The Department of Defense and the Construction Industry: Leadership Opportunities in Hazardous Waste Remediation Innovation

by
Michael A. Rossi
B.S., U.S. Military Academy, West Point 1982

Submitted to the Department of Civil Engineering in Partial Fulfillment of the Requirements for the Degree of

MASTERS OF SCIENCE in Civil Engineering

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
January, 1992

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Department of Civil Engineering
13 December 1991

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Chairman, Department Committee on Graduate Students
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ABSTRACT

The cleanup of hazardous waste sites presents both the biggest challenges and biggest opportunities for the construction industry. It is our next great engineering problem. Rather than stimulate, ten years of Superfund have stymied innovation in remediation technologies. This thesis analyzes the strengths and weakness of three key elements of the current process--Superfund, the Department of Defense, and the Construction Industry. The driving purpose in examining these elements is to synthesize their strengths, weaknesses, and interests to find a model for the federal government effectively promoting innovation.

The study found DOD's remediation program to share Superfund's problems of inconsistency, defining risk, and risk assessment. DOD, through the Army Corps of Engineers, does however have a history of successfully sponsoring R&D, contracting, and managing large construction problems, in addition to owning numerous sites of varying toxic complexity. Using Michael Porter's models for analyzing both the construction industry and the remediation market, problems in bonding, insurance, and financing combine with uncertain liability issues to keep new entrants and established firms from risking breakthrough technologies.

In addition to recommendations for internal improvements to the Defense Environmental Restoration Program, this study proposes DOD take the lead among federal agencies (vice EPA and DOE) in promoting innovation in remediation. Using their expertise to improve contracting and ensure proprietary rights of innovators, DOD should pursue two separate strategies for development--one taking the contracting and risk lessons from our experience in high-tech weapons development/procurement, the other investing in incremental development by creating a stable market, clearer specifications, and competitive bidding to stimulate competitors.

Thesis Supervisor: Fred Moavenzadeh
Title: Director, Center for Construction Research and Education
ACKNOWLEDGEMENT

I would like to acknowledge the following people for their valuable contribution to this thesis. My thesis advisor, Dr. Fred Moavenzadeh, for his guidance and insight in synthesizing the thesis. The Army, for giving me the opportunity to pursue my interests in education and the environment. To my many friends, particularly those in the Center's environmental task force, who lent resources, ideas, criticism, reinforcement, and recommendations on this subject in our weekly meetings and daily interactions. To my parents, who's sacrifice and dedication to education and family continue to serve as my model. Most importantly, to my wife Robin and my children, for their unconditional devotion, understanding, and support throughout the year.

AUTHOR

The author, Michael Rossi, is a Captain in the U.S. Army Corps of Engineers. He is Airborne, Ranger, and Air Assault qualified and has served in various staff and leadership positions in both the United States and Germany throughout his ten year career, to include Aide-de-Camp to the Commanding General of the 8th Infantry Division (Mechanized), and Commander of a combat engineer company in the 101st Airborne Division (Air Assault). He was born at Fort Sill, Oklahoma in 1960 to a career soldier.
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DEFINITIONS

BDAT: Best Demonstrated Available Technology. EPA approved remediation techniques--minimum standard for site specific cleanup.

CERCLA: the Comprehensive Environmental Response, Compensation and Liability Act of 1980, otherwise known as Superfund. The initial Federal legislation and funding ($1.6 billion) for determining the location, scope, responsible parties, and cleanup of the nation's hazardous waste sites.


DERP: the Defense Environmental Restoration Program. The Department of Defense hazardous waste cleanup program.

DOD: the United States Department of Defense

EPA: the Environmental Protection Agency.


HQDA: Headquarters, Department of the Army

IRP: the U.S. Army plan for complying with the Defense Environmental Restoration Program. Outlines procedures for identification and cleanup of Army hazardous waste sites.

NPL: the National Priorities List. List generated by Superfund legislation ranking the nation's worst hazardous waste sites.

OSD: Office of the Secretary of Defense

OTA: the Office of Technology Assessment of the federal government.

PA/SI: Preliminary Assessment and Site Inspection. Steps in the Army's remediation program in compliance with Superfund legislation.

PRP: Potentially Responsible Parties. Under Superfund, individuals or entities which may be held liable for cleanup of a hazardous waste site.


remediation: the act correcting or "healing," from the word remedy.

RI/FS: Remedial Investigation/Feasibility Study. Steps in the Army’s remediation program in compliance with Superfund legislation.

ROD: Record of Decision. Legislatively directed step in the cleanup process where the standard for cleanup is dictated and the remediation technology to be used is specified.

RPM: Remedial Project Manager. Action officer for site cleanup in the Army’s remediation program.


Superfund: commonly used name for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 and its reauthorization in 1986, the Superfund Amendments and Reauthorization Act (SARA).

USACE: U.S. Army Corps of Engineers

USATHAMA: U.S. Army Toxic and Hazardous Materials Agency
1. INTRODUCTION

Cleanup of the toxins we have systematically dumped into the land, sea, and air presents the federal government and the construction industry with its greatest challenges and opportunities for the next century. Our first attempt at fixing past sins, the Superfund, created an inefficient process which, over the past ten years, has both deterred industry from finding new, innovative technologies and failed to clean-up the mess. No other federal agency has responsibility for remediation of more sites that the Department of Defense. Likewise, no federal agency has a history of contracting, research and development, solving "mega-problems," and managing mega-projects as the Department of Defense. My challenge in this thesis is in applying these historic strengths of DOD to first cleaning-up its own mess, and more importantly, taking the lead in government in sponsoring innovation in the construction industry to find better remediation technologies.

The strategy this thesis pursues follows a simple, time-honored process: identify the problems; analyze the components of the identified problem in terms of what we know, what we don't know and want to discover, what are the strengths and weaknesses of the players and programs, and lastly; synthesize and make concrete recommendations that may solve the problem.

This paper defines the problem in terms of three key elements, the Superfund, the Department of Defense and its military waste, and the current and potential Construction and Cleanup Industry. The study then analyzes the remediation action arm of DOD (the Corps of Engineers), the Defense Environmental Restoration Program and its ties to Superfund, and a
thorough market analysis of the growing remediation sector of the construction industry and the inhibitors to innovation. In synthesizing the above analysis—packaging the identified strengths, weaknesses, and market forces to produce mutual gains for the three elements—two models for DOD emerge.

The recommendations proposed take two forms. First, recommendations particular to the Defense Environmental Restoration Program are put forward. More importantly, the paper recommends changes in contracting, standard setting, and proprietary protection. A high-tech model based upon lessons learned through weapons-systems procurement and a second, traditional low-tech model seeking incremental innovation, synthesize and implement the given recommendations.
2. PROBLEM

Are we getting what we pay for? Superfund comes up for its second reauthorization soon and may be in trouble based on its past performance. Enacted in 1980, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) had a simple mandate: "find the mess, find who did it, make them clean it up." Ten years and close to $10 billion later, only a handful of sites on the National Priority List have been completely cleaned. Worse yet, no one has yet to technically solve the problem of how to permanently "clean up the mess."

While there are numerous players in this process, this chapter will introduce and develop only three. The first and most important is Superfund. What is it? What's good about it? What's bad about it? For the purposes of this study, we will refer to Superfund the legislation; the federal policy; the law—not the pot of money to be spent on clean ups (although it is that also). Another player is the environmental services and construction industry on which the burden of physically cleaning-up the mess falls. The third, the Department of Defense, has been one of the worst polluters, yet, through the Corps of Engineers, could be a catalyst driving the other two players to both find innovative technological solutions and to actually clean up.
Federal environmental legislation in the United States finds its roots in the Resource Conservation and Recovery Act (RCRA), passed in 1976. While RCRA did legislate guidelines for hazardous waste disposal, it did not require cleanup of past disposal sites. The first Federal legislation requiring cleanup of past hazardous waste disposal sites was the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980-now known as Superfund.\(^1\) The Superfund was a $1.6 billion trust fund covering a five-year program. It would finance the investigation of dump sites and identify those responsible for the cleanups. The program would finance site remediation if it failed to identify the responsible parties.\(^2\) CERCLA was implemented by Federal regulations in December 1982 with the expansion of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to include response actions for hazardous substance release into the environment.

In 1984, Congress amended RCRA. Section 3004 of the amendment required cleanup of past disposal sites located at facilities for which a RCRA Part B permit is required. Since RCRA is administered by the U.S. Environmental Protection Agency (EPA) and the states, procedures and jurisdictions differed from CERCLA. In 1986, the Superfund Amendments and Reauthorization Act (SARA) continued the Superfund for the cleanup of non-Federal sites and resolved many of the distinctions between RCRA and CERCLA\(^3\) and accelerated the cleanup of the hazardous waste sites. It set


aside $9 billion for a five-year effort, including $98 million targeted for
studies on detecting and evaluating waste hazards and $100 million for
research, demonstration, and training programs on new cleanup
technologies.\(^4\)

2.1.1 What's Wrong with Superfund?

Detailing the frailties of CERCLA and SARA from both scientific and
policy perspectives have kept academians and political scientists arguing,
speaking, publishing, and employed since 1981. From an empirical
perspective, Superfund has disappointed on three particular points: overly-
ambitious original goals, limited results, and little value for our money.

Superfund was Congress' response to a public that, in effect,
demanded: "Find every hazardous waste site, get rid of every speck of
contamination, bill the polluters, and don't make any mistakes."
Unfortunately, Congress, the EPA, and the public all underestimated the
scope of the problem on three counts--the number of sites, the cost and
difficulty of cleaning-up, and the cost and difficulty of bringing those
responsible to court. "Now we know that the task of cleaning uncontrolled
hazardous waste sites will be with us well into the 21st century," says
Thomas Grumbly, president of Clean Sites (a "Superfund facilitation" group
in Washington D.C., with members from industry, EPA, universities and
environmental groups). Clean Sites estimates that it will cost at least $30
billion to clean the remaining sites on the national priority list. The Office of

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\(^4\)Harris and Wrenn, p. 55.
Technology Assessment estimates the total cleanup bill of all U.S. hazardous waste sites to be $500 billion.  

Pragmatically, the best yardstick of any policy or program is the net result of the legislation--the bottom line. To date, there have been too few cleanups. With EPA spending roughly $7.5 billion since 1981, only 64 of the 1200 currently listed sites have been completed. Additionally, there remains an additional 29,000 lower priority sites relegated to the states for cleanup. Admittedly, many more sites than the 64 are in some stage of investigation or remediation because of Superfund and the next ten years will most likely see more completed cleanups than the past ten. Still, to its sharpest critics, the Superfund just has not cleaned-up the mess.

A third detractor from the program has been the lack of value delivered to the customer. One facet of the program's inefficiency and failure to deliver is outlined above. A more incriminating indictment has been the excessive price the government pays for services. The Office of Technology Assessment (OTA) reports that it is not uncommon for the government to spend from 100%-500% more than a private client for the same site study or cleanup. Their report sites as an example a contractor performing a feasibility study and recommending his own proprietary treatment process--at a cost of $1.3 million more than alternative treatments. The report followed a General Accounting Office (GAO) report to the same effect. EPA acknowledges that money is being wasted. John Martin, EPA's Inspector General, admits, "Superfund is particularly sensitive

7Morse, p. 40.
to fraud, waste and abuse."\(^8\) A June 1991* Boston Globe* article charged that $62 million—nearly one-third of the $200 million spent since 1988 to clean up the nation’s worst sites—have been paid to some of the nation’s largest engineering firms for administrative services. It continued, "The payments go far beyond the terms of most government contracts, which pay only for the actual time and expenses needed to administer their projects."\(^9\) Such *gold-plating* is nothing new in the Federal government—the Department of Defense immediately comes to mind. However, when combined with such ambitious goals and costly, yet conspicuously absent results, the gouging rightly inflames the bill-payers.

This paper will raise and analyze Superfund’s and the Defense Environmental Restoration Program’s (DERPs) other less obvious, yet important, weaknesses in later sections.

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\(^8\)Ibid., p. 43.

2.1.2 What’s Right with Superfund?

What I believe has happened in the last ten years that made the Superfund program a success from the public policy standpoint is that people have begun to see the real economic impact associated with remediation of hazardous waste problems and, as a result, the importance of prevention. In my opinion the Superfund has done more as a regulatory preventative program than most people realize, and that may indeed be one of it’s greatest contributions to the solution of the hazardous waste problem. The statute has changed the behavior of almost every sector of our society by virtue of it making apparent the significant costs associated with remediation of hazardous waste problems. In economic terms the Superfund Program has internalized the externalities to the point where it has become a major factor in preventing a proliferation of future hazardous waste sites.\textsuperscript{10} 

Ira Leighton, EPA

Industry well realizes the impact of Superfund on the market. The greening of corporate America and to a great extend the Federal government can be directly traced to the stick created by CERCLA. The coincidental fallout created by Superfund's inefficiencies--exorbitant remedial costs and years of costly litigation--have raised the cost of doing business for just about every sector of productive society. Mr. Leighton succinctly captures the pervasive impact of the legislation. In the market model of our society, pollution and hazardous waste have long been considered externalities--legal by-products of the market's production. Industry is now culpable for not only the pollution they currently generate, but the waste they legally dumped years past. The cost to industry is substantial and minimizing those costs has caused the market to internalize the externality. Already, environmental compliance costs for many Fortune

500 companies are 30%-40% of annual earnings, according to Tucker Anthony studies. As later sections in this paper will show, retro-fitting industry to minimize current waste and cleaning-up old waste is big business and has sprung from obscurity to a booming, multi-billion dollar industry since 1980.

Would any other form of policy/legislation have so drastically changed corporate society or the market in so little time? There are as many different opinions and recommendations on this question as there are dollars set aside for Superfund. Without a doubt, the side effect is good—it points toward our maturing as a society. The aim of this thesis is not to rewrite Superfund, but to assess, adapt, and overcome some of its gross inefficiencies.

2.2 Military Waste

Shielded by the mantle of "national security," the armed forces and military contractors have either been exempt from environmental regulations or ignored them...Military toxins are contaminating water used for drinking or irrigation, killing fish, befouling the air, and rendering vast tracts of land usable for generations to come. Having been dumping grounds for a lethal soup of hazardous materials for decades, military bases have become health time bombs detonating in slow motion.12

State of the World 1991

While the above writer's perception and condemnation was in many ways true, it no longer accurately reflects either the environmental policy or recent performance of our military. A nation's military is a reflection of the nation and society from which it draws, and carries with it the norms and

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ethics of that society. Like corporate America, there has been a gradual greening of the military for the past decade and an intensive focusing of both manpower and resources in the past two years to cleanup old waste and minimize production of new waste. The Chief of Engineers recently forwarded this guidance.

As a commander, you are entrusted with the stewardship of the land, air, water and natural and cultural resources associated with performing your military mission. These resources must be carefully managed to serve both the Army's, and the nation's, short and long-term needs. Today, environmental considerations must be a part of your decisions...I cannot overstate the importance of your environmental stewardship."\textsuperscript{13}

\textit{LTG Henry Hatch}

\subsection{2.2.1 How much Military Waste, old and new, is there?}

The use of hazardous materials is fundamental to the readiness mission of the Army, arising from such areas as, but not limited to, weapon development and testing, training, equipment repair, and machinery maintenance. As a result, the Army is a large user of hazardous materials and large generator of hazardous waste (approximately 100,000 metric tons annually). Management of such materials is becoming more complex and time consuming due to recent environmental legislation.\textsuperscript{14}

\textit{HQDA 5-year Plan, Sep 90}

The above excerpt seems to state the obvious--that hazardous materials and thus hazardous wastes are an unfortunate part of the business of defense, and that figuring-out what to do with that material is no easy task.


Figure 2.1 shows DOD's best estimate of past hazardous waste production for the years 1985 to 1987. The table is taken from a 1989 GAO study on DOD's hazardous waste situation. A year later, the Chief of Engineers followed-up with his *Five-Year Integrated Hazardous Material/Hazardous Waste Management Plan*, acknowledging "the many useful efforts ongoing within the Army, but recognize(ing) the need for some institutional changes within the Army." The sheer size and scope of the problem is causing the Army to come to grips with the new standards and, in many cases, begin the shift from "reaction" to "proaction."

The Department of Defense owns approximately 100,000 square kilometers in the United States and leases about 80,000 square kilometers from other federal agencies. This represents almost 2 percent of the territory in the United States—roughly the size of the state of Nebraska. Over the years, the sources of pollution on these installations have ranged from fuel spills during maneuvers to lead, high explosives, and other toxins from tank and artillery gunnery ranges which remain in the ground. Finding effective solutions to the problem of existing wastes will require a flexible framework that can adjust to and hopefully anticipate the changing polis.

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15 Ibid., p. 2.
16 Renner, p. 134.
17 Ibid., p. 135.
18 From Deborah A. Stone, *Policy Paradox and Political Reason* (Glenview, Illinois: Scott, Foresman and Company, 1988): As opposed to the traditional market model, where public interest and policy are shaped by market forces, Stone describes and advocates an alternate model called the *polis*—a political community where public norms, values, and interests shape policy rather than market forces.
### Services' Hazardous Waste Generation Data

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<td>Naval Supply Command</td>
<td>332.80</td>
<td>2,307.18</td>
<td>1,068.16</td>
</tr>
<tr>
<td>Pacific Fleet</td>
<td>8,182.69</td>
<td>12,439.31</td>
<td>105,674.89</td>
</tr>
<tr>
<td>Air Systems Command</td>
<td>37,382.68</td>
<td>30,165.33</td>
<td>6,013.75</td>
</tr>
<tr>
<td>Sea Systems Command</td>
<td>50,834.64</td>
<td>56,404.00</td>
<td>51,627.20</td>
</tr>
<tr>
<td>Facilities Engineering</td>
<td>90,553.95</td>
<td>63,135.00</td>
<td>640.34</td>
</tr>
<tr>
<td>Other Commands</td>
<td>84,088.07</td>
<td>18,742.84</td>
<td>10,155.53</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>271,374.83</td>
<td>183,266.61</td>
<td>175,224.62</td>
</tr>
</tbody>
</table>

Note: Inconsistencies and inaccuracies in the reported generation data is discussed thoroughly in the GAO report.

aData furnished by the Air Force for 1987 reflects gross generations, which includes reclaimed, recycled, and reused chemicals and wastewater that is subsequently treated and removed prior to disposal.

bThe Space and Warfare Systems Command was not established until 1986.

Source: GAO

Figure 2.1

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2.2.2 The Defense Environmental Restoration Program (DERP).

The Army established the Installation Restoration Program (IRP) in 1975 in response to regulatory action at several installations where they had contaminated local streams and groundwater. Later, President Carter required that Federal activities comply with the requirements of Federal environmental legislation when he issued Executive Order 12088, "Federal Compliance with Pollution Control Standards." Congress followed with CERCLA in 1980 and the NCP in December 1982.

The Defense Appropriation Act of 1984 established a transfer account, the Defense Environmental Restoration Account (DERA), that funds the IRP for active installations in the continental United States, removal of unsafe structures or debris, and properties formerly owned or used by DOD (FUDs). Congress also amended RCRA in 1984. Most Army installations were affected by Section 3004 requiring cleanup of past disposal sites located at facilities for which a RCRA Part B permit is required.

In 1986, SARA mandated several changes for the Department of Defense. Most importantly, it established the Defense Environmental Restoration Program (DERP) which has as its primary goal "the identification, investigation, research and development, and cleanup of contamination from hazardous substances, pollutants, and contaminants."

It continued DERA as the funding source for IRP and other DERP activities and added a new Section 120 to CERCLA relating to Federal facilities. Section 120 requires that all Federal facilities "shall be subject to, and comply with, this act in the same manner and to the same extent, both procedurally and substantively, as any non-government entity." This does not mean that DERA is equal to Superfund, in fact there are a few key differences. DERP and Army IRP activities apply to all Army sites which
pose a threat to public health, welfare, or the environment. Superfund concerns only the "worst" hazardous waste sites in the nation--those on the National Priorities List (NPL). While several Army installations are on the NPL, no Army IRP activity receives Superfund funding. In fact, DOD reimburses EPA for costs incurred during investigations. Unity of responsibility (in terms of PRPs) avoids some of the administrative intricacies of Superfund. IRP activities are, however, subjected to administrative requirements which do not apply to Superfund sites--schedule requirements, interagency agreements, Annual Reports to Congress, and Technical Review Committees to name a few.20

The Department of Defense identified 17,482 sites that may have been contaminated on 1,855 installations in its FY90 report to Congress submitted in February 1991. Of these, the Environmental Protection Agency has placed 95 on its list of hazardous waste sites and 89 on the NPL. DOD requested $1.25 billion in its FY92 budget for hazardous waste sites on currently operating and former bases. Additionally, they seek another $175 million for environmental restoration as part of the base-closure program. According to DOD's Office of the Inspector General, the total Cleanup cost could reach $200 billion.21

2.2.3 The Corps of Engineers

The U.S. Army Corps of Engineers are the nation's engineers. Since 1802, their non-wartime mission has been to manage the country's largest engineering problems and undertakings--exploration west of the Mississippi,

the Panama Canal, the Manhattan Project, and the lock and dam system necessary throughout the country to manage coastal and river waterways. Currently, the Corps can be justifiably considered the largest construction management organization in the world because of both its size and the scope of its ongoing projects.

Soon after assuming duties as the Chief of Engineers, LTG Henry Hatch charted the future strategy for the force in his 1989 directive, *Our Vision*. New and foremost in this policy was his pledge:

We will assist the Army and DOD in meeting their total environmental responsibilities, including restoring the environmental quality of military installations. We must also focus the full force of our expertise in addressing the Nation's problems of: toxic and hazardous waste clean-up; disposal and maintenance of nuclear wastes; protection of water resources; and, disposal of dredge and fill material.22

As shown earlier, the Chief of Engineers draws his cue from a history of Federal legislation and the Corps' traditional involvement with the environment (some famous and some infamous)—in particular with wetlands and waterways.

2.3. The Construction and Cleanup Industries

The simple fact that no one has figured-out, technologically, how to *clean up the mess*, captures the situation for the remediation industry: opportunity tempered by liability. The number of sites needing remediation, the number of factories and production systems requiring refit, and the Federal and private dollars available point to tremendous opportunity for

engineers. Likewise, the lack of a clear standard for cleanup, exploding litigation costs, the gauntlet of regulations and codes from various Federal and state sources, and the required mountain of documentation required by the system inhibits both technological innovation and new entrants to the market. For the firms that do successfully discover how to clean up the mess, the rewards could be substantial. For those who miss the brass ring, the uncertainty associated with future liability will be costly.
2.3.1 Opportunity

The future of the industry is driven by two major forces—continued polluting and ever-tightening regulations. The long-term growth of the environmental service companies seems insured by the tremendous buildup of toxic air emissions, hazardous materials, and waste sites by every sector of industry. The unfortunate cost to society of modernization and progress is waste. It seems guaranteed that if society moves forward in a productivity sense, the market for dealing effectively with the by-products of progress is assured. Additionally, as people, and thus politicians and regulatory agencies, grow more concerned about environmental risks, the percentage of gross national product industrialized nations spend for cleanups will rise significantly higher than the 1%-2% they now spend.23

Figure 2.2 illustrates the market in terms of current and potential dollars by environmental service.

Figure 2.2

Source: Chemicalweek, 11 Oct 89

23Sternberg, pp. 21-22.
The increasingly stringent set of laws and regulations which dictate how cleanup companies treat these toxic waste sites only point toward more work for those firms who learn to navigate the growing ocean of sites. The DOD sites mentioned earlier are only a fraction of the opportunity. Figure 2.3 shows in a different way, the opportunities in the remediation arena for the foreseeable future. Of the 6,000 solid waste landfills in the U.S., over half will need some remediation to meet revised federal standards according to some estimates. Additionally, in August 1989, Energy Secretary James Watkins launched a $19.5-billion five-year plan to clean up the numerous weapons plants and their related facilities.24

<table>
<thead>
<tr>
<th>Program</th>
<th>Cleanup Costs (billions)</th>
<th>Est. number of Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superfund</td>
<td>$50</td>
<td>2,000</td>
</tr>
<tr>
<td>Correcting RCRA facilities</td>
<td>$100</td>
<td>3,570</td>
</tr>
<tr>
<td>DOD</td>
<td>$10-$15</td>
<td>6,000</td>
</tr>
<tr>
<td>DOE</td>
<td>$53-$92</td>
<td>45</td>
</tr>
<tr>
<td>State and real estate funded</td>
<td>$100</td>
<td>30,000</td>
</tr>
</tbody>
</table>

Superfund is not the only enormous hazardous waste cleanup program. (Sources for this chart are OTA, DOD, DOE and Marcia Williams of Browning Ferris.)

Source: Civil Engineering, Apr 89.

Figure 2.3

25 Morse, p.42.
2.3.2 Caution

No matter who pays for cleanups--EPA or the responsible parties--Superfund will remain a constricting environment for the civil engineer who wants to stretch out his or her arms and design a cleanup.\(^2^6\)

*Civil Engineering, April '89*

The above indictment captures the misgivings of both entrants into the remediation market and its current players. Their complaint rests on two main points: concerns over liability and the inhibiting mountain of documentation.

Superfund was a rare piece of legislation from the outset. It held parties who broke no law in the past liable for cleaning-up their waste sites to a new, undefined standard. An engineer working under a contract to cleanup a waste site today rightly fears being held liable to some new, harder standard ten years from now. *Risk assessment* is the linchpin of the program, yet conceptually is fraught with inconsistency. Is one part per million safe? Which contaminants in the site are hazardous, and to what degree? Remediators are shooting at a moving target. A hit today may be judged a miss tomorrow--and they'll have to pay. Contracting is based upon who pays not to bear risk. There's a lot of money out there but the margins quickly shrink when lawyers get involved.

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\(^{26}\)ibid., p. 40.
The above confusion naturally leads to a *cover-your-tail with paper* mindset in the industry.

Engineers designing cleanups for EPA must constantly be aware that design plans will become courtroom evidence during cost recovery proceedings...Instead of using pencils and computers, engineers performing Superfund design spend their time reviewing existing design documentation...the idea of making field decisions, which would be useful in considering that no two hazardous waste sites are the same, is dismissed because field decisions do not lend themselves to detailed documentation.27

The gun-shy environment described understandably stymies innovation. Engineers are forced to take the safest course, opting not for the best solutions, but for the most defensible. In a multi-billion dollar industry where "the answer" has yet to be found, some one or some catalyst must step forward and seize the moment.

27 Ibid., pp. 41-42.
3. DISCUSSION

Given the presented criticisms of Superfund, the challenge ahead remains to *clean-up the mess*. This portion of the study will analyze both the U.S. Army Corps of Engineers, as the action arm for the Department of Defense, and the Environmental Services/Hazardous Waste remediation Industry in terms of strengths, weaknesses, and opportunities.

The Corps of Engineers has both a historic and present role in meeting the engineering needs of the country. In its role as the government's engineering firm, it can play an even more significant role in redressing our environmental mistakes. The Corps has assumed the lead in the Department of Defense in both hazardous waste minimization and remediation. This paper will study the Army's Installation Restoration Program in terms of strengths and weaknesses.

Harvard business professor and author Michael Porter provides a useful and insightful method of market analysis in his two books, *Competitive Strategy* and *Competitive Advantage*. This section will use those tools to distill and describe the current remediation and minimization industries, discuss the risks for players in the market, and highlight competitive opportunities.

Finally, this thesis will discuss two distinct strategies for the U.S. government to create a more attractive market for firms to innovate and a case for quickening the current process.
3.1 Mandate of the Corps of Engineers

"Essayons" -- we will try.

3.1.1 Historic Role

The Corps has been and remains unique in the Department of Defense because of its civil works mission. Historically, this mission has provided the Corps a tradition of effective work with other Federal agencies, state governments, and most importantly, the construction industry. Few government agencies can match the involvement or working relationship of the Corps with their counterparts in industry. Through its supervision of the contracting, management, and construction of the nation's dams and locks, defense infrastructure, and overseas bases, the Corps has developed a hard-earned expertise in value engineering.

Like all agencies or even private firms, the Corps has "learned from experience" (aka: made mistakes) in executing its missions. Because of its breath of work, the Corps may have more organizational lessons-learned than even the largest construction corporations. However, its size and institutional knowledge quite naturally resist rapid change, particularly in terms of process and procedure.
3.1.2 Current Role

Again, the Corps current role has changed little from its historical one. They remain the primary construction organization for the U.S. Army, the Department of Defense, and the Federal government. Their major specified missions include:

- Manage and execute engineering, construction and real estate programs for the Army and Air Force.
- Perform research and development in support of above programs.
- Provide specialized engineer and technical support to:
  - Facility Engineers,
  - Staff Engineers,
  - Unit Commanders of Army engineer organizations.
- Provide specialized assistance to theater commanders in base development planning for contingency operations.
- Manage and execute Civil Works Programs.
- Perform R&D in systems, specialized equipment, procedures and techniques relevant to engineer support of combat operations.\(^{28}\)

As shown, the Corps remains deeply committed and involved in both military (combat) engineering and civil works. On the civil side, USACE has evolved from developing, designing, and constructing most of its work in-house, to an organization which primarily plays a management role. Today, about 85 percent of their design work and virtually all of their construction is executed through contracts with civilian designers and builders.\(^{29}\)

While the Army receives only thirteen percent of the Defense RDT&E budget, it accounts for more than half of all of the military’s construction R&D. This phenomenon can be partially explained by three factors. First, the Army has the most people and therefore the majority of the facilities and installations. Second, due to its ground combat role, the Army has the


\(^{29}\)Ibid., p. 85.
majority of the troop construction units. Finally, with the Corps of Engineers and its historic involvement with construction and engineering industry, the Army tends to assume the leadership role in this area.\textsuperscript{30}

Major General Patrick Kelly, Director of Civil Works for USACE, recently wrote, "As the Corps moves into its third century, its challenges are focused on natural resources management and protection while it maintains an active construction mission."\textsuperscript{31} In addition to DERP and other previously introduced environmental legislation, the Water Resources Development Acts of 1986, 1988, and 1990 increasingly expanded the Corps' environmental program and authorities, with the last containing some of the strongest environmental/wetlands protection language to date.\textsuperscript{32} As we can see, the Corps' involvement with the environment is multi-dimensional. Its recent and on-going management of wetlands, combined with its history of waterway infrastructure management, give it problem solving experience and expertise beyond any other federal agency in effectively bringing together the construction industry, environmental services, the EPA, state and local government, and public interests. The ride has not always been smooth, but the Corps is one of the few who has navigated these waters often and often successfully.

3.2 The Defense Environmental Restoration Program (DERP)

This paper introduced and charted the origins of the Defense Environmental Restoration Program in Section 2.2.2. In simpler terms,

\textsuperscript{30}Ibid., p. 136.
\textsuperscript{32}Ibid.
DERP is the program that provides DOD with authorization and money to clean-up certain environmental problems at currently used military installations and formerly used DOD sites. The statutory goals of the program include the correction of: (1) environmental problems from hazardous substances, pollutants, or contaminants; (2) environmental damage which creates an imminent and substantial endangerment to the public health or welfare or the environment; and (3) unsafe buildings and structures. Along with the cleanup program, DERP provides for a program of research, development and demonstration with respect to hazardous wastes. On the Army side, the purpose of the Installation Restoration Program (IRP) is "to provide a structured but flexible approach for identifying, evaluating, and cleaning-up sites for which the Army is responsible where hazardous substances have been released to the environment."

3.2.1 Recent Results

As required, the Department of Defense submitted its 1991 annual report to Congress detailing its progress in the Defense Environmental Restoration Program in February (the report covering Fiscal Year 1990). Highlights from their report follow.

The focus of DERP continued to be investigating and cleaning-up contaminated DOD sites and formerly used properties. Over 96% of the funds went to the Installation Restoration Program. Other significant efforts included R&D, waste minimization and management system improvements.

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33 10 U.S. Code 2701(b).
34 10 U.S. Code 2702.
By September 1990, 89 DOD installations and 12 formerly used properties were on EPA's NPL. Remedial Investigation/Feasibility Studies were ongoing at 81 of these installations. Removal actions and/or interim remedial actions were conducted at 68. The number of sites covered by the IRP increased by 20 percent to more than 17,000 at over 1,800 installations. Most of these new sites are due to the inclusion of more than 200 smaller installations, such as Army Reserve Centers. By year's end, Preliminary Assessments were completed at over 16,000 of the sites and Site Inspections at more than 9,000. Remedial Investigations/Feasibility Studies were under way or completed at over 1,400.

Work was completed and no further action was needed at more than 6,300 of the sites. Most of those sites requiring no further action represent instances where studies have shown that no threat exists to either human health or the environment.

DOD signed Interagency Agreements with EPA and the states for 31 of their NPL installations, bringing the number of installations with signed agreements for site investigation and cleanup to 51. Lastly, Defense and State Memoranda of Agreement were finalized between the Department of Defense and 12 states.36

3.2.2 Program Strengths

As shown above, the Installation Restoration Program consumes the majority of the attention and funds of DERP. USACE is responsible for executing the Army's Installation Restoration Program. This program is representative of the Navy and Air Force Programs (in fact, USACE is heavily involved in every aspect of the Air Force cleanup program). I've reviewed each program and studied the Army's IRP in depth. Because of both the Corps' involvement in the Army's IRP and its similarity to the other armed services' programs, this paper will primarily examine and discuss only the Army's program and apply the lessons across-the-board.

3.2.2.1 Meets the Letter of the Law

The Defense Environmental Restoration Program, as well as its satellite programs are meticulous in negotiating the myriad of requirements demanded by CERCLA and SARA. A detailed study of how well DERP meets the strictures of the law is beyond the scope and purpose of this paper. Figure 3.1 graphically portrays DOD's system for meeting the letter of the law.
3.2.2.2. Fixes Responsibility

One of the strengths of the Installation Restoration Program is in how it fixes responsibility at both the macro and micro levels. At the macro-level, the Department of Defense understands it is responsible for much of the existing waste. Likewise it understands that it must fund the clean-up. It is important to note here that nowhere in the IRP guidance or supplemental guidance is there anything written or implied that indicates the standard for clean-up can be something less than federal, state, or local standards. The guidance, just published, offers no double-standard for compliance, but assumes the Carter rule, requiring federal agencies to be held to the same environmental standards as private industry. Coordination with state and
local agencies is required throughout the IRP. As outlined earlier, the Army has additional requirements not included in Superfund such as annual reports to congress and technical review committees.

At the micro, or action-level, the guidance goes to great length to detail individual roles and responsibilities. It identifies and explains who the decision makers are at the installation level and for what they are each accountable. This plays-off the strengths of an organization like the military: identify who's in charge, define his role, then reward or punish him for the results *(task, conditions, and standard).* Under SARA Sections 120 and 211, DOD is required to provide information to Congress and the EPA on several levels. Installations play a pivotal role in generating and initiating information flow. Figure 3.2 graphically represents the flow.

Central Role of DOD Installation for Information Flow in SARA Mandates

![Diagram](Image)

Source: Mitre Corp.  
Figure 3.2

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39Casagrande, p. 1-11
3.2.2.3. Action Oriented

Another strength of DERP and the IRP is that they are action documents. They set out workable timetables and again play-off a results oriented organization--the military. The IRP looks for tangible results each step of the process. The best example of how the guidance works towards the ultimate goal of program (to clean up the mess) is in setting-up operable units. The guidance sets-up and defines operable units to be:

Parts of remedial actions [that] may be implemented separately: to achieve significant reductions in risk while other parts of the remedial action are being evaluated, selected, or designed; to provide a construction management tool for implementing large, complex, or multi-year remedial actions; or to expedite the completion of total site cleanup. While operable units are implemented before or after selection of the final remediation, they should not be inconsistent with the final action nor preclude its implementation.40

Operable units offer DOD flexibility in how it approaches the cleanup. It can allow them to remedy the non-controversial portions of a site while seeking remedy or consensus for others. Most importantly, it means that they don't have to swallow the whole pill in order to move toward accomplishing the mission--cleaning-up the mess. This creates positive possibilities in prioritization, funding, contracting and public participation. Figure 3.3 below graphically illustrates the process.

Source: Army IRP

Figure 3.3

40IRP, Guidance and Procedure, p. III-55.
3.2.2.4 The Rocky Mountain Arsenal

Interim Response Actions (IRAs) come about from operational units. An example of how the guidance can allow the Corps to work towards cleaning the mess up can be found in its actions at the Rocky Mountain Arsenal (RMA).

Located north of Denver's Stapleton International Airport, the Rocky Mountain Arsenal is one of the nation's largest hazardous waste sites. From the 1940's to the 1980's, it was used by the Army to make chemical munitions including incendiaries and blister and nerve agents, and by several lessees to manufacture chemicals, primarily pesticides. RMA is currently the subject of the largest RI/FS (Remedial Investigation/Feasibility Study) in history. The Record of Decision for the facility will not be completed until 1994, and the final remedy will not be finished until after the turn of the century.

Thirteen Interim Response Actions (IRAs) were identified by the Army, the Environmental Protection Agency, the Colorado Department of Health, and Shell Oil Company to be conducted prior to the final remedy for RMA. The purpose of the IRAs was to attack major problems early on by using standardized and rapidly implemented remediation techniques where feasible. The IRA for the liquids, sludges, and soils at Basin F is the largest of these actions.

Basin F was a 93-acre asphalt-lined basin with a liquid capacity of over 240 million gallons. It was used as an evaporation pond for liquid wastes from manufacturing facilities from 1956 through 1981. The highly toxic liquids, sludges, and contaminated soils in and under the basin contained heavy metals, pesticides, pesticide by-products, and other
wastes. Ebasco Services Inc. was contracted by the Army Corps of Engineers to perform the IRA on Basin F.

This $36 million construction project consisted of transferring residual Basin F liquids to temporary storage tanks and double-lined holding basins; excavating and stabilizing the asphalt liner, overlying sludges, and contaminated soils from under the liner; and placing the stabilized material in a RCRA-equivalent double-lined temporary storage pile built in the former basin. The final disposition of the liquid and stabilized solid material is being handled as a subsequent phase to this IRA.41

While the Rocky Mountain Arsenal is far from being completely cleaned, the Corps was able to take immediate action on some of its most pressing problems. The key here is that there is progress, however incremental, towards complete remediation. No one proposes the problem is solved, especially since no feasible means of complete remediation has been discovered. The difference between RMA and most other NPL sites is that action, not deliberation, ruled the day.

3.2.3 Program Weaknesses

3.2.3.1 Shares Superfund’s Problems

DERP, and especially the Installation Restoration Program are written to meet both the letter and intent of the Superfund legislation. Thus, one of DERP’s strengths also makes it one of weaknesses—especially in terms of process. In the discussion of the problem, this paper presented a broad-brushed, results-oriented overview of what is wrong with Superfund. The

purpose of this section is to present more elemental sources of CERCLA's problems. Why and how is the process inconsistent? What are the failings and problems with the way decisions are tied to risk and risk assessment—a problem DERP shares with CERCLA?

3.2.3.1.1 Inconsistency

The Science Advisory Board recently completed a report to EPA administrator William Reilly on national environmental issues and risks. This board determined that inconsistency was the factor primarily responsible for our environmental policy woes. Their insight is paraphrased in the following paragraphs.

Over the past 20 years, this country has put into place extensive and detailed government policies to control a number of environmental problems. In hindsight, many of those efforts have been inconsistent, uncoordinated, and thus less effective than they could have been. The fragmentary nature of U.S. environmental policy has been evident in three ways:

- **In Laws.** As different environmental problems were identified, new laws were passed to address each one. However, the tactics and goals of the different laws were neither consistent nor coordinated, even if the pollutants to be controlled were the same.

- **In Programs.** The Environmental Protection Agency was established as the primary federal agency responsible for implementing the nation's environmental laws. Through EPA an administrative structure evolved wherein each program was primarily responsible for implementing specific laws. Consequently, the efforts of the different programs rarely were coordinated, even if they were attempting to control different aspects of the same environmental problem.
In Tools. So-called "end-of-pipe" controls and remediation technologies have almost always been applied because of (constricting) federal, state, or local legal requirements.\textsuperscript{42}

3.2.3.1.2 Risk and Risk Assessment

In the environmental policy arena, risk is seen as \textit{the probability of a harm}. The root of disagreement in environmental disputes--particularly in sitings and cleanups--is finding exactly what is an acceptable amount of risk to the public. When is the \textit{public interest} served? Former EPA chief, William Ruckelshaus, defines risk assessment as "an exercise that combines available data on a substance's potency in causing adverse health effects with information about likely human exposure, and through the use of plausible assumptions, it generates an estimate of human health risk."\textsuperscript{43} A rationalist would view this as a problem of finding where societal costs and public benefits meet. Translated in terms of environmental risk assessment: The public costs (for the PRP or Superfund) of cleaning up a site to 1-part-per-million is balanced by the chance of only one person in ten million becoming ill (public benefit). This rationalist view governed much of our existing policy.

\textsuperscript{42}Glen Burg, "Environmental Digest--Setting Priorities and Strategies for Environmental Protection," \textit{The Military Engineer} (Alexandria, Virginia: The Society of American Military Engineers, March-April 1991), p. 28. At the request of EPA administrator William K. Reilly, the Science Advisory Board (SAB) completed a report on national environmental issues and risks. To carry out this study, the Board created a special "Risk Reduction Strategies Committee" composed of 39 Scientists and experts from academia, state government, industry, and public interest groups. The above is excerpted from the executive summary of that committee's findings.

Our Superfund experience has shown the risk assessment issue to be divided into two quarters, with a good degree of fence straddling between the two. Milton Russell highlights the dichotomy when he writes,

To risk managers, and those comfortable with modern technology, pollution is an externality of production and consumption; its reduction is to be pursued vigorously to the point that maximizes the total public interest...To others, though, reflecting traditional and deeply held values, pollution is a violation of personal rights; its generation is an evil, and its reduction is a matter of moral principal.44

Two lessons are particularly germane: the failure of what Dennis Ducsik named the "Decide-Announce-Defend" model45, and the power of "NIMBYism" (Not In My Back Yard) within the local citizenry. The first of these demonstrates that there is a systematic problem in trying to define that elusive point where costs and benefits are optimized--especially when done in a vacuum. The second has forcefully brought home the fact that because a remedy is technically feasible, and "fair" in pursuit of the overall good, it can not necessarily be forced on an unwilling citizenry.

3.2.3.2 Buried Environmental Offices

The top echelons of command and policy-making in the Department of Defense hierarchy are indeed placing a new priority on hazardous waste minimization and remediation. Their budget for cleanups, investigations, and research and development point toward a greening of DOD. While policy-making, priority-setting, and R&D are centrally driven and executed,

the actual execution of the cleanup program (the IRP) is decentralized. As shown earlier, the installation is the hub of activity in the process. The jury is out on just how green the middle tiers of command have become.

One weakness in the IRP and the system for action it outlines is in the relative importance of the installation's Remedial Project Manager (RPM). This individual is usually the installation's environmental coordinator and is commonly found working under the Directorate of Engineering and Housing (DEH) on the post. In the Army hierarchy, this means that the RPM is not someone who would necessarily "have the bosses ear." More often than not, the RPM would not be a prime player in the day-to-day mission of the installation unless a cleanup, or public pressure, or some other factor he controlled impacted upon that installation mission. The guidance is not written to lessen or diminish the importance of this player, but his place in the hierarchy places him in a reactive position--one who's importance becomes apparent only in crisis--rather than in a place where he can anticipate and garner command emphasis and resources. Much like the market, hazardous waste has traditionally been an externality, or the cost of doing business for old-school commanders and, until the hard lesson is learned, the IRP may just be another one of the many responsibilities the commander has that he trusts a subordinate to execute.

3.2.3.3 Confusion about the "Stick"

Nowhere in the study of Superfund and DERP is there more confusion than over EPA's enforcement authority over the Department of Defense: Environmentalists claim foul. Corps of Engineer officials understand
"Federal sovereignty" to be waived for Superfund.\textsuperscript{46} DERP and IRP are written with explicit rules for ensuring both EPA and local requirements are met and nowhere mention a double standard. Environmental lawyers understand the system, but are slow to tell. Michael Renner provides the environmentalists' indictment:

The military sector has long considered itself beyond the purview of existing environmental laws and regulations. Public awareness of environmental problems generated by military activities is important if the government agencies and their private contractors who inflicted the damage are to be held to greater accountability.

In 1978, President Carter signed an executive order demanding that all U.S. federal facilities comply with the government's environmental regulations. But the Reagan administration left the Pentagon to police itself, assigning it sole responsibility for base cleanups. Representative John Dingell of Michigan complained in 1988 that "the Defense Department's attitude varies between reluctant compliance and active disregard for the law.

The Environmental Protection Agency's powers to enforce environmental laws on military bases, meanwhile, are severely circumscribed, as are those of OSHA. The Justice Department has prevented EPA from suing other federal agencies, from imposing cleanup orders on them without their consent, or from fining them. And it has gone to court several times to preclude state agencies from fining federal installations. In consequence, EPA has had to settle for negotiating "voluntary compliance agreements" of doubtful value with the military.\textsuperscript{47}

\textit{State of the Word, 1991}

The military takes a different view, citing that possible fines and injunctions can severely limit, or even eliminate an installation's operational capability. Like criminal penalties, fines vary depending on the violated statute, but are generally $25,000 per day per violation. This directly affects the installation's resources. The money to pay these administrative

\textsuperscript{46}Observation based on a 6 August 1991 interview with Tony Riccio, Chief, Environmental Office, USACE New England Division, Waltham Massachusetts, in particular; and other Corps personnel throughout my research.

\textsuperscript{47}Renner, p. 151.
fines comes from the installation's operation and maintenance funds (O&M). Since violations can occur over several days, weeks, or even months, the impact on base operations could be debilitating. As significant as these fines can be, the most devastating enforcement option available to regulators is a court injunction. If the transgression involves something as fundamental as industrial wastewater (sewage) or vapor recovery (fuels management), the installation's ability to perform its military mission is stopped.48

Mary McCabe, an environmental lawyer for USACE New England Division, clearly and skillfully explains the system for dispute avoidance, but leaves unresolved questions of enforceability between executive agencies and between state and federal agencies (sovereign immunity). She explains that for federal facilities on the NPL, the EPA has developed a model interagency agreement known as the Federal Facilities Agreement. This agreement sets forth a system of dispute resolution. If attempts at the site to informally resolve the dispute fail, a written statement of dispute is sent to the Dispute Resolution Committee (comprised of one member from each party). The DRC members are likely to be heads of a division or regional office. If this committee cannot resolve the dispute in 21 days, action is forwarded to a Senior Executive committee, made up of two members at the regional level. If that is unsuccessful, the dispute can be elevated to the Administrator of EPA or the Army Secretariat. The Administrator of EPA makes the final decision.

Because EPA and DOD are both executive branch agencies, it is important to have a dispute resolution procedure in place. It is not at all clear whether one executive branch agency can sue another executive branch agency. Since both agencies are within the same branch of government, they represent the same party (the executive). There would be no case or controversy because there would only be one party involved in the dispute. It also provides that DOD will pay stipulated penalties for failing to abide by the provisions of the agreement. The interagency agreements are signed by EPA, DOD and the state (the state participates because CERCLA assures the state of an opportunity to plan and select the remedial action). EPA regional offices have not uniformly accepted EPA HQ resolution of the issues addressed in the model federal facilities agreement. The incongruity among EPA regions lengthens the negotiating process and prevents DOD from anticipating uniform consequences to its response actions throughout the country. 49

My view is that a stick does exist. EPA has the final say in the standard of cleanup or they can hit an installation where it hurts—in their operating budgets or in their ability to perform their mission. The environmentalists' concerns are most likely rooted in the fact that the stick is not in their hands and the process can go forward without their weighted involvement, as is the case with non-DOD sites (note to all current competitors and potential entrants into the remediation market).

3.2.3.4. R&D/Technology's Slow Crawl

Established technologies such as stabilization and incineration are still specified in nearly two-thirds of the cleanup plans, according to the report by EPA's Office of Solid Waste and Emergency Response. There are now more than 1,200 sites on the Superfund National Priorities List...(and) despite the growing numbers, few innovative technologies have yet to make their way through the entire cleanup pipeline. 50

Much like the rest of the players in Superfund, Department of Defense cleanups suffer from a lack of innovative cleanup technologies. The forces that constrain remediation engineers in designing solutions to individual cleanup problems are active whether the customer is DOD, DOE, EPA, or a private company. Inconsistencies in both the legislation and the programs, liability issues, and the paper-trail have all been discussed earlier.

Professors C. A. Geffen and J. F. Keller of the Pacific Northwest Laboratory offer another, more subtle explanation of the problem.

EPA's current approach to hazardous waste site remediation is based on the assumption that all important information about a site can be known before remediation begins. This approach, based on the conventional engineering paradigm of study, design and construct, leads to the selection of a single remedial alternative with no contingencies for variations encountered during construction. This conventional approach works well for traditional engineering activities (i.e., building bridges), where uncertainty can largely be eliminated by study and investigation and by the existence of a large body of empirical evidence. However, hazardous conditions, geohydrology, transport mechanisms, waste source, and chemical and physical characteristics make it impossible to completely characterize and understand actual site conditions. This, the remedial process has to a large extent become "bottlenecked" by the uncertainties associated with fully understanding the nature of hazardous waste problems. DOE needs to understand and manage these uncertainties within the current and evolving regulatory framework.

To manage uncertainties associated with the environmental restoration process, DOE should take into account regulatory, science, and engineering considerations throughout the process. Classically, scientists tend to be responsible for the remedial investigation (RI) portion of the process, with the engineers generally not involved until the feasibility study (FS) phase. The engineering input early in the CERCLA process will help keep the process focused and ensure that the information obtained through characterization is useful for engineering purposes. Scientific input in the later stages (i.e., during the FS portion of the CERCLA process) will ensure that the alternatives/technologies chosen are protective of the environment. Regulatory, scientific, and engineering input should be incorporated into all phases of the cleanup process, from initial planning to post-closure monitoring.  

DOD, through its use of DERP and the Installation Restoration Program, suffers through the same institutional barricades as DOE (for whom the above analysis was conducted). Again, hazardous waste is a new and unique problem and time-honored, institutionally-driven methodologies may not lead to effective solutions. DOD should also look to change the process in order to accept uncertainty in test-bed technologies.

Leaders and policy makers in DOD and EPA see and understand the problems above and are working to push innovative solutions to their environmental problems, but change comes slow. Walter W. Kovalick, director of EPA's Technology Innovation Office, noted that in the spring of '91, EPA planned to issue a policy statement "that shows our intention to have incentives for innovative technologies. We must consider ways to show we'll either provide funding or give extra time to complete the project." Rather than strive to find the answer in one of it's four laboratories or in-house, USACE should also actively look for the answer in

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industry, providing a market and clearing the path with incentives for technological innovations.

3.3 Market Analysis

The hazardous waste segment, however risky an investment, is definitely positioned for a boom. U.S. industry now generates more than 275 million m.t./year of hazardous waste,...leading to a $4-billion cleanup industry that is growing at the rate of 25%-35%/year. By the end of this year, an estimated $4-$5 billion will be spent on hazardous waste services, and that should reach $9 billion by 1992.53

*Chemicalweek*, 11 October 1990

While the Corps and academia race to find technological solutions to the remediation problem in-house, the greatest probability for success may lie in the market. Driven by the opportunity for sustainable profits and growth, firms should be pushing their limits to gain first-mover advantages. Why aren't they? What is it about this market structure that relegates firms to a fast-follower market strategy, while customers would pay a premium now for workable innovations?

In his first two books, *Competitive Strategy* and *Competitive Advantage*, Harvard Business Professor Michael Porter provides a useful methodology for analyzing markets and how firms compete in different markets. He introduces many tools that first tell a firm how to assess their industry, then how to formulate a strategy to sustain a competitive advantage over rivals. This portion of the thesis will use applicable tools from both these books to better understand the hazardous waste remediation industry and find what changes could better garner more innovative technologies. Porter's industry segmentation and five

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competitive forces will provide this insight. Lastly, we will analyze the risks and opportunities in pursuing first-mover advantages by innovation.

3.3.1 Industry Segmentation

"With an 8.3 percent share of the gross national product (GNP) in 1989, construction remains the largest industry in the United States, a position it has held for the past six years," reads the opening sentence of the 1990 Cumulative Supplement to KPMG Peat Marwick's Construction Accounting Manual. The construction industry is not homogeneous. Segments of the construction industry differ greatly in their structural attractiveness to competitors and future entrants. Composed of 1.2 million firms, this is particularly important in a fragmented industry like construction, where there are no Exxons or AT&Ts—it is impossible to be all things to all people. As opposed to market segmentation, which tends to focus on the marketing activities in the value chain, industry segmentation combines buyer purchasing behavior with the behavior of costs (both production costs and the costs of serving different buyers). Porter's segmentation matrix from *Competitive Advantage* provides a framework to view and analyze the construction industry, the existing market forces, and the role of government in the emerging hazardous waste market.

Segmenting and analyzing only the environmental services industry is not useful to this study for two reasons. First, such a narrow segmentation neglects many of the factors that influence the relationships of the five

55 Martin, p. 120.
competitive forces, particularly between segments. Next, a narrow segmentation, perhaps by technology (as in earlier Figure 2.2), shows what exists now in terms of product but lends no insight to either new technologies or customers. Both of these seem particularly important from my perspective since the technological answers have yet to be found and the ultimate purpose of this study is to find from where the "carrot" for innovation should come. However, I feel a strong case can be made to analyze the emerging industry as a segment of the construction industry.

Construction, as an industry, is diverse and complex. The matrix offered at Figure 3.4 proves a useful tool in understanding how and why hazardous waste services are actually part of a larger market and the framework for further strategic analysis.

Segmentation Matrix of the Construction Industry (Partial)

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<tbody>
<tr>
<td>PUBLIC</td>
<td>EPA (Superfund)</td>
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<td>DOD</td>
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<td></td>
<td>DOE</td>
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<tr>
<td></td>
<td>State Agencies</td>
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</tr>
<tr>
<td>PRIVATE</td>
<td>Petro/Chemical</td>
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<tr>
<td></td>
<td>Manufacture</td>
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<tr>
<td></td>
<td>Other Industries</td>
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<tr>
<td></td>
<td>Global Mkts</td>
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</tr>
</tbody>
</table>

Figure 3.4

On the horizontal axis are the broadly grouped services provided by the industry, including the emerging hazardous waste services (H.W. remediation and H.W. minimization). On the vertical axis are the broadly grouped customers or buyers. Note that these are additionally grouped into public and private. I've done this because of the unique impact each of these sectors has on the five competitive forces in the construction industry (in no small way due to the impact of the Federal Acquisition Regulation). For a construction or engineering firm, differences in the firm's competitive strategies for competing in various segments increase as the distances across the matrix between segments increase.

The usefulness of the segmentation matrix depends particularly upon separating "product varieties" and "customers" into meaningful pairings. Our first choice is whether to examine hazardous waste services as part of a larger construction industry or treat it as its own industry. I've chosen to look at it in the larger context--understanding that some of the largest competitors to date in the segment may not have roots in the traditional construction industry. The reasons are compelling:

- In the remediation services, the preponderance of work done throughout the first ten years of CERCLA has been site evaluation, risk assessment, and to a great extent litigation. The next decade promises an explosion of projects in the pipeline to progress to the design and construction stages of the process.58

- Again in the remediation sector, many of the "products/services" in the value chain mirror those in the traditional construction process: An owner with little expertise, a designer who proposes a solution to the

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58Leighton, p. 16.
problem, and a contractor who actually puts spade to ground and "builds" the project; a contract that details the relationship of the three and allocates risk; a product that is often-times a "one-off"; a gauntlet of codes to meet and inspections to arrange and pass throughout the process; use of sub-contractors who lend to the process skills or proprietary processes integral to the ultimate success of the project; unique insurance and bonding requirements, and not least of all; the managerial expertise and physical capacity to execute a large amount of traditional construction (particularly horizontal work).

- In the minimization sector, construction will be involved in the creating a cleaner industrial base and refitting older, "dirtier" factories. Whether, as an industry, construction decides to vertically integrate and offer design in-house, or execute traditional vertical construction and sub-work as part of an outside design service, its participation is assured.

- A history of contractual work in both the public and private sector for both design and "product delivery."

- Lastly, the rush of large, multi-national construction firms to hire expertise and add environmental services to their platter introduces heavyweights with considerable resources to what has been a focused market.

The second dimension of the buyers axis, public versus private, segregates the role of public construction on the industry. Federally funded construction accounts for over seventeen percent of all construction in the United States.\textsuperscript{59} This is only part of the public construction. When state

\textsuperscript{59}This is based upon KPMG Peat Marwick placing the U.S. construction industry at roughly $350 billion per year from 1987 thru 1990, and President Bush's '92 budget proposal at roughly $60 billion.
budgets for prisons, hospitals, transportation, infrastructure, universities, and now hazardous cleanups are added, the impact of public construction on the entire industry cannot be overstated. The table in Figure 3.5 shows the President's 1991 and 1992 Federal construction budget. Note both the sheer size of the budget and the increases in environmental commitments. In a fragmented industry such as construction, Uncle Sam is far and away the market's biggest customer--an impact player.

**Proposed Federal Construction Budgets**

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<tr>
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<tbody>
<tr>
<td>Highway Obligations</td>
<td>$15.675 bil.</td>
<td>$16.272 bil.</td>
<td>4%</td>
</tr>
<tr>
<td>Highway Obligation ceiling</td>
<td>$14.5 bil.</td>
<td>$15.772 bil.</td>
<td>8%</td>
</tr>
<tr>
<td>Military construction</td>
<td>$5.0 bil.</td>
<td>$4.5 bil.</td>
<td>-10%</td>
</tr>
<tr>
<td>DOD family housing</td>
<td>$3.3 bil.</td>
<td>$3.6 bil.</td>
<td>9%</td>
</tr>
<tr>
<td>DOE environmental mgmt.</td>
<td>$3.2 bil.</td>
<td>$4.6 bil.</td>
<td>44%</td>
</tr>
<tr>
<td>DOE conservation and renewable energy R&amp;D</td>
<td>$423 mil.</td>
<td>$494 mil.</td>
<td>17%</td>
</tr>
<tr>
<td>Superfund</td>
<td>$1.616 bil.</td>
<td>$1.750 bil.</td>
<td>8%</td>
</tr>
<tr>
<td>FAA airport limit grant</td>
<td>$1.8 bil.</td>
<td>$1.9 bil.</td>
<td>6%</td>
</tr>
<tr>
<td>EPA construction grants/loan fund</td>
<td>$2.1 bil.</td>
<td>$1.9 bil.</td>
<td>-10%</td>
</tr>
<tr>
<td>EPA Clean Air Implementation</td>
<td>$339 mil.</td>
<td>$516 mil.</td>
<td>55%</td>
</tr>
<tr>
<td>Corps construction</td>
<td>$1.375 bil.</td>
<td>$1.482 bil.</td>
<td>8%</td>
</tr>
<tr>
<td>DOD environmental restoration</td>
<td>$1.1 bil.</td>
<td>$1.3 bil.</td>
<td>18%</td>
</tr>
<tr>
<td>BuRec construction</td>
<td>$692 mil.</td>
<td>$618 mil.</td>
<td>-11%</td>
</tr>
<tr>
<td>Supercollider</td>
<td>$267 mil.</td>
<td>$534 mil.</td>
<td>100%</td>
</tr>
<tr>
<td>GSA new construction</td>
<td>$1.461 bil.</td>
<td>$477 mil.</td>
<td>-67%</td>
</tr>
<tr>
<td>Mass Transit</td>
<td>$3.259 bil.</td>
<td>$3.329 bil.</td>
<td>2%</td>
</tr>
</tbody>
</table>

*Source: ENR, Feb 91 Figure 3.5*

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The share of the budget allocated to environmental services is growing. Figure 3.6 portrays the environmental share of the current Federal construction budget. This does not include state budgets and cleanups or the huge volume of other kinds of now-legal wastes, generated by mines, steel mills, and paint plants.61

![1992 Federal Construction Budget: Environmental Share](image)

Figure 3.6

As the primary construction agency for the Department of Defense, the Corps of Engineers finds itself directly involved in purchasing about $10 billion per year (or 16 percent) of federal construction. This does not count the numerous instances the Corps represents other Federal agencies in letting construction contracts.62 Figure 3.7 graphically represents DOD's share of the segmentation matrix as a customer.

![1992 Federal Construction Budget: DOD Share](image)

Figure 3.7

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61 Karen Heller, "The Garbage Heap Is Where It's At," Chemicalweek, 11 October 1989, p.25. While these don’t classify as trash or hazardous waste, Heller makes a case that it is just a matter of time before they too will be regulated.

62 As an example, the New England Division does most of the contracting for EPA in the northeast per 6 August interview with Tony Riccio, Chief, Environmental Office, USACE New England Division.
3.3.2 Five Competitive Forces

The strength and interaction of five competitive forces determine an industry's profitability—the entry of new competitors, the threat of substitutes, the bargaining power of buyers, the bargaining power of suppliers, and the rivalry among the existing competitors. Industry profitability is not a function of what the product looks like or whether it embodies high or low technology, but of industry structure. The five forces determine industry profitability because they influence the prices, costs, and required investment of firms in an industry—the elements of return on investment.63 The goal in this analysis is to show how the buyer—in this case the Federal government—can influence the five forces to stimulate competitors to be more aggressive in seeking innovative technologies for the cleanup problem.

3.3.2.1 High Threat of New Entrants

Large construction firms represent the largest share of new entrants to the hazardous waste services markets. These new entrants bring new capacity, a strong desire to gain a share of the market, and substantial resources to the table. The strength of this competitive force depends upon barriers to entry and reaction from existing competitors. With the current vacuum in meeting the needs of the market, reaction from existing competitors is not yet a factor in our analysis. Erecting effective barriers to entry remains one of the most potent weapons in a firm's competitive strategy.

63Porter, Competitive Advantage, pp. 4-5.
Of the seven major sources of barriers to entry (economies of scale, product differentiation, capital requirements, switching costs, access to distribution channels, cost disadvantages independent of scale, and government policy), capital requirements and cost disadvantages independent of scale have particular influence in this market segment. Currently, the threat of entry is high in the hazardous waste market. What is obvious from reading the papers is borne out in examining these two key sources.

Because this is both a new and rapidly expanding market with no clear technological "answer," entry capital requirements are mixed. The barrier to entry is low for firms bartering low-risk, approved technological processes. For them, relatively small capital is required for up-front advertising, R&D, production facilities, customer credit, inventories, covering start-up losses, or other traditional initial capital sunk costs. For firms pursuing innovative technologies, high research and development costs and risks combine with a long period of market acceptance and entry to create a sizeable barrier to entry. In this light, it's easy to see why firms are rushing to enter the market but not to find innovative answers to the cleanup problem. Without a front-running remediation technique, the most important start-up cost is "know-how." In the larger scheme, this is relatively inexpensive.

Another reason the threat of entry is high is the current clear lack of cost disadvantages independent of scale. There are no important proprietary process technologies, process know-how or design characteristics kept proprietary through patents or secrecy. Additionally, there are no preferential government subsidies which would give firms
lasting advantages in the market. Lastly, there are no "cost advantages" held by firms now in the market due to learning or experience curves.

Not all the factors at work in the current industry make it attractive for either new entrants or new technologies. The following are institutional obstacles to both entry and technological innovation:

- Pollution Insurance. The hazardous waste contractors insurance program could include as many as eight insurance coverage parts: Commercial General Liability Insurance; Contractors Pollution Liability; Architects and Engineers Errors and Omissions; Specialty Environmental Engineers Errors and Omissions Policy; Asbestos Abatement Liability; Asbestos Consultant’s Errors and Omissions; Commercial Automobile Liability; Worker’s Compensation, and; Specialty Policies. The average premium for the insurance increased to as much as 11 times its 1982 level.

- Bonding. Bonding companies are equally uneasy about becoming involved in the hazardous waste services market. Courts are unreasonably holding contractors and sureties responsible above and beyond the terms of the contract, even if claims turn up years after the cleanup is completed.

- Financing. Wall Street analysts have taken strong notice of the growth in the environmental engineering and contracting markets. These funds (Openheimer, Fidelity,...) tend to focus on the large environmental firms. The market is not as aggressive for smaller companies and seems to have an uneasiness about investing in companies that perform research and development in hazardous waste. "Major companies and venture capitalists are nervous about possibly being held liable for any environmental damage that occurs from the use of a new process" states Oppenheimer’s Paul Zonfass. Lending institutions are also wary of becoming involved with companies that perform hazardous waste cleanups.
• EPA Institutional Obstacles. The government itself can be one of the main barriers to commercialization of innovative technologies. Superfund project managers must develop records of decision (RODs) that will stand the test of engineering review, public scrutiny, regulatory requirements and even court verified legality. This tends to create an environment that will make the ROD process risk-averse and therefore biased away from innovative technologies. The ROD must promote a technology that is effective the first time. There are programmatic obstacles as well as institutional ones (the RCRA "land-ban; the Best Demonstrated Available Technology (BDAT) for the waste; SARAs cost recovery provisions; EPAs procurement procedures; and sole source procurement processes).64

What can government or policy makers do to make both the small firm pursue technological advances while the entry barriers are low and the industry giants pursue technology advances in order to raise these entry barriers?

3.3.2.2 Low Intensity Among Existing Competitors

The principal reason there is little internal rivalry in the hazardous waste remediation market may be that the industry is so new. Typically, as an industry matures, growth rates and profits decline, resulting in intensified rivalries. This sector is an infant in a dynamic market--there is a backlog of work for all current competitors.

Another reason for the current lack of internal rivalry in this market are the low exit barriers. Lack of specialized assets, low fixed costs to exit, loose strategic interrelationships between the hazardous waste component of the firm and the other subdivisions, and few if any emotional barriers in within management make the cost of cutting losses and leaving the market low. While this makes business comfortable for present and future competitors, it does nothing to stimulate innovation. If necessity is the mother of invention, the current market is an orphan.

Liability issues described in the following section of this thesis raise doubt about the lack of exit barriers. Will the remediator be held fiscally liable if the cleanliness standard changes years after the cleanup? At first glance, this would appear to refute the above discussion. This future threat would be an obvious exit barrier. I contend that remaining in the market in no way alters or improves a firms ability to mitigate these future liability issues. I don’t think this issue would deter firms from leaving the market, but only serves as an additional barrier to entry for the farsighted.

Diverse competitors, expansion into or invasion from the global market, and high strategic stakes are all factors poised to rapidly intensify the internal rivalry as the market matures. One technological breakthrough--especially if proprietary--could send shock waves through the market and spell the end of gentlemanly competition.

3.3.2.3 No Pressure From Substitute Products

One of the principal reasons that this industry is so attractive for competitors is that there is no threat of substitution for the remediation process. Without a clear-cut technological solution for any of the numerous hazardous waste problems, it is unlikely the customer would switch. In fact
the customer is likely to accept willingly any product it can get past EPA and the local population. This service is mandated by law so in a broad sense (that forwarded by Porter), no threat of substitution exists. In a narrower sense, there is a threat of substitution by competing remediation technologies. For a competing firm, there is a danger that their product will become an insufficient or unacceptable remedy if baseline risk assessments grow more restrictive.

3.3.2.4 High Bargaining Power of Buyers

The buyer in these market segments exert high bargaining power. More so in the public sectors than the private, the EPA has review authority in every phase of the remediation process. In this way, the buyer can exert a tremendous amount of leverage over competitors. This paper has introduced and discussed the way that the required meticulous documentation influences engineers in designing and executing a remediation. This is again another aspect of the way the current strength and character of the five competitive forces attract numerous new competitors, yet deter innovative technologies. Here, government intervention is working against the market’s desire and tendency to seek competitive advantage instead of nurturing that desire.

3.3.2.5 Bargaining Power of Suppliers

Currently, suppliers exert little or no influence in the remediation sectors of our segmentation matrix. The value-added for competing firms is experience and know-how, not raw materials or subcontractors. Unless a breakthrough remediation technology is dependent upon a supplier’s skill or materials, the influence of this competitive force is not likely to strengthen.
Figure 3.8 illustrates the impact and interaction of Porter’s five competitive forces and entry barriers to technological innovators.

Porter’s Five Competitive Forces and The Hazardous Waste Remediation Market Segment

In addition to evaluating the market in terms of Porter’s five forces, a useful tool in gaining insight into an industry or market segment is to evaluate the risks to entrants and rivals. While some of the risks will routinely surface in the above discussion, it is useful to inspect them separately especially in the context of risk to the remediation technology developer.

- Liability Risks associated with hazardous waste remediation work arise out of the potential for accidental releases of hazardous substances during the remediation process. Persons injured by hazardous chemicals can potentially seek common law remedies through four legal actions:
Trespass, nuisance, negligence, and strict liability. These remedies are referred to as toxic torts. Another risk for the innovator is that he will be held liable for a site if either the standard for cleanup increases in later years or the technology tried has unforeseen by-products or latent side-effects (as in bio-remediation or incineration today).

- Financial Risks to the technology developer manifest themselves in several ways. The most obvious are the financial risks due to a law suit judgement as discussed above. As mentioned in barriers to entry, a financial risk particular to market are the large capital costs if a technological first-mover strategy is pursued. The high research and development/process equipment development costs coupled with the long period of market acceptance or entry can make this a high financial risk market.

- Business Risks to this market segment are not altogether different than business risks to other innovative technology markets. The need clearly exists for improved technologies and the market is still new, so the business risks for a carefully designed technology may be no different than those for any other business venture in a dynamic market.

- Market Risks are unusual for hazardous waste remediation. The market is driven primarily by federal and, to a lesser extent state regulation, as well as industry and public opinion. The risk for the hazardous remediation market as a whole continuing is small. The risk for a particular technology becoming unacceptable is far greater. An example would be the increasing difficulty in siting a commercial incinerator facility. Again, the concern resulting from unsteady regulations is the possibility that
regulations and technology might change and leave companies liable for what they thought they had cleaned up already.\textsuperscript{65}

3.3.4 Opportunities

What can government do to change this market segment’s five competitive forces to favor aggressive technological advances by the competitors? \textit{To divorce government from the process is unreasonable.} The market exists because of legislation, and the day to day involvement of the federal government as both regulator, inspector, and customer tie it tightly to any solution. The question then becomes, "Which part(s) of the government should become the agent for change?" For a firm, the choice of whether to be a technological leader or follower is based on three factors: The degree to which that firm can \textit{sustain} its lead over competitors in a technology; the \textit{advantages} a firm reaps from being the first to adopt a new technology, and; the \textit{disadvantages} the firm faces by moving first rather than waiting for others.\textsuperscript{66}

In order to court competitors into pursuing first-mover advantages through technological innovation, the threat of entry in the market must be altered. The goal should be twofold: \textit{First, we have an interest in keeping the industry entry barriers low for new entrants. The difference is that by some means we must force them lower for those firms--large and small--who are willing to pursue new technologies.} As mentioned above, some of the deterrents are initial capital investments in R&D, difficulties in insurance, bonding, and financing, and most importantly the institutional barriers (EPAs

\textsuperscript{65}The above paraphrases Andrew Hoffman's observations, pp. 58-62. A more detailed explanation of these risks is found in Mr. Hoffman's thesis.

\textsuperscript{66}Porter, \textit{Competitive Advantage}, p. 182-183.
standard procedures for remedy selection). Secondly, we must hold-out the potential for innovators to erect effective entry barriers (thereby enabling them to sustain their competitive advantage) if and when they find successful remedies. This can be done by insuring proprietary processes and know-how developed while sponsored by the government will be protected in the future.

Ideally, stronger internal rivalry would push industry to seek newer, better technologies. The government cannot wisely do much to directly influence the internal rivalry in this industry. Currently, the lack of rivalry is due more to the "infancy" of the market than to any other factor. The market is due to heat-up as it matures. Tightening up by government on the current huge margins (especially in terms of waste and abuse in Superfund) could do much to stir current competitors to action.

Less is best in terms of buyer power. On the one hand, to say above that the government should involve itself in the market to court entrants and stimulate rivalry, and on the other to recommend it quit exerting its muscle seems contradictory. The fact remains that the current process and mountain of documentation mandated by law and EPA stifle innovation. In this case, the customer is choking the producer.

The government can do little to affect either the forces of substitution or supplier power. In this market, neither will push competitors toward technological innovation.

I've discussed the reasons for framing the hazardous waste remediation market as a segment of the construction industry. The attractiveness of a particular segment is a function of its structural attractiveness, its size and growth, and the match between a firm's
capabilities and that segment's needs. Major customers, DOD, DOE, and EPA all currently propose to "take the lead" in sponsoring innovation--solving their own cleanup problems and solving the market's problems in the process. The dispersed responsibility for technology apparent in our Federal government is unusual among industrialized countries. Most national governments maintain a ministry of science and technology or a ministry of trade and industry that has broad responsibility for research and technology-related activities. Obviously, the federal government should not continue to pursue separate disjointed strategies on three fronts--they should mandate leadership to one of these three principal players. I feel DOD, and in particular the Corps, is most experienced of the three in working with the construction industry and is best positioned to take the lead. It's expertise in the owner-designer-contractor process, contracting, sponsored research and development, and multi-billion dollar projects set it apart from EPA and DOE in the context of buyer power in this market. This expertise alters the impact of the five forces on the DOD-hazardous waste remediation segment of the industry to favor innovators. The learning curve is less steep for both producer and buyer in working through the Corps and DOD.

The burden for government is to find, then pursue, strategies which remedy the unfavorable market forces presented and synthesize the disjointed recommendations above. Strategy in this case has two elements: First, weight the effort by giving one agency the power and the resources to take the lead. Second, commit to a plan which is elementally sound and

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67Ibid., p. 256-257.
executable, sending a clear message to industry that it is in their competitive and strategic interest to innovate for the government.

3.4 Government and Innovation--Two Potential DOD Strategies

If given the mandate, two reasonable strategies take shape for the Department of Defense in promoting research and development in the hazardous waste remediation sector of the construction industry. The two strategies align roughly with the probable class of technology development resulting from the strategy--"high tech" and "low tech" remediation solutions. The high-tech course follows a model presented by DOD sponsored research and development in the weapons area. The low-tech course follows an older model for innovation best exemplified by the construction of our nations federal highways.

3.4.1 A High-tech Model

The probability of success for one of these possible models for stimulating innovation is tied directly to how that model meshes the strengths and weaknesses of one party (DOD) to counteract the strengths and weaknesses of the other (Superfund). The one great obstacle to success is the amount of cultural change needed by the parties to pursue the new strategy.

The high-tech model applies the experience the Department of Defense has in contracting for defense technology to redress many of the competitive deterrents identified earlier in this paper and to make innovation strategically attractive to the construction/remediation industry. My reasoning for proposing this tact follows from this observation. For years, pursuit of a technological advantage in modern warfare has had three
positive effects: tremendous technological innovation (particularly in terms of smart weapons, mechanics of materials, and avionics), an attractive market for firms doing this innovative work (giving rise to the description "defense-industrial complex"), and recognized global leadership in terms of our ability to sell the product, yet not the technology in it, overseas to the advantage of the firms who produce the technology. The question then becomes, *what lessons from this success can be applied to the remediation problem?* Some of the goals seem quite similar: technological innovation, making the market attractive for innovators, and global leadership in terms of exporting the technology.

The key lessons to be applied may be in how we contract. Contracts, in serving their most elemental purpose, allocate and compensate risk. As discussed at length in our market analysis, the major barriers to entry for innovative remediation firms involve risk--risk of future liability, risk of a shifting standard, risk of forfeiting R&D investments, and difficulty in financing and bonding because of risk. The attractiveness of pursuing a strategy roughly modeled on DOD's weapons development and procurement is that it can mend some of the above risk issues for the contractor. In simple terms, the model pays/compensates the contractor for his risk. In its most base form, DOD determined the broad set of *goal specifications* for the product it wanted. The specifications, by definition, were high and in many cases the requisite technology may yet be feasible or conceived. The risk remained with the competing firms in funding and developing the prototypes/proposals for consideration. DOD and Congress then awarded the contract to the most promising prototype (politics and pork-barreling aside) and began subsidizing the contractor's risk--usually in a cost-plus arrangement whereby the innovator is reimbursed for their value added--in
production of the "one-off." Future contracts are awarded to the defense contractor based upon the success of the one-off. Should it be applied to DOD's mission of cleaning-up the mess?

The model would also redress some of the market unattractiveness identified by our Porter analysis. By reducing risk, barriers to entry for firms pursuing a strategy of developing new remediation technologies would be effectively lowered. New contracting philosophies which compensate contractors for their risks would begin to correct an industry perception which claims there is no profit in working for the government. As mentioned earlier, willingness to allow firms to protect their breakthroughs rather than lose them to DOD, would only lend to the attractiveness of this market segment. This is not a lesson/technique taken from the weapons development model but may be the linchpin in drawing competitors into the market. Lastly, much like the current defense industrial complex, increased market attractiveness would drive up the internal rivalry within the industry, whereby innovating is a legitimate means of gaining a competitive advantage.

Wise adoption of the model may call for a more efficient use of the Corps' R&D funds and a new mandate to their laboratories. Instead of devoting time, personnel, and money to developing their own remediation technologies, the Corps may be better and more efficiently served by using their expertise in setting remediation standards and verifying contracted remediation work and contractors' claims—as quality control and quality assurance in this still ill-defined process. The key is not to rely on the Corps traditional weakness in exporting its innovations to private industry, but in its strengths in project management, quality control, and contracting.
The Corps' contracting expertise now actually deters firms from working for them--the contracts are too tight, the margins are too small, and they aren't necessarily compensated for their risks. The model recognizes the anomaly of bid contracting. Fair contracts properly compensate the parties for their risks in the project or work. The aberration in this philosophy is the fixed-bid contract--where the contractor takes all the risk yet gets minimally compensated. The Corps has been able to make this work for their construction contracts for a number of reasons: the relatively low-tech nature of the work; the Corps' involvement in the design, management, and quality control of the projects, and; the market forces which compel firms to bid for the work, even given the narrow profit margins. The challenges and the risks presented for the remediation contractor, particularly the innovator, make working for the DOD unattractive under current contracting conditions. The Corps has problems courting some of the best firms to do innovative work for DOD because of their contracting record. Some large firms feel there's little money to be made working for the Corps.69 There are a number of reasons for this perception: most of the contracts are fixed-bid and go to the lowest qualified bidder; owner involvement in quality control and quality assurance; years of experience and research have developed "tight" contracts and, most significantly; a lengthy and expensive processes and outcomes in resolving contract disputes. All add up to small margins for firms doing work for the federal government. The best case for the new contracting

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69Observation based upon questions to representives of numerous companies in the construction industry at The Global Environment and the Construction Industry Symposium held at M.I.T. 21-22 October 1991.
philosophy may be in the eroding of value delivered by the traditional low-bid model\textsuperscript{70}.

The downside of changing the way the Corps contracts for services is that it is counter to the existing contracting culture within this arm of DOD. The acquisition arms of the different services in the Department of Defense have traditionally operated under a different governing philosophy than the Corps. Their philosophy is driven primarily by the end product, the performance, the technology—not necessarily the cost. The heuristic parallels the goals of the program, where the premium is on innovation and making it attractive to the market. Contrast this with the traditional contracting model for the design and delivery of construction where the value is not in the technology but in the cost. Construction has been admittedly "low-tech" in the past, particularly in comparison to smart bombs and stealth fighters. The heuristic in this case has borne a culture which rewards and admires inexpensive yet inelegant solutions to technological problems. While policies and governing regulations and procedures are changed with the stroke of a pen, organizational cultures evolve over time. This may be the greatest obstacle in adapting the weapons development model to the remediation problem.

3.4.2 A Low-tech Model

A second, less abrasive approach to spurring innovation is based upon the construction of our federal highways early this century. The heuristic for this model requires both the government to provide for (and

\textsuperscript{70}A thorough analysis of contracting types and value delivered is presented in Christopher Gordon, \textit{Compatibility of Construction Contracting Methods with Projects and Owners} (Cambridge, Massachusetts: a thesis submitted to the Department of Civil Engineering, Massachusetts Institute of Technology, September 1991).
industry to recognize) a stable future market. The burden is then on
government to set high, yet achievable standards for industry competitors.
The traditional bidding process then drives competitors in the market to
finding technological advances which meet the established standards and
increase their margins and therefore their competitive advantage. In this
model, two of the three pieces are mostly in place--the market and the
bidding process.

As shown earlier in this paper, federal legislation and DOD reaction
has made a strong case in fulfilling the first precursor--creating a stable
market. In fact, the Department of Defense's market may indeed be more
stable than either private or other federal clean-up markets into the next
century. My reasoning is that DOD budgets and funding are not tied to the
Superfund and its anticipated gut-wrenching reauthorization. The instability
in this particular market's future is more tied to the litany of risks and
uncertainties outlined in our discussion of Superfund's frailties than to
DOD's fiscal commitment to cleaning-up their mess. If under this strategy,
DOD were to contract in such a manner as to ensure firms proprietary rights
for the technologies they develop working for the Corps, the market would
encompass even larger borders. Firms would find assurance and stability in
knowing they could export their competitive advantage to other markets.

The work ahead for government is in setting high, definable, yet
attainable standards for their cleanups. This is no easy task. Risk and risk
assessment are at the root of Superfund's problems. While the Corps has
some leverage by virtue of the courts, any stable standard setting would
have to be reached through a concentual process involving EPA (an perhaps
environmental advocacy groups and congress). Defining acceptable risk has
proven to be more political than technical. DOD and the Corps may not be
adept at massaging the political-decision making piece of the problem. They can, however, lend their considerable resources and expertise to the technical aspect.

As the nation's largest owner and buyer of construction, the military has always been concerned with construction research and technology. Currently, there are six major military laboratories devoted to construction R&D--four in the Army, and one each in the Navy and Air Force. These labs spend approximately $250 million per year on construction-related research. As a percentage of construction investment, the investment the Corps makes in construction research is roughly 100 times greater than the industry average.71 One of the most significant and far reaching aspects of DOD's construction R&D program are two $15 million grants made in the mid 1980's--one to MIT, and the other to the University of Illinois--to conduct basic research in advanced construction technology. These are the largest grants for basic construction research ever seen in the US. 72

While these labs have contributed immeasurably to the readiness and functionality of the military, over the years, they have traditionally found difficulty in exporting their innovations to the market. As a means of helping the given problem, this detractor could mesh a DOD strength (technological expertise) with a national need. By redirecting some R&D at its existing laboratories to the mission of standard setting and certifying the viability of remediation innovations--rather than towards developing and selling military innovations--the Corps could contribute to not only cleaning-up its mess, but some of the rest of the mess.

71Note that although DOD’s construction R&D program represents less than one percent of the total military R&D budget, it would be large enough to rank in the top one-hundred R&D programs in corporate America.
72Martin, pp. 133-134.
The major effect of this effort would be to "still the moving target" for industry. Clear, definable, attainable standards and specifications limit the ambiguity in contracted performance. This plays to another institutional strength of the Corps--quality control and quality assurance. Measurable specifications minimize contract and performance disputes. This is the language the government and the industry understand and have comfort in executing. The Corps could then use in expertise and credibility to "certify" to the viability of new technologies. The most likely trickle-down benefit from the reduced riskiness is lower insurance and bonding costs for remediers and more entrants to the market.

The third component of this model is to rely on the competitiveness of the stable and defined market, driving rivals to innovate in order to improve their margins and bidding strength. The government's role in this activity is already defined. The Federal Acquisition Regulation (FAR) dictates the competitive nature of bidding and contracting with the federal government. Continuing with a Porter-like analysis, the internal rivalry within the attractive market will cause competitors to innovate incrementally to increase their competitive advantage. Innovations in both product and process lower costs to the firm throughout the value chain, thereby increasing their margins (profits). In the traditional nature of the construction industry, innovation improves a firm's ability to bid versus its competitors.

Innovation in construction has traditionally been incremental. In *Harvard Business Review*, Ralph Gomory makes a clear distinction between major new innovations and a less dramatic process of innovation that he believes to be far more critical to commercializing technology profitably. He calls this process "cyclic development" whose hallmark is incremental
improvement not breakthrough.\textsuperscript{73} Both government and industry need to be willing to invest the time and money necessary to make incremental improvements in the remediation technology business.

The attractiveness of this model versus the high-tech model proposed earlier, is that it doesn't try to change the \textit{culture} of either the government (in this case, the Corps) or the construction industry. There is a certain comfort in "business as usual." Additionally, as the U. S. is now finding in its pursuit of the HDTV market after abandoning the perceived low-tech television market several years ago: there is a tremendous amount of technology transfer from traditionally low-tech industries and processes to emerging high-tech markets. The unattractiveness in this model is that invites \textit{only} incremental risk-taking by competitors. Additionally, because of the traditionally narrow margins and lengthy dispute process over claims, many \textit{major} players may continue to shun federal work under low bid conditions.

Particular to the argument for a "low-tech" strategy is the need to imperative to set standards for the market. Well conceived and thorough specifications limit liability and invite innovation. Where to set this standard and for which sites is particularly important in developing a strategy. One tact may be to set a very high standard from the start on all sites and hope for industry to \textit{reach} for it by innovating. This can easily have the undesirable effect of increasing the risks for the innovative firms. Another course is to set reasonably high standards and thorough specifications on a majority of sites which would have the effect of inviting firms to compete in producing a relatively known "product." While the past ten years have

\textsuperscript{73}Ralph E. Gomory, "From the 'Ladder of Science' to the Product Development Cycle" \textit{Harvard Business Review}, November-December 1989.
pragmatically shown this to be more of a policy choice than a solution based upon technical merit, the increasing costs and continued uncertainty call for at least consideration of a "less than pristine" solution for some of our sites.

3.5 "Pristine" versus Safe

Any responsible academic discussion of the hazardous waste problem must turn at some point to the balance between cost and risk. A necessary precondition to analysis is to divorce from the discussion the political (or emotional, non-technical) input to the decision making process presented earlier in this study. The importance of this sterile analysis to DOD’s problem is that DOD may have the best justification for and the best means of pursuing this ideal-world solution. No other entity has as many or as varied sites to be remediated. Additionally, unlike private industry or other federal agencies, DOD will perpetually "own" the majority of their sites and can exercise active control over future exposure to risk--allowing it to defer "pristine" in favor of "safe" until technology and market forces make pristine affordable.

Man traumatizes nature in pursuit of modernization and industrialization. The earth and nature have a unique ability to heal these injuries over time by photolysis, hydrolysis, biodegradation, and oxidation/reduction processes. When the rate of injury outpaces the environment’s ability to absorb the trauma and mend itself, pollution problems become acute. One factor I find neglected in defining risk and in risk assessments is this ability for the earth to heal. In the case-by-case business of site investigation and remediation selection, this may seem justified. In the macro-sense, when looking at the prospect of cleaning-up
thousands of sites of various complexities, distributed in varying proximities to mankind, perhaps the surgery we perform on some injuries should bring the patient back the point where it can heal over time without imposing a risk to man. Why treat every site the same? In a society with unlimited resources, a pervasive moral argument for pristine wins. In a society of competing interests for limited resources (right now, federal and private funds), a pragmatic, dispassionate argument for safe should carry more weight. The crux of the problem is that in this society the moral argument is applied to a problem of competing interests and limited resources.

In examining the pragmatic argument presented, two tacts take shape--the costs of adding 9's and the costs of indecision. The first observation/analysis is based upon a composite of the myriad of resources available bemoaning the high costs of investigations and cleanups. The second applies personal lessons and observations in crisis decision making.

The costs of adding 9's rise exponentially in remediating a hazardous waste site. Costs are two-fold: time and money. Differing sites, various contractors and remediation technologies, and shifting standards make attaching number's to the phenomenon prohibitive. Qualitatively, the changing effect on cleanup costs can best be explained graphically. Figure 3.9 represents the costs in terms of time and money.

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74Adding 9's refers to the cleanliness of the site. For example, six 9's refers to a site being 99.999999% clean, or 1 part contaminant per million. Nine 9's refers to a site cleaned to 1 part per billion.
Exponential Increases in Cost for "Adding 9's"

The problem lies in defining safe in terms of concentration (C)--just what is the risk to human health. What does one chance in one-million of developing a chronic illness mean? How does it compare to more common health risks like passive smoke inhalation, commercial flight, or alcohol consumption? The pragmatic question to me is, what are we responsibly willing to pay to lower the risk posed by a cleanup. Is it worth spending six or ten times the money to minimally reduce the risk of a site--from say one one-hundredth the risk of a normal person in a common living and working environment falling ill from passive smoke inhalation to one two-hundredth that same risk? If this were an apolitical problem, that elusive point where costs "intersect" benefits would show us where and how to spend.

Because DOD will maintain ownership of the majority of its sites perpetually, and can control development or human access, a strong case can be made for DOD to clean all of their sites to safe, and some of their sites to pristine, and allow the earth or technological improvements to heal the remaining trauma over time.

The second anomaly in the process relates to the opportunities lost to untimeliness. What additional needless risk do we incur because of
indecision? The best example we can give is from the hard-learned lessons of crisis or disaster management. In almost every case, a simple, feasible plan—maybe only the 90% solution—acted upon immediately and executed vigorously conspicuously outperforms the complicated, 100% solution, developed over time and only then, acted upon. The decision-maker simply becomes overcome by events. The distinction between the two tacts is that in the former the emphasis in terms of time available and resources is given to physically fixing the problem. In the latter, the time available and resources go toward finding the perfect solution—while the problem persists or worsens. Figure 3.10 graphically represents this dynamic.

![Decision-Time-Risk Relationships](image)

Figure 3.10

What are the costs in terms of additional exposure to the contaminants or opportunities for use of the site lost to finding the 100% solution? What are the gains in adding 9's if it takes five times as long to execute? In the above figure, the shaded area under the curve shows the
additional exposure/risk incurred while deliberating over the pristine solution. The first figure showing the current situation, the second graphically depicting the effect of action. This shows the lost opportunities at just one site. Lengthy ROD's (the Record of Decision specifying the remediation technique for a site) also deny timely action on subsequent sites. Crisis management is a strength of DOD and treating the problem as a crisis meshes well with this part of DOD's culture. As discussed earlier, the concept of operable units attempts to compress the space and time for the cleanup.

If it were politically free to pursue this rationalist strategy for cleaning up the mess, the Department of Defense could make a strong case for expeditiously taking care of business. While morally distasteful to some parties, a pragmatic argument could be made in favor of vigorous pursuit of remediating to safe.

What adds to the persuasiveness of this argument is that DOD can pursue this rationalist strategy on select sites--those which it will not turn over; those which pose no long term threat to human safety because of access, and; those in which the contaminant is such that the earth can heal the remaining damage over a relatively short period of time. Additionally, as either funds continue to be allocated by Congress or as better, cheaper technological solutions arise, the DOD can hold out the promise or guarantee of cleaning these select sites to pristine.

The weakness in this argument is in the track record of pragmatists in the existing process. The political realities of getting a ROD from the EPA have progressively pushed the 9's higher in the ten year life of the legislation.
4. RECOMMENDATIONS

Finding a Win-Win Solution

After researching and analyzing the players and the problem, the task becomes inventing workable, reasonable solutions or strategies. Optimal strategies create a "win-win" solution for the players. The purpose becomes meshing the strengths and weaknesses of DOD and the strengths and weaknesses of RECRA to produce innovative technologies to clean-up the mess.

Thus far, this paper has discussed the Hazardous Waste Remediation Industry, the Environmental Protection Agency, and the Department of Defense--the players. It has analyzed the strengths and weakness of both Superfund and the Defense Environmental Restoration Program. We've then analyzed the interaction of these players and the problem in the context of the market--in this case, the construction industry--using an industry segmentation matrix and Porter's five competitive forces. Lastly, we've discussed recent examples of government involvement in stimulating technological innovation in other industries and proposed two quite different models for sponsoring innovation.

Our recommendations should be realistic--we shouldn't expect to rewrite or undo CERCLA, but work within the existing framework. They should prove beneficial to each of the players at the expense of none. Most importantly, the recommendations should expedite cleaning-up the mess.
Ten years of military service have shown that the view is always different from the inside. I can say with certainty that there are competent, dedicated and influential people within DOD that are working to improve the system.

Given either model presented, the Corps of Engineers, in executing the cleanup of our military hazardous waste sites, presents the best opportunity for the construction industry to both enter the market and seek innovative cleanup technologies. The burden now is on the Corps (or Congress, by directing the Corps) to take the baton, and for the construction industry to see the opportunity. To be the leader, the Corps must present a viable and stable market, subsidize or underwrite the risks of innovation, and protect competitors who break-through. First, DOD and the Corps have some in-house work ahead.
4.1 Vision

While the Defense Environmental Restoration Program and the Army go to great lengths to comply with all EPA, state, and local regulations, none have clear leverage against the Department of Defense through the courts. This should not be a problem unless both have valid competing interests concerning the federal lands. In these cases, I think it is important to not lose sight of the goal: to clean up the mess. This does not mean that there is a double standard—just an ill-defined one. Given the goal and this unavoidable relationship, the Corps of Engineers is presented with a mandate for action. They have a real opportunity to do what Superfund can not do—they can actually clean up the mess. With this opportunity comes expectation and a responsibility for both action and vision.

The opportunity calls for vision beyond a decentralized plan, where individual installations select remedies for their individual sites. Much of the process can and should be initiated and executed locally. However, with the Department of Defense recently adding approximately 3,000 new sites in its latest annual report to Congress (making the total number of identified sites number over 17,000)\textsuperscript{75} the Corps has the opportunity to exercise vision and become an incubator for both technology\textsuperscript{76} and process.


\textsuperscript{76}Alex Dornstauder, Hazardous Waste Remediation and the U.S. Army Corps of Engineers: Facilitating Technological Innovation Through Construction Management (Cambridge, Massachusetts: a thesis submitted to Department of Civil Engineering, Massachusetts Institute of Technology, May 1991).
4.2 Tightening-up In-House

A natural fall-out of conducting research to write this paper is a newfound familiarity with DERP and the Army's Installation Restoration Program, in particular. The following recommendations for improvement within the Army and its system for cleaning-up the mess serve two purposes. First, I have a personal interest as a professional officer in helping the Army to most effectively reach its goals—militarily or environmentally. Additionally, as is, DOD's current system may be the best chance for actually getting any site cleaned-up. As discussed earlier, problems with procedure, confusion about standards, and litigation risks slow the remediation process under EPA (Superfund—the money and the NPL) and DOE to a crawl or even a standstill. Improving the actual set-up, philosophy, and DOD remediation process will make it an even more inviting market segment for the construction and remediation industry to enter and especially to innovate. Lessons learned could help other agencies and the private sector clean-up their mess.

4.2.1 Central Database

One of the great strengths of both the military construction system and the U.S. construction industry is their decentralized system of both

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77 Maureen Ann McCabe, *An Introduction to the Defense Environmental Restoration Program* (Washington D.C.: a thesis submitted to the National Law Center, George Washington University, September 1990), pp. 39-40. Ms. McCabe forwards one little known difference between DERP and other Superfund cleanups that might make liability less an issue in DOD cleanups. The provisions of section 119 of CERCLA apply to contractors who carry out response actions under DERP. In it, the contractor in not liable for injuries, costs, damages, expenses, or other liability resulting from the release or threatened release of a hazardous substance unless the response contractor causes a release and his action was negligent, was grossly negligent, or constituted intentional misconduct. In certain instances, the President may agree to indemnify a contractor even where his action was negligent.
responsibility and authority. This system has traditionally allowed Corps personnel in the field the freedom and flexibility to do their jobs and execute their missions without being confined by micro-management from headquarters.\footnote{Martin, p. 117.} A graphic representation of DOD’s current construction delivery system is presented in Figure 4.1.

Military Construction Delivery System\footnote{Ibid., p.80.}

During wartime, divisions and districts within a unified command’s theatre of operations, will fall under that theatre command.

Unfortunately, many of the advantages that make decentralization work in managing over $10 billion of construction a year, work against finding innovative solutions to remediation problems. Coordinating the vast resources available, both in terms of money and manpower, cannot happen if individual contracting officers at individual installations have the primary
part to play in selection of individual remedies. This one step in the process, selection and contracting of remediation techniques should be influenced "centrally" for a number of reasons. First, each site should be a part of a larger plan for the total cleanup. Its remediation should contribute purposefully to increase our knowledge about a technique, process, or technology--adding to the empirical database by design rather than by coincidence. No single PRP has responsibility for the cleanup of as many or as many varied sites as the Department of Defense. In this area, lessons should only be learned once. The costs of inefficiency are unnecessary and, as Superfund has shown, too high.

This paper does not propose the Corps change its construction delivery system. Their decentralized system continues to be the best one for traditional construction services. Hazardous waste remediation, however, is a new problem. The changing dynamics of the industry, the incrementally evolving technologies, and the high cost of mistakes, call for changes in attacking this particular problem. The inability of the construction industry as a whole to take advantage of the information revolution may plague the Corps in how they approach remediation. Who actually has the lead for the Corps in the cleanup, and where are they? The Omaha District was a center of expertise for cleanups. USATHAMA in Aberdeen is the proponent for the Installation Restoration Program. Huntsville is the expert agency for explosive cleanups...Almost everyone has there fingers in some part of the pie.

What is necessary is a lead office for the big picture. This office should create and maintain a database of the collective experience of the Corps (and especially the industry) in cleaning up its mess--perhaps much
like DOE's WIN system\textsuperscript{80} for installation waste minimization. They've already had numerous cleanups and sites across the country, have either experimented or sponsored experimentation on numerous technologies, and are in the process of contracting for new cleanups. Some agency should know or have available what works, what might work, and what didn't work so mistakes will not be made twice and technological "leads" can be followed-up. This office or agency presents industry with a viable target to propose innovative solutions. As discussed earlier, one of the biggest deterrents to entrants is the bureaucratic maze.

Improvements are in progress. The Corps was DOD's lead agency in producing their \textit{Five Year Integrated Hazardous Material/Hazardous Waste Management Plan}. In this plan, the Corps identified a single centralized Army HM/HW Technology Transfer Manager (and Office) be created and empowered to centrally coordinate technology transfer for HM/HW initiatives now being developed independently by the many Army and DOD facilities. They've additionally created a technology implementation "Support Center" to be the point of contact for solutions to problems that arise when technologies are implemented and especially as the center for technology exchange between other Services and the private sector.\textsuperscript{81}

Currently USATHAMA publishes literature documenting ongoing remediation R&D either conducted by the Corps in one of its four laboratories or sponsored by the Corps on site. In \textit{Installation Restoration and Hazardous Waste Control Technologies} the Corps purpose is outlined as

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providing a convenient reference of current installation restoration and hazardous waste control technologies. The detail provided in each technology summary is intended to explain the capabilities and limitations to the reader and to provide a point-of-contact for additional technical information.82 By presenting this information to users as well as other developers, *U.S. Army Toxic and Hazardous Materials Agency Pollution Abatement and Installation Restoration Research and Development Program Activities FY 90* hopes to avoid duplication of effort by other R&D agencies with similar responsibilities and missions, and timely technology transfer can occur so that other developers may build upon the research results already obtained.83

### 4.2.2 Streamline, Systemize, and Execute Vigorously

The following fine-tuning in the Army’s Installation Restoration Program could make DOD cleanups more attractive to industry, particularly if they help the Corps to build a *track record* of success. Given the lethargic, risk-averse history of Superfund cleanups--with the mountain of documentation, liability issues, and special interest group impact--the ability to work through the Corps could be the fastest way to incremental advances in remediation techniques for a firm.

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4.2.2.1 The "Negotiated" Baseline Assessment

The public has a critical role in the decision-making and review processes associated with environmental restoration. The legal and political issues surrounding hazardous waste, which are driven by public opinion, have had more impact in setting the direction of cleanup programs than have the technical issues associated with site cleanup. In the future, the public is likely to demand even greater input into the decision-making process as special interest groups become more savvy in their dealings with DOE and EPA, and concerns about waste issues continue to grow.84

Strategies for Environmental Restoration
In An Evolving Regulatory Environment

One way the Army and the Corps of Engineers can avoid the "decide-announce-defend" syndrome is to involve the interested parties earlier in the process--particularly in the Installation Restoration Program. A supplemental publication called the Commander's Guide to Public Involvement in the Army's Installation Restoration Program is an honest attempt to make the public a part of the process. The existing system should work for non-controversial sites and the Corps should be able to make strides in cleanups, working-off the lower-end or "easy" problems. The more challenging sites--the tough ones--will require greater effort from the command and the Army in terms of trying to address the interests of all the key players: EPA, state, citizen groups, and not least of all the military.

The Guide to Public Involvement makes a clear distinction between public relations and public participation, describing the first to be "a planned effort to influence opinion through socially responsible performance"85 and advocating the second as "a planned effort to involve citizen's in the

84Geffen and Keller, pp. 9-10.
decision-making process." Public Affairs Officers are formally schooled in balancing these two concepts and the guidance recommends the commander use his PAO and staff to prepare and manage public involvement in the process. The issue for the command becomes which of the two--public relations or public participation--is actually pursued when the stakes are high. The Army should act against its natural tendencies to ensure that, as an identified problem becomes less defined and more complex, it tips the scales toward public participation and away from public relations. To the greatest extent possible, in these cases where controversy can be anticipated, work to get the stakeholders to set the baseline risk.

The military often has strong ties to the surrounding civilian communities--witness the recent uproar over proposed base closures. A heavy proportion of the adjacent communities either are employed by the military, are military and their dependants, or are economically dependent upon the soldiers and their families for business. Historically, the relationship has not necessarily been adversarial and the stakeholders have worked through problems in the past like noise abatement and land use. A viable inroad exists for public participation in defining that elusive point where costs and benefits balance.

A baseline risk assessment in which all the stakeholders can accept--whether through negotiation for hard sites or public announcement and comment for relatively easier ones--is the one area that public participation can most effect a defense site cleanup. As Robert Harris and Grover Wrenn summarize about the Superfund experience, "If given equal access to technical resources and allowed to participate in the planning process, the

86 Ibid.
public is likely to develop a greater appreciation of the complexity of hazardous waste problems and to be more accepting of on-site remedies."87 This works with and not against the military work ethic which can be paraphrased as, "tell me what standard is expected and when I have to achieve it, but not how to do it!"--task, condition, standard again. For this cultural reason, negotiated solutions later in the process such as remedy selection or contracting, hold less potential for a successful cleanup within DERP.

4.2.2.2 Unearth the Remedial Project Manager

One potential weakness in the Army's Installation Restoration Program and the system for action it outlines is in the relative importance of the installation's Remedial Project Manager (RPM). This individual is usually the installation's environmental coordinator and commonly be found working for the Directorate of Engineering and Housing (DEH). In the Army hierarchy, this means that the RPM is not someone who would necessarily "have the bosses ear." More often than not, the RPM would not be a prime player in the day-to-day mission of the installation unless a cleanup, or public pressure, or some other factor he controlled impacted upon that installation mission. The guidance is not written to lessen or diminish the importance of this player, but his place in the hierarchy places him in a reactive position--one who's importance becomes apparent only in crisis--rather than in a place where he can anticipate and garner command emphasis and resources. Much like the market, hazardous waste has traditionally been an externality, or the cost of doing business for old-school commanders and, until the hard lesson is learned, the IRP may just be

87Harris and Wrenn, p. 58.
another one of the many responsibilities he has that he trusts a subordinate to execute.

The Remedial Project Manager is the action man in the program. He is the individual responsible for implementing the program and ultimately cleaning-up the site. If cleanup is indeed an Army priority, we should move him to a position in the hierarchy where he can better effect command attention and action.

The Air Force has seen this problem and has adjusted its system for installation cleanup. The following excerpt details this incremental improvement in their program and their willingness to give the installation the visibility necessary to accomplish the mission.

The solution to the needs of access and authority is the establishment of a single Environmental Management Office (EMO) comprising all the key experts who report directly to the installation commander. The Air Force's first EMO was organized in 1985 at McClellan AFB, CA, as a local initiative to provide a unified body to respond to mounting regulatory, media, and public interest in hazardous waste contamination at the installation...All bases with EMOs support the concept. They cite vastly improved communications from the environmental experts to the installation commander (access), an ability to compel base organizations to change procedures to achieve compliance (authority), and a greatly enhanced, even synergistic, responsiveness to environmental problems by combining various disciplines into one organization...

I recommend these organizational guidelines:

- The Environmental Management Office be comprised of the current functions of the Environmental Co-ordinator and the Bioenvironmental Engineer and be staffed with funded positions that reflect the number and scope of environmental issues at the installation.
- The Chief of Environmental Management report directly to the installation commander.
• The Staff Judge Advocate (SJA) assign one judge advocate to give priority to responding to requests for staff assistance by the Chief EMO.  

One possible reason the Air Force was able to lend a fresh perspective to the problem is their unique engineering structure. In the Army, the Corps of Engineers both staffs the installation DEH and the regional contracting offices which manage the cleanup. The Corps of Engineers does not run the installation DEHs for the Air Force, yet maintains responsibility for contracting cleanups and military construction. Their ability to look at the system from the "outside" lent them insight in this case.

4.2.2.3 Hanscom A.F.B.: Case Study in Possibilities

I've included the following short case to emphasize the possibilities for industry, the Corps, and DOD if they can find and institutionalize process improvements in their program. The key as that the players do not lose sight of the overall goal--to clean up the mess and move on.

From 1952 to 1974, the U.S. Air Force leased and operated the Hanscom Air Field in Bedford, Mass. During that time, the Air Force had generated various spent fuels, paint thinners, solvents, solid wastes and other combustible liquids and disposed of some on-site. In 1985, an Air Force investigation revealed the effects of the past disposal practices: Four waste sites were found within the 100 acre confines of the air field.

The relative speed with which the cleanup progressed from feasibility study to contract awards was possible through the Installation Restoration Program (IRP), the military version of EPA's Superfund Program...While civilian cleanup programs can drag on for years as "potentially responsible parties" are identified to share costs, military cleanups can move along more quickly because of IRP. At

Hanscom, IRP provided the military with a shortcut around the cumbersome and time-consuming cost recovery procedures required at Superfund sites. Because there was sufficient information available from previous studies at Hanscom to document the presence of contamination, the Air Force undertook phases 2 and 4 (of the IRP process) concurrently.

As the studies were undertaken, the Air Force held regularly scheduled meetings with official parties interested in the results. These parties included the property owner—the Massachusetts Port Authority (Massport)—the town of Bedford, the DEQE, EPA and the Corps of Engineers. As a result, draft reports were formulated as a consensus of opinion and required only minor changes to comply with the requirements of all parties.89

4.3 Message to Industry

Government has a tremendous impact on how firms compete in the market. Government has a particular interest in the remediation market because it is a market born from legislation. The in-house recommendations made above addressed identified problems in the way the Department of Defense cleans-up its hazardous waste. The remaining recommendations take-on broader issues and speak more towards seizing opportunities than fixing problems.

Shifts in social attitudes and norms can have an impact on industries—but the governmental influences on industries that result from them usually have the most significant and tangible impact on industry structure...There is usually some lead time in the introduction of government regulatory changes. The firm must constantly monitor trends in governmental influence on the industry, and analyze the structural impact of the range of possible government options under consideration. It is then in a position to attempt to influence regulation ... and to prepare strategically for the regulatory changes that are a real possibility.90

Michael Porter

First, Congress or the civilian leadership of the Department of Defense should mandate the Corps "go on record" as having a policy of sponsoring innovation and new technology in industry, DOD laboratories, and universities for cleaning-up its old waste. This new mandate would send a powerful signal to industry that a stable, sustainable market underwritten by a credible "buyer" favors technological risk.

4.3.1 Wrest Control of the Disjointed Situation

Currently, three players are aggressively working towards becoming the leader in Federal government's cleanup program. The EPA, with its traditional ties to CERCLA and SARA, feel they are best suited to continue the process when more and more of the sites on the NPL move through the pipeline from investigation to actual remediation. I feel strongly that inexperience in construction-like contracts and relationships combined with relative inexperience in large scale R&D programs make the learning curve too steep for them for them to be an effective leader. Additionally, the integrity of the impartiality EPA lends to the remediation contracts and technologies they sponsor may present a conflict of interests given their role as the regulatory agency.

DOE has a tremendous stake in the process. While the number of sites they own are few, they are some of the most complex and expensive sites on the NPL. Their case for a leadership role is stronger than EPA's, but for reasons outlined throughout this paper, not as strong as DOD's. The following is excerpted from DOE's Five Year Plan, 1992-1995:
The DOE plan to restore and properly operate its sites should be the national testbed for environmental restoration and waste management technology development and implementation. A fully successful Technology Development Program constituting about 10 percent of the Office of Environmental Restoration and Waste Management's budget will result in DOE not only achieving its goal, but achieving it faster, more safely, and at lower cost. Even if only partially successful, technology development will provide significant benefits. Technology transfer to industry, including the development of a cadre of DOE technical specialists, will support and expedite national efforts in restoration. The investment in technology development will be more than repaid by savings in operational costs. The absence of a Technology Development Program will result in a continuation of the old practices of "suck, muck, and truck." The result will be exorbitant costs, probable delays, and unnecessary exposure of workers and the public to chemical and radiological hazards.

DOE recognizes that OTD must expect to have a high rate of failure. Technological breakthroughs cannot be planned or depended upon. Progress will instead largely be made as the result of a series of incremental advancements...

Remediation technologies are available for many applications but have rarely been completely tested and evaluated for uses in specific DOE situations. Testing and evaluation of promising existing technologies for mixed wastes and contaminated sites will provide environmental restoration technologists with an arsenal of available methods with known costs and effectiveness.91

DOE can and should actively pursue technological innovations. The case here though is for a lead agency. While competition may drive the marketplace towards innovative solutions, it can be wasteful and overly expensive for the taxpayer if federal agencies compete for R&D resources and capital. DOD is better suited to be the lead agency for technological improvements in remediation. Many of the issues raised earlier in this paper--a history of sponsoring R&D, experience with industry and contracting for services and technology, the physical aspects of managing

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cleanups--cannot be learned or bought by the DOE. I also strongly believe that innovation will most likely be incremental, especially in the next five to ten years. With their limited number of sites, all of which are among the most complex on the NPL, DOE may not have the luxury of learning to crawl before they can walk and run.

This current situation is a microcosm of the fragmented, inconsistent legislation and current procedure for cleaning up. Government should halt the dysfunctional, unspoken competition among these heavyweights and pin the rose on the player best able to sponsor, direct, and manage an efficient, unified program for finding the best means and technologies for cleaning up the mess. I think DOD is that agency.

4.3.2 Education, R&D Sponsorship

Government programs have always contributed importantly to the education of scientists and engineers, provided equipment and facilities, and encouraged the basic research that industry utilizes in its efforts to commercialize technology. Sustained investments in these areas are critical to our nation's economic future. 92

The Corps will continue to be a leader in construction technology research. Hazardous waste remediation is the next big frontier for the construction industry and the time may be now for the Corps to shift focus and resources to this new element of construction. Funded and directed university research to augment that remediation research conducted in its labs and research that it sponsors in industry, would benefit both the military, the industry, and most importantly society. One of the lessons the

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Corps may take from its past, combined with the opportunities presented by advances in information technology, may be to ensure their research effort is efficient. As discussed earlier, a more efficient use of its labs and expertise may be to use each to certify potential technologies proposed by industry. They can be the catalyst in the two proposed models for innovation. The same problems with decentralization addressed above can equally apply in how the Corps spends its research dollars. Perhaps the labs or the office recommended above could help to ensure sponsored researchers at MIT, Illinois, or Berkeley are not making the same mistakes, looking at exactly the same problems, or are unaware of each other, industry's advances, or work ongoing in its own labs.

A commitment to remediation research and certification, both in universities and in its labs, is not out of line with the Corps' culture. This time, because the problems are so ill defined, the Corps must know what it wants for its money and ensure that it creates a synergistic rather than random effort among the separate minds they sponsor.

4.3.3 Improve Contracting

As discussed earlier in this study, some of the most formidable obstacles to innovation by remediation contractors are the liability risks. How can they be sure that the standard they clean to today will stand the test of time? The current system allows little room for innovation because it allows neither party (buyer or contractor) to accept the risks associated with responsibly trying new technologies. The room for improvement in this area for DOD seems limitless given their experience with contracting and the construction industry. Already, some headway has been made. An example from the Navy follows:
A "Comprehensive Long Term Environmental Action, Navy" (CLEAN) contract is an engineering service agreement for one year, with nine option years, and has a maximum value of either $100 or $130 million. All of the EFDs (Engineering Field Divisions) and the EFA (Engineering Field Activity) have such contracts in force, or award is imminent...Selected under Brooks Act procedures, the CLEAN contracts are of the cost plus award fee type...Although these contracts are intended primarily to provide engineering services from initial studies through design, they have a provision that allows them to be used for remedial action under certain circumstances...The NAVFAC acquisition strategy is to have a portfolio of contracting options so that the best fit can be made in consideration of a variety of factors.

For construction and remediation, the NAVFAC concept is similar. The Remedial Action Contract (RAC) is the newest type on the scene...This contract is designed to satisfy the need for quick access to remediation contractors and the latest technology, irrespective of geographic EFD...Each contract is focused toward a specific contaminant type, is a one-year agreement with four option years, and is cost plus fixed fee...RACs are intended for modest size cleanups--up to about $1 million each. RAC contractors may also be requested to try innovative, cost-saving technologies to help learn new cleanup techniques. 93

Contractors, owners, and designers enter different contracts for a number of varied and important reasons--to outline responsibilities; to save money; to gain input in the construction process, and; to speed-up the construction process. However, the two most important reasons these parties enter into contracts are dispute avoidance (keep out of court) and the specified, if not fair, allocation of risk. Hazardous waste cleanups are a new and unique problem. The waste presents latent risks new to the construction industry and the cleanup of those wastes compounds and confuses the risks for the traditional three parties. The courts muddle even traditional construction processes and contracts--the specter of claims and

liability in the environmental arena cast a dark cloud over the entire industry. The new challenges and risks presented by this new and evolving problem demand new contract types and methods. Traditional contracts like lump-sum, or newer methods like design-build or cost-plus, may not be the best or even an adequate template to both allocate these new risks or avoid disputes. I recommend the Corps, with its long ties to construction, sponsored research in contracting, and position of leadership in the federal government, study and invent new contracts and contract-types for the hazardous waste remediation of federal lands. As previously discussed, lessons from DARPA and our weapons procurement history could prove invaluable in providing a precedent and lessons learned in sponsoring innovation or "buying risk." Innovation in contracting may need to precede innovation in technology in this dynamic market.
4.3.3.1 Dispute and Claim Avoidance

Somewhere in our agenda we must remove some barriers to innovation, one of which is litigation. Innovation and advances in technology benefit all of us. But innovation is accompanied by risk--a risk we should understand, learn to deal with, and be willing to share. Unfortunately, that hasn't happened. We in the U.S. have become a litigious society. Whenever we don't like the results of anything, we sue...

Behind war, litigation is the second most wasteful and destructive activity of mankind--some think litigation is even worse than war. The cost and strain of litigation is probably one of the most significant demotivators in our society. Litigation is destructive, demoralizing and it sucks the creative energy out of any enterprise. Bluntly put, litigation and lawyers sap economic vitality. Lawyers are a drain even if they work for free.\(^9\)

William D. Lewis
CEO, ASL Consulting Engineers

The above sentiment is not an exception, rather the norm in the engineering and construction industry. Players in the world of construction and design despise the court and the added costs in bonding, insurance, and fees litigation brings. Owners, architect/engineers, and contractors enter contracts to avoid litigation and its costs. Today, construction contracts provide for mediation and arbitration in order to settle disputes out-of-court. If society or the government expect the market to solve remediation's technological problems, they need to lower the entry barriers (liability risks) for potential innovators and market segment entrants discussed earlier.

The Corps is no stranger to the courts. In fact, their contracting expertise now deters top firms from doing business for the Corps because of the small margins and claims process. However, as the federal government's engineer and the principal government researcher in

contracting, they have both the expertise and the opportunity to seize the challenges presented by these new problems. After first understanding exactly what the law requires of it and what power or leverage it has in the execution of its cleanups (the stick), the Corps should innovate beyond the current limits of the Federal Acquisition Regulation (FAR) in contracting its cleanups. They should ensure that these innovative methods, tailored to hazardous waste remediation, have as a primary objective dispute avoidance yet maintain sufficient leverage that they are not patsy’s for unacceptable or sub-standard performance by the contractors. Contracting has long been the subject of research and debate both inside and outside the Corps--the problem just got tougher.

4.3.3.2 Underwrite "Risk"

When the Five Competitive Forces and their impact on the market do not favor firms seeking first-mover advantages through technological innovation, and when the cost of technological stagnation is so grave, the Federal government should get involved. Unfortunately (or rather, fortunately), Congress can’t legislate innovation. The government must be seek other ways to prime the pump. Again, I recommend DOD be the lead agency in altering these five forces--at first in their market segment, then later to export process and innovations to other federal segments.

Shifting the market forces requires an agency/buyer with significant resources and credibility. The Corps is one of the few players who can create this kind of impact in the market. The best way for DOD to create incentives for innovators in the industry is to underwrite or buy some of the technological, legal, and market risks endemic to the current market. Again,
through innovative contracting, the Corps could sponsor or test new technologies for cleaning-up. The probability that remedial breakthroughs will be incremental, not monumental, suggest a long-term commitment by the government to finding an answer. In this way, government and industry can create a new expert team and should evolve into true experts—given physicist Niels Bohr’s definition of an expert as "a man who has made all the mistakes which can be made in a very narrow field." 95

This paper does not pretend to be the only beacon of light for either DOD or the market. Both are moving towards improving the current contracting process in relation to both dispute avoidance and, to a minimal extent, underwriting risks. One example is a recent series of executive level "contracts forums" sponsored by the Society of American Military Engineers Environmental Affairs Committee. Senior members of the Department of Defense and remedial action contractors (RACs) attended. The most recent forum focused on liability, indemnification, and bonding in environmental contracting. Three key issues were discussed:

- There is a risk to the remedial action contractor (RAC) performing environmental work. Part of this risk are the unknowns associated with the work. Another part is the potential for third-party liability suits resulting from the performance of such work.

- RACs are unable to obtain professional performance liability insurance for hazardous waste site cleanup projects. The insurance industry is reluctant to provide insurance because of the high risk of liability associated with performing such work. Available insurance covers only the period of work performance, not the time during which RACs are most susceptible to third-party liability suits.

• RACs cannot obtain the surety bonds required for federal hazardous waste cleanup projects because the surety bond industry sees a high liability risk in issuing such bonds. Available bonds are generally for projects of less than $5 million value. Some companies are self-bonding to meet government requirements.

• RACs feel that the DOD is responsible for the presence of hazardous material on the site and, therefore, should be responsible for their portion of the risk associated with cleanup. RACs believe that DOD should indemnify RACs performing work against third-party liability to cover the government's part of the risk.

In response to the concerns raised by RACs, DOD representatives indicated they would consider these potential solutions to resolve the issues raised:

• Change the laws so that RACs are excluded as potentially responsible party for liability suits resulting from cleanup.

• Revise the Federal Acquisition Regulations (FAR) to extend the applicability of indemnification to contractor work done as part of the Defense Environmental Restoration Program.

• Limit the statute of limitations for contractors on environmental cleanup projects and limit the contractor's liability for a project.

• Limit the contractor's liability to that resulting from their negligence.

• Negotiate the risks of a project with the contractor and determine equitable distribution of the risk between the contractor and the government as part of the contract.

These considerations and related issues will be addressed in a Congressionally mandated DOD study of the liabilities faced by firms providing environmental restoration services to DOD.96

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4.3.4 Protect the Innovator--Proprietary guarantees

Knowledge, know-how, experience and technological expertise are essential to an E&C firm's ability to secure jobs. Research conducted by MIT shows that international E&C firms are not only knowledge-intensive; their expertise and knowledge are the basis for their competitiveness in the global market... (In the past) the construction firm's comparative advantage has been mostly in its human capital. The emergence of a pure service output as the main function of many E&C firms has reinforced its importance... Today, firms are defining themselves in terms of the knowledge that is embodied in their organizations and human capital... In this emerging picture of the E&C industry, the relative importance of knowledge becomes greater and each firm's specialization becomes a major factor in the client's selection process.97

Fred Moavenzadeh
Editor in Chief, CBR

The one, golden rule espoused by Michael Porter in his two books, Competitive Strategy and Competitive Advantage is that a firm's goal is always to pursue strategies which enable it to sustain its competitive advantage.

One more way the Corps can stimulate industry to seek innovative solutions to our nation's remediation problems is to guarantee firms can gain proprietary rights to the technologies they develop. While this recommendation seems intuitive, our strategic analysis of the market, its segmentation, and competitive forces which shape it demand its careful consideration. Contracts and incentives which invite aggressive new entrants to the market and stimulate innovation from existing rivals are only half the story. Firms which strategically plan and vigorously execute and pursue ways to create then sustain competitive advantage.

The key for the Corps is to combine the innovative contracting proposed above with a new policy that protects contracted firms if they innovate while working for the Corps. Firms which gain first-mover competitive advantages by technological advancement will want to erect barriers to entry in their market segment and keep current rivals off-balance as long as possible. What firm would be willing to shoulder the financial, market, and liability risks of forwarding a new technology if the buyer (in this case, the government) is willing to give away their secrets for the public good? The answer is: not a very smart firm. DOD must look at the situation from industry's point of view. A recent article in Construction Business Review spelled out this perspective.

Protecting your intellectual property rights is good business in today's market. Contractors have large investments from developing inventions, trademarks and written works, but they have not had a tradition of protecting the proprietary technology that they have developed. Today, technology, expertise and procedures are providing the competitive edge in the construction industry. Construction contractors' intellectual property should be and can be legally protected.\footnote{Richard Edmister and Calfee H. Griswald, "Exclusivity in the Marketplace--How to Protect Proprietary Technology," Construction Business Review (Vienna, Virginia: HLK Global Communications, Inc., January-February 1991), p.45.}

The challenge for the Corps is in creating a win-win solution in this situation for DOD and the innovating firms. One way to do this is to grant the innovator proprietary rights over the technologies they develop while "underwritten" by the Corps. In return, the Corps should ensure contractually that they have first priority on the new proprietary technology for DOD cleanups. They can then release the firm to shop, sell, or use their excess capabilities in other market segments. This ensures the Corps can
complete its mission, the firm can sustain its competitive advantage, and other markets and messes can benefit from the innovation.

4.5 Conclusion

Pursue both strategies for innovation. I believe the Department of Defense is in the enviable position of pursuing both strategies discussed in Section 3.4. Both the weapons procurement model (high-tech) and the highways model (low-tech) can benefit DOD, the construction and hazardous waste industries, and society as a whole in cleaning-up the mess. Both are unifying, mutual-gains, package methods of implementing the myriad of recommendations proposed by this study.

While the high-tech model requires the most change (especially cultural) within the Department of Defense, it represents the best chance for finding truly break-through technologies. Restructuring of our contracting relationships and a new role for our federal laboratories represent a new direction for the Corps.

A mandate for setting definable, clear specifications (demanded by the second model) creates less structural/cultural change within the DOD. The collaborative effort between the Environmental Protection Agency, the Corps, and the long list of interested stakeholders is daunting, yet achievable. It is here where pervasive arguments for "safe" versus "pristine" should be pushed by DOD--again a daunting mission. The value of incremental advances in process and product can not be overstated and mandate pursuing the second model.
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