Cleanup By Design

Rapid prototype development and robust engineering design can improve waste cleanup operations.

By Warren Niederhut, P.E., Phil Rogan, CPG and David Cleland, CPG

Systems for the cleanup of hazardous wastes traditionally have been developed and installed via a design-bid-build process. For many applications, however, systems created in this manner have not performed as designed, frequently falling well short of plans and expectations. This typically results in additional cleanup costs and extended cleanup schedules, creating a frustrating situation for government property owners.

An alternative approach to waste treatment system design and construction, designed by Tesoro Corp., optimizes the deployment of systems that will perform well, be more robust and have lower operating costs. Dubbed “Challenger Technology,” the process mimics the design-build trend in the construction industry by assembling scientists, engineers and builders into one integrated project team. However, it goes a step further by borrowing the manufacturing sector’s use of rapid prototyping and robust engineering design.

Developing a Prototype

Rapid prototype development is a relatively new technique in the manufacturing and software industries where it is used extensively in new product development. The goal is to reduce the time between new product conception and implementation or deployment. A key aspect of the process includes the tight-coupling of design with implementation, which speeds delivery and assures a higher-quality product. Intrinsic to the process is periodic testing of prototypes, prototype components, or models, with design modifications made as indicated.

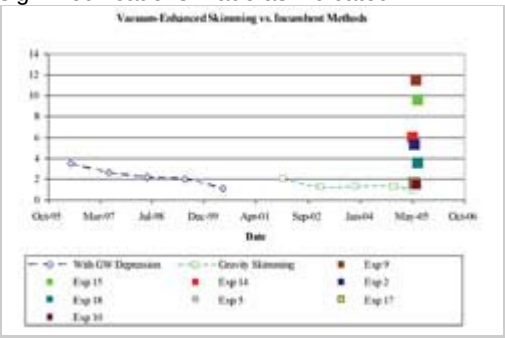

Figure 1. In this figure, the quantity of petroleum recovered is plotted as a function of time. The petroleum recovery is presented on a per functional skimmer bases so that one technology can be directly compared to another.

For success, interaction during prototyping must be rapid and requires that all aspects of product development, fabrication and testing be completed by one company and one integrated product development team. The one-team approach minimizes the duration of development-fabrication-Testing and evaluation was completed using a matrix experiment approach. These techniques, frequently called design of experiment approaches, use a matrix of operating or test conditions and a fixed number of experiments. Each test was conducted over a two-week period, with a total commissioning period of eight weeks. Using a one-at-a-time approach would have required 102 weeks for completion.

The Challenger Technology VES was evaluated for performance against two incumbent technologies, which had been or were concurrently operating at the same site.

The original technology selected for this site was petroleum skimming with groundwater depression. This technology enhances petroleum recovery by depressing the groundwater via active pumping on the water table. The premise is that the resulting cone of depression will drive the petroleum to the recovery well, thereby enhancing recovery.

The second incumbent technology was petroleum skimming with no enhancements, or simply gravity skimming.

Challenger Technology VES uses petroleum-skimming units, which are enhanced by the application of low vacuum pressure to the subsurface. The reduction in the pore pressure is thought to enhance the recovery of the petroleum by increasing the flow of the petroleum through the soil.

During our commissioning period, vacuum pressures between 10-in and 40-in water column, three types of skimmer designs, the elevation of the skimmer in the recovery well and the time duration between the evacuations of the skimmer reservoir were systematically evaluated.

Technology	Capital Cost ($)	Time to Deploy (yrs)
Skimming with Groundwater Depression	$228,000	2.0
Gravity Skimming	$10,000	1.0
Challenger Technology Vacuum Enhanced Skimming	$22,536	0.75

Table 1. Comparison of Capital Cost and Deployment Times. Time to deploy represents the time period from conceptual design through deployment of an operational system.

Rating Success

The results of the commissioning conducted in May

testing cycles and maximizes the amount of information carried through the product lifecycle.

The "product" in our test project was a vacuum-enhanced petroleum skimming system (VES). We postulated that this skimming system, whose prototype was named "Tinman" would maximize the removal of jet fuel floating on the water table while minimizing the unwanted recovery of groundwater. The prototype, or prototypic components, was tested at several stages during development.

While not elegant, Tinman functioned well enough to continue pursuing this particular design. Modifications were made to the process flow and automatic controls were added. The prototype control system was bench-tested and system components were field tested prior to testing the second-generation Tinman.

Input from operations personnel indicated that the system would have shorter downtime if it were built with off-the-shelf components. Thus, Tinman II includes only one component that requires a special order.

With the prototype testing completed, five operating units were fabricated by the team and put into service under a documented test and evaluation, or commissioning, plan to determine optimum operating conditions. A statistically defendable process, robust engineering design, was used to achieve these goals.

Taking a 'Test Drive'

The test and evaluation process was the culmination of the rapid prototype development process, where specific operating conditions may not be, nor need to be, rigorously estimated during the design stage.

Commissioning of this system took place over the course of two months. This duration was necessary because the treatment system interacts with the natural environment that can experience substantial variation over time. The duration of the commissioning allows for the dampening of the temporal variation in environmental factors like rainfall.

and June of 2005 revealed that many of the test conditions showed improved performance over the incumbent technologies. For example, one test condition achieved a recovery of about 11.5-gal of petroleum per-day, per-skimmer—more than three times better than the best performance of the incumbent technologies. This indicates the benefit of performing systematic and well-planned commissioning of these systems.

Capital costs were normalized so that one-dollar of capital cost is based on the best performance by a system to achieve 2-gal of petroleum per day, per-skimmer. The best a gravity skimming system has ever done at this site is 2-gal per day, per skimmer so the capital cost equals one unit. Equivalently, skimming with groundwater depression requires 0.57 units to achieve 2-gal per day, per skimmer and VES will require 0.17-gal per day per skimmer. All costs discussed here have been adjusted to equivalent 2005 dollars.

Having designed, deployed and tested the Challenger Technology VES in less than a year—and for a total cost (capital and man-hours) of less than $133,000—the project team was satisfied with the overall system performance. However, even before completion of the commissioning phase changes were being discussed that could make the system more energy efficient, easier to service, and potentially have lower capital and maintenance costs. In November 2005, the second-generation system was deployed at a different test site. The same design, prototype and deployment processes were used for this second generation system. The results were just as encouraging and the capital cost of the system was reduced by roughly 50 percent.

Conclusion

In many ways, this development process mimics the design-build trend in the A/E/C industry. While the long-term operating costs are still unknown, the Challenger Technology VES for cleanup systems is faster than comparable systems, more effective than systems that result from a design-bid-build process and shortens the time required to achieve cleanup goals.

Warren Niederhut, P.E., is Vice President, and Phil Rogan, CPG, is Project Manager, Tesoro Corp., Virginia Beach, Va. Niederhut and Rogan can be reached at 757-518-8491, or NiederhutW@TesoroCorp.com, or RoganP@TesoroCorp.com, respectively.

David Cleland, CPG, is Remedial Project Manager, U.S. Marine Corps North Carolina IPT, NAVFAC–Mid Atlantic, Norfolk, Va.; 757-322-4813, or david.t.cleland@navy.mil.