. The demonstration was conducted in the following manner. The scaffold was used on the job over a period of three months to provide a long-term production rate for the two scaffold systems. All of the towers were erected to meet OSHA light duty standards. Only in one case was the scaffold used in exactly the same location. At this time the workers were videotaped setting up the two scaffold towers. In the other situations, a test engineer was present to time and observe the set-up and dismantlement of the scaffold. Photos were taken, but video was not taken in all situations. Workers were interviewed to determine their observations regarding the ease of scaffold set up and dismantlement. In addition to the carpenter interviews, the asbestos workers were interviewed to determine if there were differences in the two scaffold systems, in terms of the work performed on the platforms. The same carpenter was used throughout the duration of the D&D activity. In all cases, the scaffold towers were setup using two trained and competent INEEL craft workers.

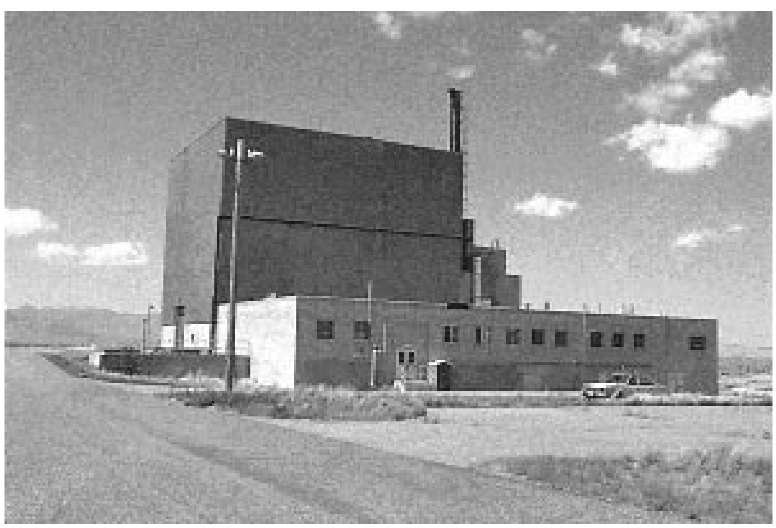

Figure 4. Security Training Facility

Key Results

The key results of the demonstration are summarized below. Detailed descriptions and explanations of these results are in Section 3 of this report.

- The innovative technology was set up and dismantled in 30% to 40% of the time it took for tube and clamp to be set up.
- The innovative technology was easier to set up and dismantle.
- Premanufactured gates and floor hatches add to the safety of the product.
- The innovative technology has fewer pieces to transport, deteriorate, or misplace (comparing Excel and baseline scaffold, Excel used 47% fewer pieces than did the baseline).
- The innovative technology minimizes the use of tools.
- The ability for personnel to tie off to the scaffold adds to the overall safety of the workers.
- The cost to assemble and dismantle the Excel Scaffold is 52% of the cost of the baseline for the same activities.

Contacts

Technical

James Elkins, Excel Modular Scaffolding & Leasing Corp.,

P.O. Box 1800, 60 Industrial Park Road

Plymouth, MA 02360

Plymouth, MA (800) 652-7712, fax (508) 830-0997

CT office, (860) 873-9987, fax (860) 873-1753

Email: elkins@cwix.com Web Site: www.excelscaffold.com

Thomas Thiel, D&D Project Manager, Idaho National Engineering and Environmental Laboratory, (208) 526-9876, tnt@inel.gov

Neal Yancey, Test Engineer, Idaho National Engineering and Environmental Laboratory, (208) 526-5157, yancna@inel.gov

Management

Steve Bossart, Project Manager, U.S. Department of Energy, Federal Energy Technology Center, (304) 285-4643, steven.bossart@fetc.doe.gov

Chelsea Hubbard, U.S. Department of Energy, Idaho Operations Office, (208) 526-0645, hubbarcd@inel.gov

Dick Meservey, INEEL Large Scale Demonstration and Deployment Project, Project Manager, INEEL, (208) 526-1834, rhm@inel.gov

Cost Analysis

Wendell Greenwald, U.S. Army Corps of Engineers, (509) 527-7587, wendell.l.greenwald@usace.army.mil

Web Site

The INEEL LSDDP Internet web site address is http://id.inel.gov/lsddp

Licensing

No licensing activities were required to support this demonstration.

Permitting

Both the innovative scaffold and the baseline scaffold meet the requirements in 29 Code of Federal Regulations Subchapter L for scaffolding. In addition, managers, carpenters and workers must set up and use the scaffold in accordance to INEEL Management Control Procedure (MCP) 2712 Scaffolding, MCP 2727 Performing Safety Reviews, MCP 2714 Signs, Color Codes, and Barriers, and MCP 2710 Fall Protection. In addition, the Excel Scaffold will meet the new OSHA handrail requirements for 2000.

Other

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under “Publications.” The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for [insert technology name] is #[insert number].

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using the innovative scaffold over using the baseline scaffold. This was done by comparing the two technologies. The demonstration collected valid operational data so that a legitimate comparison could be made between the innovative technology and the baseline technology in the following areas:

- Safety
- Productivity rates
- Ease of use
- Limitations and benefits of both the baseline technology and the innovative technology
- Cost.

Description of the Technology

The Automatic Locking Scaffold System produced by Excel, is an improved, positive-locking modular system scaffold using lightweight and easy-to-handle components. The innovative scaffold does not require the hours of tedious nut and bolt tightening which is required with baseline scaffold. Since commencing production, the Excel design has proven itself capable of dramatically lowering total scaffold labor expenditures while reducing critical path time for maintenance work activities in many areas which include drywell, reactor building, containment, auxiliary building, turbine building, condensers, etc. Another important fact is that the scaffold will meet the new OSHA handrail requirements for the year 2000. Like tube and clamp systems, the Excel scaffold can be erected for light, medium, and heavy-duty work, as required by OSHA.

Specific advantages of the scaffold include the following:

- Simple premanufactured attachments, such as swing gates, floor hatches, ladders, stairs, trusses, cantilevers, lifting rigs, and trolley attachments (see Figures 5 and 6).
- The only scaffold approved by the manufacturer for safe anchorage points for fall protection of workers.
- The only scaffold to successfully complete a seismic shake-out bench test in accordance with the Institute of Electrical and Electronics Engineers (IEEE) seismic test standards qualification at the Wyle Laboratory in Huntsville, Alabama.
- Forty to fifty percent fewer parts to handle during mobilization and setup.
- The vendor stated that typically, 35% to 45% reductions in scaffold project expenditures can be realized by use of the Excel Scaffold. This saving is due primarily to the increased production rate during set up and dismantlement of the scaffold.
- ALARA dose reduction resulting from quicker erection and takedown.
- Elimination of metal face slivers.
- Less repetitive motion during set up.
- Workers can access the scaffold from within the tower rather than climbing the outside of the scaffold, thus reducing the risk of falls.
- The vendor has reported an increase in the rate of erection and take-down by 4 to 5 times, although in this demonstration, the increased time savings was approximately 2.5 times faster with the Excel Scaffold.
- A material credit for exchange of the tube-and-clamp scaffold.

Figure 5. Truss and Trolley System

Figure 6. Lifting Attachment

System Operation

Table 1 summarizes the operational parameters and conditions of the Excel Automatic Locking Scaffold demonstration.

Table 1. Operational parameters and conditions of the Automatic Locking Scaffold demonstration

Working Conditions	
Work area location	Inside the Security Training Facility at the INEEL
Work area access	Access controlled by D&D project through use of fencing and posting
Work area description	Work area posted as asbestos-controlled area and D&D/construction hazard area, requiring training, hard hat, safety glasses, and safety shoes for entry. D&D support trailers were available at the job site. Under certain conditions, respirators and anti-C clothing were required.
Work area hazards	Asbestos contamination Heavy equipment operations Tripping hazards Strains and sprains from lifting and from uneven surfaces Temperature extremes Falling Hazards Confined Spaces
Equipment configuration	Scaffold was staged at the job site as needed
Labor, Support Personnel, Special Skills, Training	
Work crew	Minimum work crew: • 1 equipment operator (operates equipment to move scaffold from storage to staging area) • 1 yardman (assists the carpenter in scaffold assembly and dismantlement) • 1 carpenter (assembles and disassembles scaffold)

Labor, Support Personnel, Special Skills, Training (cont'd)	
Additional support personnel	• 1 data taker • 1 health and safety observer (periodic) • 1 test engineer
Special skills/training	Special training was required for the workers setting up and taking down the scaffold.
Waste Management	
Primary waste generated	No primary wastes were generated
Secondary waste generated	Disposable personal protective equipment
Waste containment and disposal	All secondary wastes were collected and packaged for disposal with the D&D project waste.
Equipment Specifications and Operational Parameters	
Technology design purpose	Scaffold needed to access pipes and ductwork containing asbestos-containing insulation in areas where mechanical means of accessing these pipes was not feasible.
Portability	The scaffold must be moved either by laborers or by an equipment operator using a forklift or crane.
Materials Used	
Work area preparation	No preparation was necessary for the demonstration. The D&D project already had necessary controls and preparations in place.
Personal protective equipment	Cotton scrubs Cotton glove liners Tyvex coveralls Respirators Pair of rubber gloves Shoe covers Steel toe shoes Hard hats Safety glasses
Utilities/Energy Requirements	
Power, fuel, etc.	None required specific to the technology tested. Generators were used to provide electricity for lighting and heat.

SECTION 3
PERFORMANCE

Demonstration Plan

Problem Addressed

Scaffold is used to access pipes and equipment for maintenance and D&D projects at many of the DOE facilities. At most of the facilities at the INEEL, the baseline tube-and-clamp scaffold is used. The baseline scaffold (tube and clamp) performs well but requires extensive time and tedious repetition to set up. There is need for a scaffold system that can be set up quickly to reduce exposure to radiation, chemical, airborne, or physical hazards. The scaffold should offer equal or better performance and safety attributes. At the INEEL Security Training Facility, workers are using scaffold to access elevated pipes, ductwork, and boilers in order to remove asbestos-containing insulation in areas where mechanical methods cannot be used.

The purpose of this demonstration is to compare the performance of the innovative technology to the baseline technology, which is tube and clamp scaffold. The scaffold will be used for overhead access of pipes during asbestos abatement activities associated with D&D work.

Demonstration site description

The INEEL site occupies 569,135 acres (889 square miles) in southeast Idaho. The site consists of several primary facility areas situated on an expanse of otherwise undeveloped, high-desert terrain. Buildings and structures at the INEEL are clustered within these primary facility areas, which are typically less than a few square miles in size and separated from each other by miles of primarily undeveloped land.

The test area for this demonstration was the Security Training Facility. This facility was selected based on the need for scaffold to access pipes throughout the facility that were insulated with ACM. This insulation must be removed prior to demolition of the facility. The facility is now undergoing D&D action to remove the facility and restore the area to natural conditions.

Major objectives of the demonstration

The major objectives were to evaluate the Excel Automatic Locking Scaffold against the baseline scaffold in the following areas:

- Cost effectiveness (based on speed of assembly and disassembly)
- Safety
- Ease of use
- Limitations

Major elements of the demonstration

Both the baseline technology and the innovative technology were used to assemble typical scaffold towers. The intent of the demonstration was to gather information helpful in deciding which scaffold to use in the future. This demonstration included a wide variety of scaffold applications. The following were the common elements of demonstration:

- Scaffold erection time
- Scaffold breakdown time
- Number of workers required
- Safety
- Worker comments
- Cost
- Advantages/Disadvantages.

Results

Both technologies were evaluated under similar physical conditions. Scaffold towers were erected to meet OSHA standards for light duty scaffold. Every attempt was made to allow work to proceed under normal conditions with no bias. All parties involved in the demonstration were requested to perform the work normally with no special emphasis on speed or efficiency. Both technologies were demonstrated in various rooms throughout the STF during the months of February, March, and April of 1999.

During the comparison, the same carpenter, assisted by another carpenter or laborer, assembled the baseline and innovative scaffold. A total of 12 towers were erected, six with each scaffold type. A video was taken of the innovative and baseline scaffold as each was being assembled in the same location to validate the results obtained in other rooms (Figures 7 and 8). The performance of the two technologies is compared in Table 2.

Table 2. Performance comparison innovative vs. baseline technology for a 5-ftx7-ftx12-ft tower.

Performance Factor	Baseline Technology Tube-and-Clamp Scaffold	Innovative Technology Excel Automatic Locking Scaffold
Personnel/equipment/ time required to ready scaffold for erection	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT Equipment: • 1 forklift Time: • 15 minutes to move the scaffold from the staging area into the work zone	Personnel: • 1 EO or HEO • 1 yardman • 1 RCT Equipment: • 1 forklift Time: • 15 minutes to move the scaffold from the staging area into the work zone
Personnel/equipment/ time assemble 5-ftx7-ftx12-ft scaffold tower	Personnel: • 1 Carpenter • 1 yardman • 1 RCT (provide periodic inspection) Equipment: • Socket and ratchet • Level Time: • 2 hours	Personnel: • 1 Carpenter • 1 yardman • 1 RCT (provide periodic inspection) Equipment: • Socket and ratchet • Level Time: • 45 minutes
Personnel/equipment/ time required to disassemble 5'x7'x12' scaffold tower	Personnel: • 1 Carpenter • 1 yardman • 1 RCT (provide periodic inspection) Equipment: • Socket and ratchet Time: • 45 minutes	Personnel: • 1 Carpenter • 1 yardman • 1 RCT (provide periodic inspection) Equipment: • Socket and ratchet Time: • 15 minutes
Total Time per Tower	• 180 minutes	• 75 minutes
Capacity	Scaffold can be assembled to meet light, medium, or heavy duty use	Scaffold can be assembled to meet light, medium, or heavy duty use
Time to assemble and disassemble Comparison	165 minutes	60 minutes
PPE requirements	Both technologies required the same level of PPE. The number of workers required to wear PPE is the same for both technologies.	

Performance Factor	Baseline Technology Tube-and-Clamp Scaffold	Innovative Technology Excel Automatic Locking Scaffold
Superior capability	• In areas where there is a significant amount of obstructions that inhibit the set up of scaffold, baseline is easier to set up. • Baseline scaffold is easier to decontaminate.	• Workers considered the Excel Automatic scaffold much easier to use. • The tower legs can be used as fall protection anchorage points, thus increasing the safety of the worker. • The availability of attachments increase safety and utility of the scaffold (Figure 9). • Fewer parts mean less maintenance, storage, and setup. • Easily stored and stacked (Figures 10 and 11)

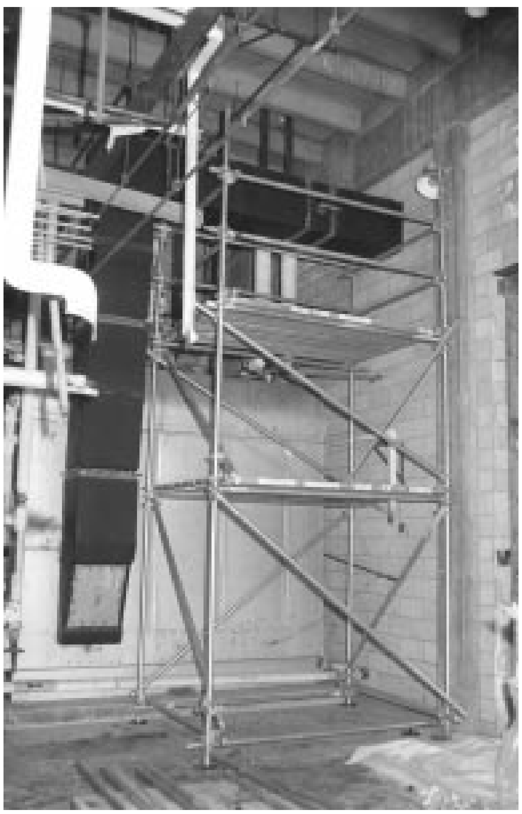

Figure 7. Tube and Clamp Scaffold

Figure 8. Excel Automatic Locking Scaffold

Figure 9. Excel Scaffold with cantilever, lifting attachment, and truss attachments.

Figure 10. Storage frame for scaffold

Figure 11. Stacking storage frames in storage area

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline technology

The baseline technology for this demonstration is the tube and clamp scaffold. There are various manufacturers that produce variations of the baseline scaffold.

Other competing technologies

A broad range of system scaffolds are available, such as painter scaffold or baker scaffold, which also connect together without clamps, but only at the corners or ends of the horizontal and vertical pieces and do not have the flexibility in use that the innovative Excel scaffold has.

Technology Applicability

The innovative technology is fully developed and commercially available. Its superior performance over the baseline in most areas makes it a prime candidate for deployment throughout the DOE complex. It has potential to reduce costs for many D&D projects. The INEEL has deployed this scaffold now on other D&D projects where scaffold is used.

Patents/Commercialization/Sponsor

U.S. Patent No. 5,028,164 and U.S. Patent No. 5,078,532. Other patents pending.
The Excel Automatic Locking Scaffold is commercially available from Excel Modular Scaffold & Leasing Corp. of Plymouth, MA.

Excel Division General Manager Jim Elkins

telephone	1-800-652-7712
fax	1-860-873-1753
email	elkins@cwix.com
pager	1-800-278-3734
cell phone	1-860-227-0700

Mailing address
60 Industrial Park Road
Plymouth, MA 02360

SECTION 5
COST

Introduction

This section compares the installation and removal costs for the innovative technology with similar costs of the baseline method. In this demonstration, the cost to erect and disassemble the innovative technology is approximately 52% of the baseline technology cost, while the cost of the innovative technology is 73% of the baseline technology cost for an 8-day, 80-hour job using a 5-ft x 7-ft x 12-ft tower. This cost analysis is based on observing work demonstrations consisting of mobilizing to the demonstration site, set up of various scaffold platforms, removal of the platforms, and demobilization for both the automatic locking scaffold system (innovative) and the tube and clamp scaffold system (baseline).

Methodology

The costs for the innovative and baseline technologies are derived from observed duration of the work activities that are recorded as the demonstration proceeds as well as the Test Engineer's judgement and experience. The demonstration was performed using INEEL workers in an uncontaminated area (no PPE or decontamination of scaffold required). This cost analysis assumes Government ownership of the equipment and operation by site personnel. The cost analysis for the innovative technology is for a 5-ft X 7-ft X 12-ft scaffolding platform and includes costs for moving the equipment from storage area to the work area, job briefing, erection of the scaffolding, use of the scaffold, disassembly of the scaffold, and return to the storage area. The cost analysis for the baseline technology is also for a 5-ft x 7-ft x 12-ft scaffolding platform and includes costs for moving the equipment from storage area to the work area, job briefing, erection of the scaffolding, use of scaffolding during D&D work, disassembly of the scaffold, and return to the storage area.

This cost analysis assumes a one time set-up and disassembly of a 5-ft x 7-ft x 12-ft scaffolding platform for both the innovative and the baseline technologies and uses the average production rate observed during the demonstration to compute production rates for the scaffolding erection.

A crew of two persons performed the scaffold erection and take down in the demonstration, and this is considered to be representative of normal work. The cost analysis uses one Carpenter and one Laborer to perform all the erection and take down work. An Equipment Operator, Laborer and Fork Lift are used to stage and store the equipment. Both technologies include a Job Supervisor for the Pre-Job Safety Meeting. The crew rates are not considered for cost of using the scaffolding during the D&D work. The crew's labor cost was not included for the time that the D&D work was performed because it would be the same for both the innovative and the baseline costs (would cancel each other out in the comparison of costs) and would vary for every type of D&D work. Consequently, the cost of the labor for performing D&D is not included to avoid obscuring the more important costs. The equipment cost for using the scaffold during the D&D work is considered in this analysis. Labor rates for crew members are based on standard rates for the INEEL site. Specific labor classifications for surface characterization work may vary at other sites.

The equipment rates are based on the amortized purchase price and maintenance costs. The Baseline Technology equipment calculation includes the price of the scaffolding materials and an allowance for small tools not covered by overhead or included in the labor rates. Small tools comprise of a ratchet and associated accessories. Additionally, an equipment rate for the forklift was based on the standard rates from the site.

Additional details of the basis of the cost analysis are described in Appendix A.

Cost Analysis

Costs to Purchase, Rent, or Procure Vendor Provided Services

The innovative technology equipment is available from the vendor by purchase or on a lease basis. The purchase prices of the basic equipment used in the demonstration are shown in Table 3. Rental of the equipment is not considered in the cost analysis, but is provided in Table 3 for the reader.

Table 3. Improved Technology Acquisition Costs

Acquisition Option	Item Description	Cost
Equipment Purchase	5-ft x 7-ft x 12-ft Excel Scaffolding Tower	$3,746.56
Equipment Rental	Rental – Less than 2 Months (per month rate)	4.5% of purchase
	Rental – Greater than 2 months (per month rate)	3.5% of purchase
Vendor Provided Service		Not Available

Unit Costs

The unit costs for erection and disassembly are based on the costs summarized in Tables B-1 and B-2 in Appendix A and include amortization of the equipment purchase. The figures also show a relative contribution to the total for each of the work activities. Additionally, the site-specific conditions that can significantly affect the cost of the activity are identified on the figure under the title Site Specific Conditions. Two examples of the site specific conditions that affected that cost of this demonstration are: 1) PPE were not required; and, 2) the distance to the storage area was approximately 2 miles.

The unit cost for erection and disassembly for the innovative technology is $0.25 per cubic foot of tower volume as compared with $0.49 per cubic foot for the baseline (see Figure 1 and Figure 2). While the innovative technology is less expensive for the erection and disassembly, using the innovative technology during D&D work (having the tower in place during work) is more expensive (for 5-ft X 7-ft X 12-ft tower; $0.53 per hour for the innovative vs. $0.26 per hour for the baseline). This is based on ownership of the scaffold, and the scaffold was amortized over a ten year period with 1000 hours per year usage of the scaffold. Consequently, the situations that involve frequent scaffolding setups and moves will favor the innovative technology more than situations where the scaffolding remains in place for an extended duration.

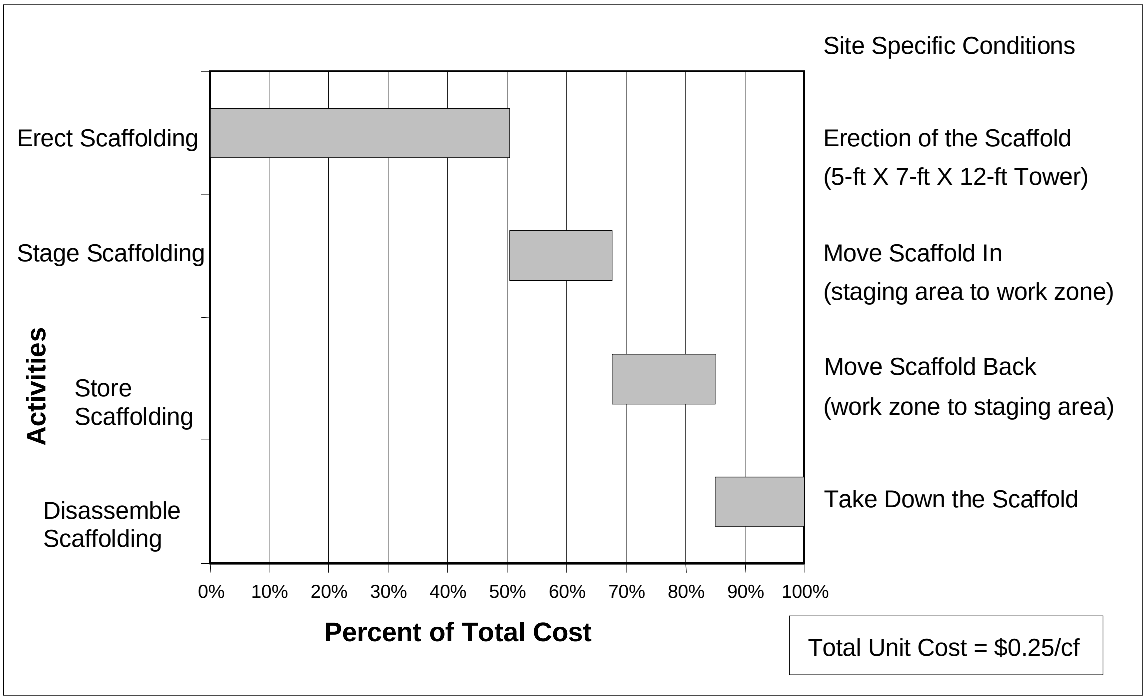

Figure 1. Breakdown of Innovative Technology Unit Cost.

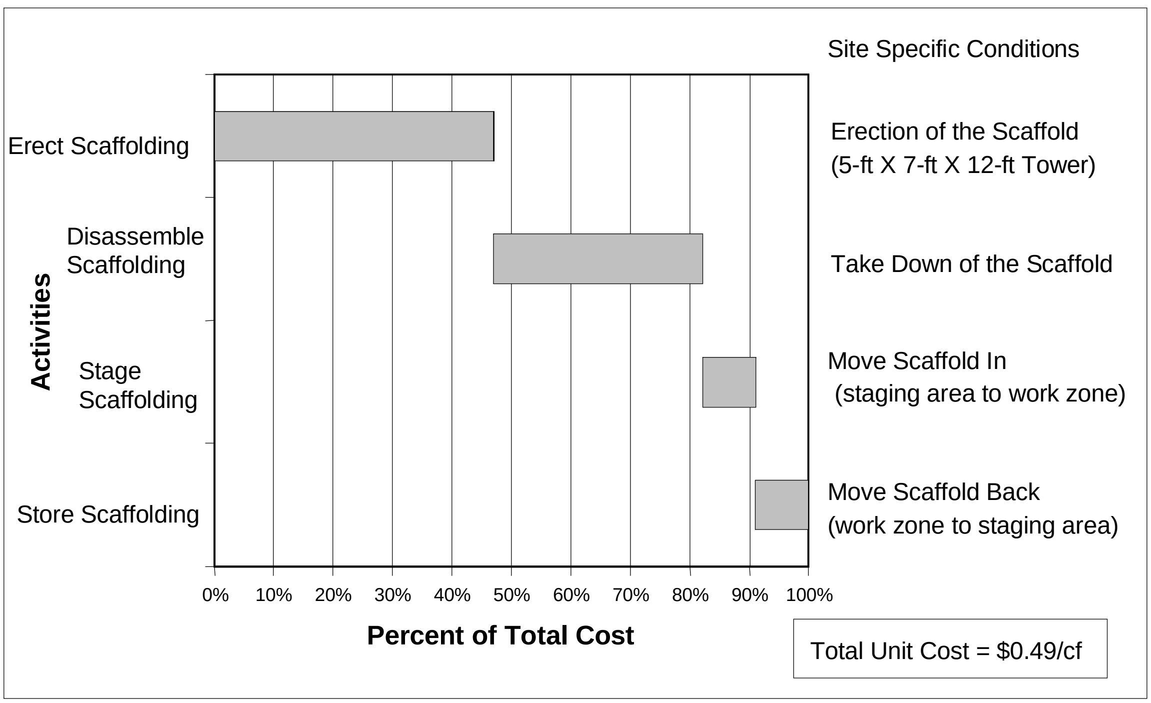

Figure 2. Breakdown of Baseline Technology Unit Cost.

One factor that was not accounted in the cost analysis that would decrease the cost of the innovative technology relative the baseline technology is the time required for daily inspections of the scaffold. New OSHA standards require that workers must inspect the scaffold (including all the connection) prior to each time workers access and work from the scaffold, particularly between shift changes. The positive locking trigger mechanism for the EXCEL scaffold can easily be inspected visually, while the tube and clamp scaffold must be physically examined to determine that all connections are properly tightened. This difference could potentially account for a significant cost savings which is not accounted for in this analysis.

Break Even Analysis

While the innovative technology is less expensive for the erection and disassembly, it is more expensive as an hourly rate during work (for 5-ft x 7-ft x 12-ft tower; $0.53 per hour for the innovative vs. $0.26 per hour for the baseline). A break even point (where the less expensive erection and disassembly balances with the more expensive use of the scaffold while it stands in place during work) will occur when a 5-ft x 7-ft x 12-ft tower remains in place for a period of 360 hours, approximately 9 weeks. Consequently, the situations that involve frequent scaffolding setups and moves will favor the innovative technology more than situations where the scaffolding remains in place for extended periods. Another component of this break even analysis is the job size. The total savings will increase as the job size increases, this will also increase the duration before a break even point is reached.

Payback Period

For this demonstration, the innovative technology saves approximately $76 per job over the baseline for a 5-ft x 7-ft x 12-ft scaffold tower used for 80 hours of D&D work. At this rate of savings, the difference in the purchase price of $1,879 ($3,747 innovative technology purchase minus $1,868 baseline technology purchase) would be recovered by erecting approximately 25 towers using the innovative technology.

Observed Costs for Demonstration

Figure 3 summarizes the costs observed for the innovative and baseline technology for one 5-ft x 7-ft x 12-ft scaffold tower. The details of these costs are shown in Appendix B and includes Tables B-2 and B-3 which can be used to compute site specific costs by adjusting for different labor rates, crew makeup, lab costs, etc.

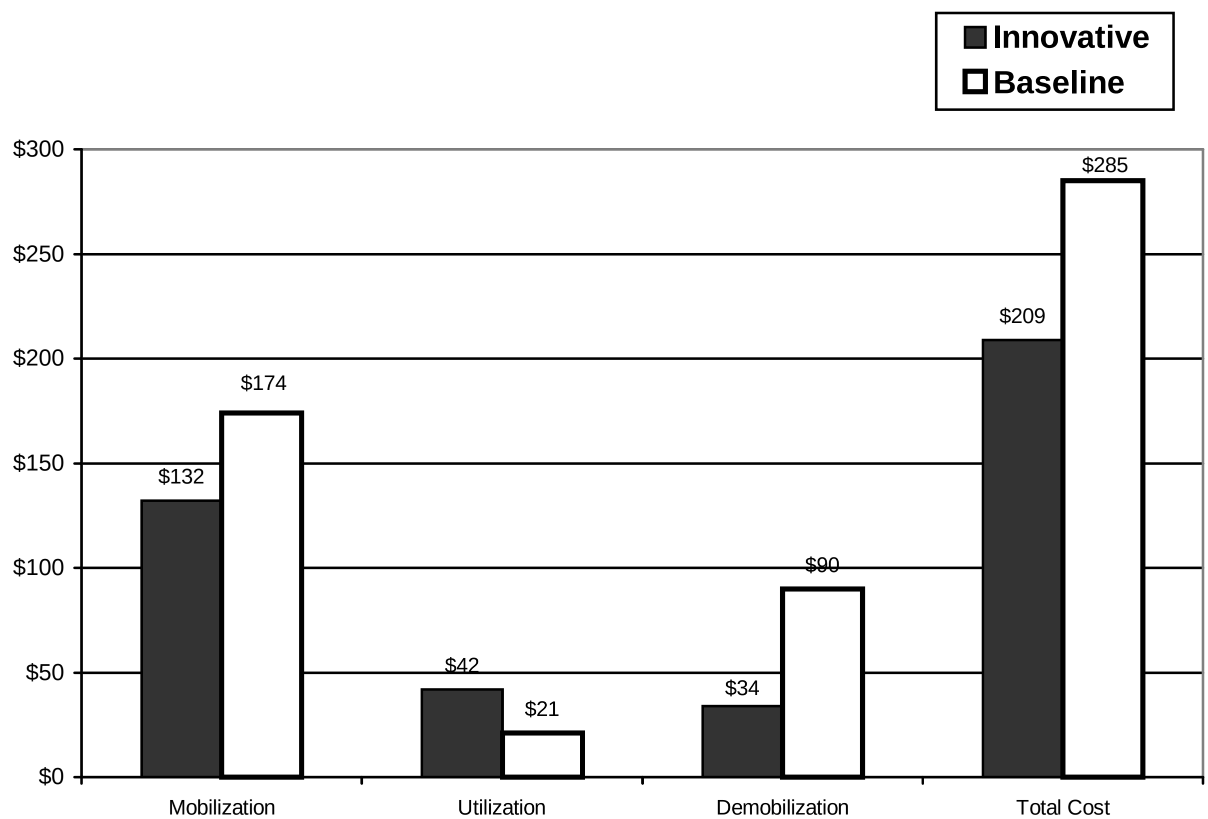

Figure 3. Summary of Technology Costs (for 80-hr D&D job)**.**

Cost Conclusions

The innovative technology approximately is 52% of the baseline technology cost for erection and disassembly, while 73% of the baseline technology cost for a complete job with a 5-ft x 7-ft x 12-ft tower used for 80 hours of D&D work.

The most significant differences for this demonstration were the erection and disassembly of the scaffolding. The scenario used in this demonstration would be typical for normal work up to 20 feet high. Different types of analyses such as greater heights, varying working conditions, and additional features of the scaffolding may be associated with other situations. Job specific criteria should be considered when pricing this activity, if required for the type of analysis prescribed. Use of the Excel Scaffolding eliminated the need for additional small tools in this demonstration.

The production rates for the innovative and the baseline technologies are significantly different, with the innovative being more efficient in this demonstration. The observed duration for various scaffold erection and disassembly activities were used to calculate a production rate for each activity. The innovative technology calculated to 540 cubic feet per hour for erection and 1800 cubic feet per hour for disassembly while the baseline calculated 300 cubic feet per hour for erection and 402 cubic feet per hour for disassembly. The difference in production rates reflects inherent differences in the technologies. The innovative technology uses a positive locking system that allows horizontal bearers to be attached to the vertical legs without the use of tools. Additionally, once the base of the tower is leveled, no other leveling is required. Conversely, the baseline technology requires each connection to be made with the use of a ratchet and accessories and requires each horizontal piece to be leveled. This process can be very labor intensive.

Because the demonstration was only used on structures less than 20 feet, no data was provided to indicate the additional effort required for erecting the scaffold to various heights. The manufacturer estimates the additional effort required for the innovative technology:

- Twenty Feet to Forty Feet use a labor multiplier of 1.08 (an 8.0% additional effort required)
- Forty Feet to Sixty Feet use a labor multiplier of 1.16 (an 16.0% additional effort required)
- Sixty Feet to Eighty Feet use a labor multiplier of 1.24 (an 24.0% additional effort required)

Mobilization and demobilization costs will depend upon the distance that the equipment must be moved between the storage area and the work area. In this cost analysis, both the innovative technology equipment and the baseline technology equipment were assumed to be stored in areas away from the job site, thus requiring travel time. Site specific variations for this cost element will not affect the cost comparison.

The duration of the D&D work being performed can affect the cost comparison. This is because the innovative technology is less expensive for erection and disassemble, but it is more expensive when it is standing in place and being used for work. The purchase cost of the innovative technology scaffold (no labor or other costs considered) is higher than the purchase price of the baseline scaffold. Since the only cost incurred during the time the scaffold stands in place, is the scaffold cost, this results in the innovative technology being more expensive than the baseline (while it stands in place). But, the innovative technology has higher production rates for the assembly and disassembly than the baseline technology. Consequently, the higher scaffold cost for the innovative is offset by the lower labor cost during the assembly and disassembly. Consequently, jobs using a 5-ft x 7-ft x 12-ft tower that last longer than 9 weeks may favor using the baseline technology and jobs with frequent setups and moves will favor the innovative technology.

Several other factors need to be taken into account during the cost analysis for each individual job. For instance, the time it takes to inspect the equipment before each use should also be considered. The trigger locks on the innovative technology can be inspected visually. The tube and clamp connections must be physically inspected to determine that the clamps are properly tightened. Other factors include the final platform height, ease of mobility upon each scaffold (safety), and amount of modification to each platform after completion, complexity of the area of work (physical obstructions), and any site-specific considerations.

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

The innovative technology meets OSHA requirements for light (25 lbs/sq ft), medium (50 lbs/sq ft), and heavy-duty (75 lbs/sq ft) use. In this demonstration, all scaffold was set up to meet light duty use. According to INEEL Management Control Procedure (MCP) 2712, scaffold must use swing gates to allow access onto the working platform of the tower. The innovative technology has a premanufactured swing gate for its scaffold that will allow carpenters to easily meet the requirements of MCP 2712 with respect to swing gate use. The Excel Automatic Scaffold also has been engineered and tested to provide fall protection anchorage points for working above 6 ft. MCP 2710 and 29 CFR 1926 require fall protection for workers above 6 ft. The Excel Automatic Scaffold has already been designed to meet the new OSHA handrail requirements for the year 2000.

Safety, Risks, Benefits, and Community Reaction

Because the Automatic Locking Scaffold System can be assembled and disassembled faster than the baseline, there is a reduction in exposure to workers involved in assembling and disassembling the scaffold. The exposure may be to radiation or chemical exposure, or asbestos, as was the case in this demonstration. The worker may also be exposed to physical hazards such as extreme heat or cold. Excel has also made various attachments to the scaffold that increase the safe use of the scaffold for the workers involved in assembly, disassembly, and working on the scaffold. These attachments include, but are not limited to trusses (can support up to 3000 lbs.), ladders, swing gates, floor hatches, lifting devices, stairs, and cantilevers. Because of the ease of using these attachments, workers are more likely to use the premanufactured swing gate and ladder systems, thus resulting in a safer working scaffold.

SECTION 7
LESSONS LEARNED

Implementation Considerations

The innovative technology is a mature technology that performed very well during the INEEL demonstration.

The workers found the innovative technology to be much easier to setup and dismantle than the baseline scaffold. There are several items that should be considered during the use of the Excel Scaffold. These recommendations are listed below, along with items that have already been addressed by the manufacturer.

- The premanufactured floor hatches allow the workers to climb the scaffold from inside the tower framework. The premanufactured ladders do not attach on the inside of the tower, and the carpenters should use horizontal bearers to create steps for climbing inside the scaffold tower.
- Use of the premanufactured swing gate and ladder eliminated the need for workers to climb through the handrails of the scaffold. This adds to the overall safety for the workers while using the scaffold.
- Asbestos workers commented that they did not observe differences in working on the two scaffold types. Both were equally user friendly for performing the work in the elevated areas.
- Both the asbestos workers and the carpenters involved in assembling and disassembling the scaffold can use the Excel vertical scaffold legs as anchorage points for fall protection tie off. Presently, there are concerns with workers tieing off to other scaffold, and when there are no other options for tie off, there is an inherent danger from falling from the scaffold.
- The Excel Automatic Locking Scaffold is galvanized to minimize the corrosion of the scaffold material.

Technology Limitations and Needs for Future Development

The Excel Automatic Locking Scaffold performed well during this demonstration. There were no significant technology limitations. Minor problems are discussed below and have already been addressed by the vendor where applicable.

- In assembling scaffold in areas where there is an excessive amount of obstructions such as pipes and electrical conduit, it may be more effective to use the baseline scaffold.
- The innovative technology is slightly more difficult to decontaminate than the baseline scaffold. The attachment point cups on the vertical legs can collect airborne particulates and must be sprayed out or cleaned individually.
- The workers recommended that the vendor design ladder brackets so the ladder can be attached on the inside of the tower rather that only for the outside.
- Based on the cost determination of this demonstration, if the scaffold is left in place more than 11 weeks, the baseline technology would be more cost effective to use.

Technology Selection Considerations

Based on the INEEL demonstration, the innovative technology is better suited than the baseline technology for most scaffold projects. The innovative technology is easier to use, more cost effective in the long run, and increases the safety of the workers. There are instances where the baseline technology would be preferable:

- If the area where the scaffold is to be erected is very cluttered with obstructions such as pipes.

APPENDIX A

REFERENCES

Lockheed Martin Idaho Technologies Company, 1996, Idaho National Engineering and Environmental Laboratory Document MCP-2712, Rev.00, *Scaffold*

Lockheed Martin Idaho Technologies Company, 1996, Idaho National Engineering and Environmental Laboratory Document MCP-2710, Rev.00, *Fall Protection*

Occupational Safety Health Administration, 29 Code of Federal Regulations 1926, *Safety and Health Regulations for Construction,* Subpart L*, Scaffolding*

Occupational Safety Health Administration, 29 Code of Federal Regulations 1926, *Safety and Health Regulations for Construction,* Subpart M*, Fall Protection*

APPENDIX B
COST COMPARISON DETAILS

Basis of Estimated Cost

The activity titles shown in this cost analysis come from observation of the work. In the estimate, the activities are grouped under higher level work titles per the work breakdown structure shown in the ***Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*** (HTRW RA WBS) (USACE 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards.

The costs shown in this analysis are computed from observed duration and hourly rates for the crew and equipment. The following assumptions were used in computing the hourly rates:

- The innovative and the baseline equipment are assumed to be owned by the Government.
- The equipment rates for Government ownership of the innovative and baseline equipment are computed by amortizing the purchase price of the equipment, plus a procurement cost of 5.2% of the purchase price.
- The equipment hourly rates assume a service life of ten years for the innovative technology equipment. A ten-year service life is used for the baseline equipment with a one-year service life is assumed for the baseline's miscellaneous small tools allowance. An annual usage of 1000 hours per year is assumed for both the innovative and baseline equipment.
- The equipment hourly rates for the Government's ownership are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, ***Cost Effectiveness Analysis***.
- The standard labor rates established by the Idaho National Engineering and Environmental Laboratory (INEEL) are used in this estimate and include salary, fringe, departmental overhead, material handling markups, and facility service center markups.
- Equipment rates for fleet and other common construction equipment are based on the standard rates for the INEEL.
- The equipment rates and the labor rates do not include the Lockheed Martin general and administrative (G&A) markups. The G&A are omitted from this analysis to facilitate understanding and comparison with costs for the individual site. The G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the INEEL.

The analysis does not include costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation costs.

The analysis assumes a ten-hour workday.

Activity Descriptions

The scope, computation of production rates, and assumptions (if any) for each work activity is described in this section.

Mobilization (WBS 331.01)

Stage Scaffolding: The equipment will be stored in a equipment/supplies storage area. The time required to transport the equipment to the work area is based on the judgement of the test engineer and the actual demonstration. The transport for the baseline and innovative equipment were recorded in the demonstration. The baseline equipment includes the tube and clamp scaffolding and miscellaneous small tools, such as a ratchet and appropriate accessories. The innovative equipment includes only the excel scaffolding system (small tools are negligible).

Pre-Job Briefing: The duration for the pre-job meeting is based on the judgement and experience of the test engineer. The duration for the pre-job briefing does not have a set duration time and may vary during each meeting conducted in the demonstration. The labor costs for this activity are based upon the actual demonstration participants. All subsequent activities are also based on the assumed crews. The crew members reflect anticipation of actual field performance for the INEEL site.

Mobilization (D&D) (WBS 331.01)

Erect Scaffolding: This activity consists of unpacking the equipment and assembling the components for the baseline and innovative technologies. The productivity is based on the observed time for the demonstration. An average was calculated using the multiple times and sizes observed in the demonstration.

Decontamination & Decommissioning (D&D) (WBS 331.17)

Scaffolding Cost during Work: This activity accounts for the cost of using the scaffolding while D&D work is being performed. The cost of the labor is not accounted for in this activity. The duration of this activity, 80 hours, is based upon the duration of the demonstration.

Demobilization (WBS 331.21)

Disassemble Scaffolding: This activity consists of disassembling the components for the baseline and innovative technologies and packing the equipment for transportation to storage. The productivity is based on the observed time for the demonstration. An average was calculated using the multiple times and sizes observed in the demonstration.

Store Scaffolding: Similar to Stage Scaffolding.

Cost Estimate Details

The cost analysis details are summarized in Tables B-1 and B-2. The tables break out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration and all production rates so that site specific differences in these items can be identified and a site specific cost estimate may be developed.

Table B-1. Innovative Technology Cost Summary

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement									**TOTAL COST FOR DEMONSTRATION =**			**$ 208.71**
Mobilization (WBS 331.01)										Subtotal =		$ 131.94
Stage Scaffolding	ea	18.32	1	$ 18.32		0.250	1EO+LA	69.44	EXC + FL	3.83		Move Scaffolding to Site
Pre-Job Briefing	ea	60.12	1	$ 60.12		0.500	1CA+1LA+1JS	119.70	EXC on standby	0.53		30 Minute Meeting
Erect Scaffolding cf/hr	cf	0.13	420	$ 53.51	540 cf/hr		1CA+1LA	68.17	EXC +MST	0.63		540 cf of tower per hr
				$ -								
D&D (WBS 331.17)										Subtotal =		$ 42.40
Scaffolding cost during wo	khr	42.40	1	$ 42.40		80			EXC	0.53		
Demobilization (WBS 331.21)										Subtotal =		$ 34.37
Disassemble Scaffolding	cf/hr	0.04	420	$ 16.05	1800		1CA+1LA	68.17	EXC+MST	0.63		1800 cf of tower per hr
Store Scaffolding	ea	18.32	1	$ 18.32		0.250	1EO+1LA	69.44	EXC + FL	3.83		Move Scaffolding to Storage

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Excel Scaffold	0.53	EXC			
Carpenter	35.83	CA				Fork Lift	3.30	FL			
Laborer	32.34	LA				Mis. Small Tools	0.10	MST			
Equipment Operator	37.10	EO									

Notes:

1. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs
2. Abbreviations for units: ea = each, hr = hour.
3. Other abbreviations not identified: RMA = Radioactive Material Area, WBS = Work Breakdown Structure.

Table B-2. Baseline Technology Cost Summary

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement								**TOTAL COST FOR DEMONSTRATION =**				**$ 284.82**
Mobilization (WBS 331.01)										Subtotal =		$ 174.17
Stage Scaffolding	ea	18.25	1	$ 18.25		0.250	1 EO + 1 LA	69.44	T&C + FL	3.56		Move Scaffolding to Site
Pre-Job Briefing	ea	59.98	1	$ 59.98		0.500	1CA+1LA+1JS	119.70	T&C on standby	0.26		30 Minute Meeting
Erect Scaffold cf/hr	cf/hr	0.23	420	$ 95.94	300		1CA+1LA	68.17	T&C + MST	0.36		300 cf of tower per hr
[redacted]				$ -								
D&D (WBS 331.17)										Subtotal =		$ 20.80
Scaffolding cost during work	hr	20.80	1	$ 20.80		80			T&C	0.26		
Demobilization (WBS 331.21)										Subtotal =		$ 89.85
Disassemble Scaffolding	cf/hr	0.17	420	$ 71.60	402		1CA+1LA	68.17	T&C + MST	0.36		402 cf of tower per hr
Store Scaffolding	ea	18.25	1	$ 18.25		0.250	1 EO + 1 LA	69.44	T&C + FL	3.56		Move Scaffolding to Storage

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Tube & Clamp Scaffold	0.26	T&C			
Carpenter	35.83	CA				Misc. Small Tools	0.10	MST			
Laborer	32.34	LA				Forklift	3.30	FL			
Equipment Operator	37.10	EO									

Notes:

1. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs
2. Abbreviations for units: ea = each, hr = hour.

Other abbreviations identified: WBS = Work Breakdown Structure.

APPENDIX C
ACRONYMS AND ABBREVIATIONS

DOE	United States Department of Energy
D&D	decontamination and decommissioning
DDFA	Deactivation and Decommissioning Focus Area
INEEL	Idaho National Engineering and Environmental Laboratory
LLW	low-level waste
LSDDP	Large Scale Demonstration and Deployment Project
ACM	Asbestos containing material
OST	Office of Science and Technology
MCP	Management Control Procedure
OSHA	Occupational Safety and Health Administration
CAL-OSHA	California Occupational Safety and Health Administration
OD	Outer Diameter
STF	Security Training Facility
EOCR	Experimental Organically Cooled Reactor
ALARA	As Low As Reasonably Achievable
IEEE	Institute of Electrical and Electronics Engineers
RCT	Radiation Control Technician
EO	Equipment Operator
PPE	Personal Protective Equipment
OMB	Office of Management and Budget
G&A	General and Administrative
WBS	Work Breakdown Structure
CF	Central Facility