

THE ENVIRONMENTAL MANAGEMENT PROGRAM USES PERFORMANCE MEASURES FOR SCIENCE AND TECHNOLOGY TO: FOCUS INVESTMENTS ON ACHIEVING CLEANUP GOALS; IMPROVE THE MANAGEMENT OF SCIENCE AND TECHNOLOGY; AND, EVALUATE THE EFFECTIVENESS OF THOSE INVESTMENTS

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ABSTRACT

Since Congress passed the Government Performance and Results Act in 1993, the Office of Environmental Management (EM) has used a series of performance measures to direct investments, improve management, and evaluate the effectiveness of its science and technology investments. The performance measures have changed over time due to increased program maturity, expansion of program responsibilities, changes in the data available for measurement, and improvement of our understanding of performance measures as a management tool. Performance measures for science and technology are currently used at two levels within the EM program: at the corporate level on a complex wide basis and at the program level.

This paper provides background information on the historical use of performance measures for science and technology within the EM program but is primarily focused on introducing the corporate level measures discussed in the *EM Research and Development Program Plan*. The four complementary performance measures described in the Plan are expected to drive EM's science and technology investments to achieve four goals: meet the highest priority site needs; reduce the cost of EM's costliest cleanup projects; reduce programmatic, in particular, technological risk; and accelerate and increase technology deployment to allow schedule acceleration.

While the impacts of federally funded research and development are generally difficult to measure, we believe EM has developed the right set of measures to not only evaluate program performance but to drive the program to better achieve our goals. Finally, and perhaps most importantly, the data associated with these performance measures are provided by our customers, the end users of the science and technology investments.

INTRODUCTION

The Office of Environmental Management's (EM) mission is to clean up the environmental legacy of U.S. nuclear weapons production and other sources of pollutants such as Department of Energy (DOE) nuclear research. EM's goal is to cleanup the majority of sites by the year 2006, allowing the focus of efforts thereafter to concentrate on the most complicated and difficult problems. The EM cleanup effort is expensive, technologically complex, closely regulated, and relatively unique in the world. Achieving the goal of accelerated cleanup within the current budget requires targeted investments to respond to hundreds of needs identified by cleanup project managers at the affected sites.

EM's investments can provide more effective, less expensive, and safer environmental remedies, including technologies where no effective remedies currently exist. These investments can also

provide the data or alternative approaches that reduce the risk that cleanup will be delayed or will exceed the available budget. Science and technology efforts within EM span the full spectrum from research to direct assistance for cleanup projects and lead to fully integrated, technically defensible solutions for cleanup and long-term environmental stewardship at DOE sites. In order to maximize the value to the cleanup effort, EM's investments in science and technology must be:

- **Solution Driven**—All science and technology investments must support implementation decisions, enable action where solutions are lacking, enable actions that significantly reduce cost and schedule while maintaining or enhancing health and safety, or fundamentally transform the nature of the problem.
- **Fully Integrated with Cleanup Projects**—All activities must be linked directly to cleanup goals that reflect stakeholder values and site compliance agreements, with financial accountability transitioning from the technology developers to the cleanup project manager as efforts mature toward technology deployment.
- **Comprehensive in Scope**—Activities must cover the full range of science and technology; i.e., from basic research to technology development to technology demonstration to technical assistance supporting implementation.
- **Selected Using Credible Decision Processes**—Processes used to establish priorities, set program and project direction, allocate funding, and select project teams must be based on a clear set of criteria and are applied in an open, transparent manner.

EM's vision for science and technology is: "science and technology investments will provide the scientific foundation, technical assistance, new approaches, and new technologies that contribute, as an integral part of EM programs, to significant reductions in risk (both technology and safety/health), cost, and schedule for completion of the EM mission. The strongest advocates for investing in science and technology will be the EM cleanup project managers."

BACKGROUND ON RESEARCH AND DEVELOPMENT PERFORMANCE MEASURES

Since Congress passed the Government Performance and Results Act in 1993, federal agencies have been aggressively working to determine, implement, and evaluate the use of performance measures on a wide range of activities. Historically, one of the more difficult areas for the proper use of performance measures has been in the area of research and development. In March 1997, the General Accounting Office released a report titled "Measuring Performance—Strengths and Limitations of Research Indicators." The key findings of the report were:

- American taxpayers invested more than \$60 billion in federal funds in R&D efforts in 1996, and that there was no widely accepted method of measuring the results of that research.

- The amount of money spent on R&D, the primary indicator of the investment in research, is useful as a measure of how much research is performed, but is not a reliable indicator of the level of results achieved by research.
- Historical indicators include quantitative analyses of return on investment, patents granted, and biblio metrics, as well as qualitative assessments based on peer review.
- Measures are highly specific to the management and mission of each federal agency and no single indicator exists to measure the results of research (which are reinforcements of previous findings).

With this assessment in mind, the remainder of this paper addresses the early evolution of performance measures for science and technology within the Office of Environmental Management (EM) and the lessons learned from these efforts, reports on the metrics associated with these measures over time, and concludes with a detailed discussion of the four complementary measures that EM is in the process of implementing.

EM'S EARLY EFFORTS TO USE PERFORMANCE MEASURES FOR S&T

When EM was formed it was recognized that technology development would be needed to successfully complete the EM mission. The Office of Technology Development (OTD), currently known as the Office of Science and Technology (OST), was established to meet this need. Because cleanup baselines did not exist, EM's science and technology investments were focused on technology development activities in areas deemed appropriate by subject matter experts. This was a period of growth for both the EM program and OTD. The growth led to an OTD organization that was diverse and distributed. Investments went beyond technology development activities and included education, emergency management, transportation, and laboratory construction. Technology development activities were managed separately through over two dozen individual programs.

When Congress passed the Government Performance and Results Act, OTD was tracking a limited number of financial indicators, e.g., project and program cost and schedule variance, carryover, and milestone completion. While these indicators were solid tools for financial management and are still being used today, they did not meet the intent of GPRA. That is, they did not help drive the program to achieve specific goals, they were not effective in improving non-financial management processes, and they were limited to evaluating the effectiveness of financial management not the effectiveness of the science and technology investments.

In 1994, the need to focus the technology development efforts on the emerging EM baseline was recognized. To achieve this focus EM developed a new approach through the formation of Focus Areas and Site Technology Coordination Groups. The Focus Areas were established to provide a management approach to unifying EM's distributed technology development activities under a single umbrella and to focus the investments on the major cleanup areas identified by EM. It was during this period that EM held a two-day stand down to develop performance measures. Following this stand down, OTD established performance measures aimed at improving program management and evaluating investments. The following performance measures were adopted: the

number of bench-, pilot-, and full-scale demonstrations and the percentage of funding to the private sector.

Based on the maturity of EM, and the OTD program in particular, these performance measures were targeted at two specific objectives. The first objective was to force the research to move rapidly through specific demonstrations at increasing levels of development. By achieving this objective OTD would be able to have a solid basis for eliminating work that was not progressing and that tangible results of the investments would start to be made available. In 1994, there were a limited number of OTD-developed technologies being deployed; the maturity of the program was such that most work was still in the earlier stages of development. (OTD had been in existence for only four years.) As such, deployment would not have been a good performance measure at this stage in the program.

The second objective was to increase the rate of technology transfer and thus make technologies available earlier and in greater number. This was done by setting goals for a percentage of OTD funding to be provided to industry. By setting a goal of 50% of technology development funding provided to industry, it encouraged program managers to have the national laboratories and universities, who had typically been doing the work with limited industry involvement, to seek out and build partnerships with industry. The ultimate goal was to have a suite of commercial technologies available for direct purchase by the cleanup project managers.

In 1996, it was recognized that EM's site remediation and waste management efforts were going to extend well into the 21st century and that the Department needed a better scientific understanding of the complexity of the problem being addressed. With this in mind, EM changed OTD's name to the Office of Science and Technology (OST) and, as directed by Congress, established the EM Science Program. At the same time it was becoming apparent that too few of the technologies developed by OST were being deployed. The program had five solid years of investments and by that time the output of those investments should have been more visible. In an effort to accelerate the use of new technology, EM changed its performance measures for science and technology in 1997 to: the number of technology demonstrations and the number of technologies available for transfer. The number of technologies available for transfer was added to drive the availability of cost and performance data and to encourage program managers to move technologies from successful full-scale demonstrations to actual use. The percentage of funding to industry was dropped as a performance measure because it had been successful in accomplishing its goal of increasing the number of laboratory-industry partnerships.

EM ADVISORY BOARD GUIDELINES FOR EM S&T PERFORMANCE MEASURES

In 1997, EM commissioned the Environmental Management Advisory Board (EMAB) to assist in improving EM's performance measures for investments in science and technology. The EMAB Technology Development and Transfer Committee's findings were that performance measures for any solution-driven approach will require collaboration across EM and that measures jointly defined with end-users are essential for an effective science and technology program. The committee also stated that the performance measures for science and technology should:

- address key organizational objectives;
- be outcome versus process oriented;
- measure outcomes as trends over time, allowing use as management tools;
- use information that is directly understandable and applicable;
- assure measures are within the span of control of those accountable; and
- operate at a series of levels, reflecting appropriate operating levels.

ESTABLISHING DEPLOYMENT AS A CORPORATE MEASURE

With these recommendations in mind, EM developed the first corporate performance measure for science and technology: the number of new technology deployments. With seven years of operation, OST had become a mature program with hundreds of technologies ready for deployment and the EM baseline had clearly started to take shape. With the number of Records of Decision significantly increasing it was time to take additional action to drive the deployment of new technology. The Technology Acceleration Committee, a group of senior managers from Headquarters and the Field Offices formally approved the technology deployment measure in 1997 and established metrics to be used in Fiscal Year 1998.

The metrics for technology deployment were established by Field Office and were based on a combination of historical data and the amount of annual funding. The number of sites within a Field Office as well as the site's closure schedule were also considered. The overall metric for EM was roughly based on one new technology deployment per \$100 million. However, this was adjusted higher or lower by Headquarters based on Field Office input. Figure 1 illustrates the significant increase during the last three years in the deployment of new technologies that were developed by OST.

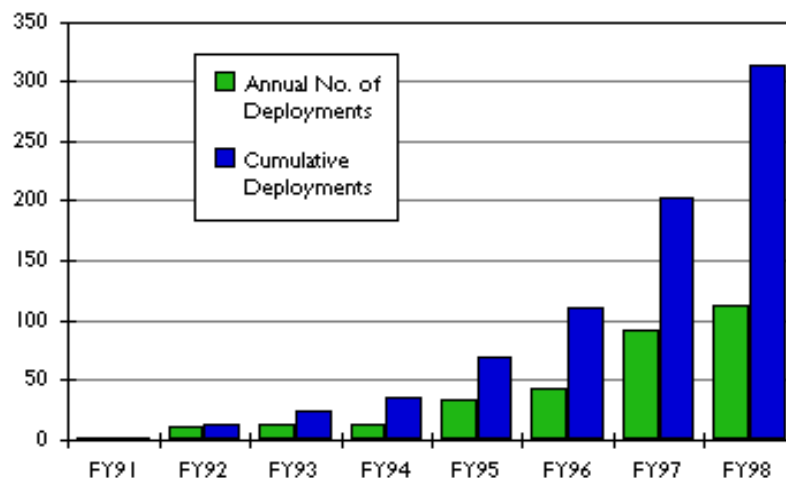


Fig. 1. Deployment of New Technologies FY91-FY98

There are a number of issues associated with using only the number of deployments as a performance measure. These issues include:

- The number of deployments is a simple output measure. It implies that all deployments are of equal value and that the value was something worth measuring. In fact, deployments vary greatly in terms of impact on EM cleanup.
- Under this approach there is no value attributable to the deployment of new scientific knowledge. That is, science and technology investments do not always result in pieces of hardware that can be counted. Often the scientific data or demonstration results allow the project manager to make a better and more informed decision.
- Several EM developed technologies, while not selected for actual cleanup, have served to increase competition and hence reduce cost to the taxpayer. Their value is not captured.
- A sizeable number of EM developed technologies are in use by the private sector at military installations and non-federal U.S. industrial sites. A small number are also in use in the countries of the former Soviet Union. These deployments are difficult to track but have resulted in a net benefit to the country.

EM exceeded its metric for deployment in Fiscal Year 1998. The target was 49 deployments of new technology and 122 were actually achieved. Each Field Office met its targets, and the majority exceeded their goals. The Savannah River Field Office reported the highest number of technology deployments at 39. The Richland Field Office was second at 24. The Oakland Field Office achieved the largest percentage over the goal with the target being one deployment and achieving eight.

The metric established for deployment of new technology in Fiscal Year 1999 is 60. Following receipt of data for Fiscal Year 1999, EM will reevaluate its basis for establishing the metrics associated with this performance measure.

EVOLUTION OF EM'S S&T PERFORMANCE MEASURES: 1998 TO 2000

In 1998, EM reviewed the Focus Area approach and decided it was the correct management approach but that it needed to be both strengthened and better integrated with the cleanup projects. The Focus Area -centered approach places full responsibility for all investments, science through deployment, under the management of the Focus Areas. However, along with this additional responsibility are requirements that the Focus Areas make the cleanup project managers an integral part of the Focus Area's management and obtain their approval of all projects. As such, integrating the science, technology, and deployment activities with the cleanup projects is the next step to creating a seamless program that provides solutions needed to complete the EM cleanup mission.

Four Complementary Corporate Performance Measures for EM's S&T Investments

A set of four performance measures was approved in Fiscal Year 1999 for use starting in Fiscal Year 2000. Note that because the development of metrics has not been completed, these performance measures, with the exception of deployment, are not included in EM's Fiscal Year 2000 budget. The measures were developed to: (1) evaluate the impact of EM's investments in science and technology and (2) determine how effectively EM's project managers use both the advances in science and the availability of new technology to execute their projects. These measures are illustrated in Figure 2 and outlined below:

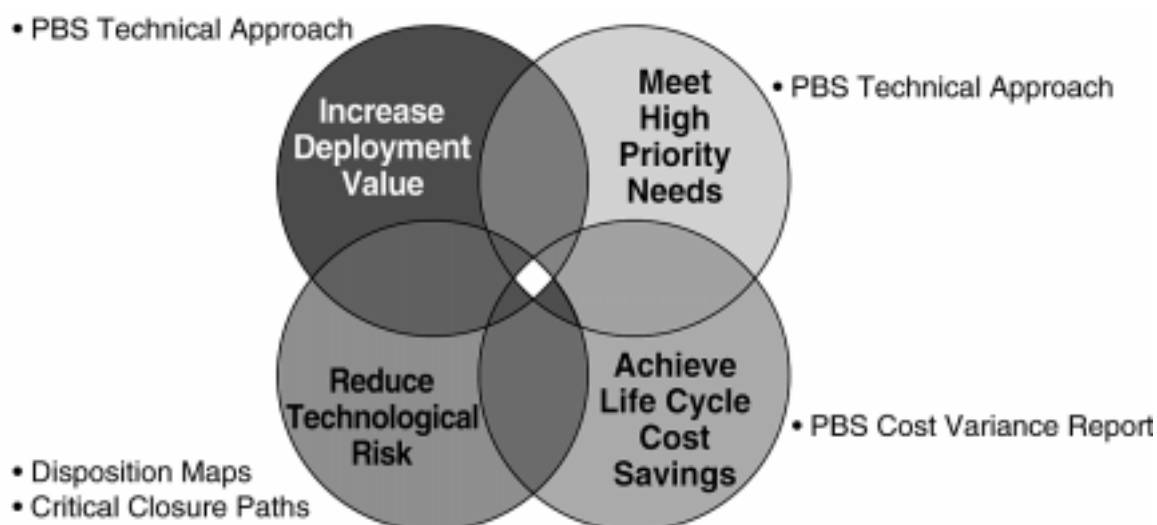


Fig. 2. Corporate Performance Measures

- the number of technology deployments and, more importantly, a quantitative or qualitative discussion of the value or impact of the deployment;
- the number of high priority site needs being addressed by S&T investments and the successful elimination of those needs in time to meet site schedule requirements;
- reduction in the programmatic risk (technological risk in particular) associated with the site's critical closure paths and the management of contaminated media, waste streams, and materials identified in the site disposition maps; and
- reduction in the cost of cleanup resulting from EM's S&T investments as identified through changes in the Project Baseline Summary life-cycle cost variance analysis. These are the S&T based contributions to achieving progress towards accelerated cleanup goals.

IMPLEMENTATION OF EM'S PERFORMANCE MEASURES FOR S&T

The four complementary measures being proposed meet the EMAB recommendations in that they are user-owned and determined, are outcome-oriented, can be tracked over time, and relate directly to cleanup. User-owned was a key element in the development of the performance

measures and will be key in their implementation and reporting. To meet this EMAB recommendation we needed a set of corporate measures, not OST measures, that were reported by the Field Offices, through the project structure EM is currently using to manage and plan cleanup activities.

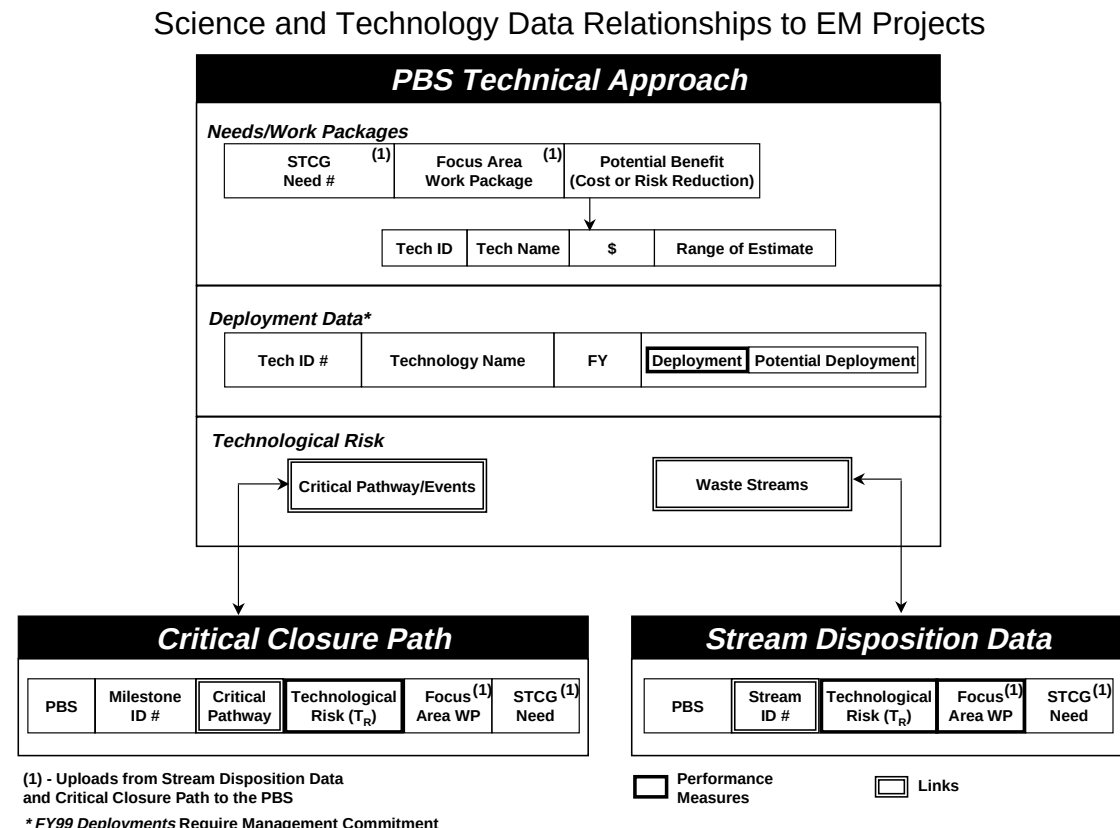


Fig. 3. Performance Measure Reporting Mechanism

The data associated with the four performance measures is collected through the *Paths to Closure* process within the construct of EM's Integrated Budget Accounting and Planning System. The mechanisms for reporting three of these measures is illustrated in Figure 3. Life-cycle cost savings is reported through the Project Baseline Summary Cost Variance Analysis Report which is described later in this paper.

The performance measures are outcome oriented and relate directly to the cleanup. That is, they report the solution to needs, the reduction in risk, and the achievement of cost savings that EM needs to meet site closure goals. These measures will be tracked on an annual basis with the site submittals of *Paths to Closure* data and are not expected to change at a rate that warrants more frequent review. Given that the new measures meet the EMAB recommendations, it is important to understand how EM is implementing and will implement these measures.

Measuring the effectiveness of the investments in terms of deployment

EM started to track both the deployment of new technologies and the value of those deployments in 1997. OST made a concerted effort to capture deployments prior to 1997 as well, but this data was difficult to capture due to changes in personnel, varying definitions of deployment, and poor historical data. While individual deployments in past years (pre 1997), may be suspect the trend illustrated in a previous figure is definitely on the rise. EM established technology deployment as a corporate measure in 1998, asked the sites to review and comment on the data, and is currently improving the process for collecting, analyzing, and validating this data. EM is also working on better ways to capture the value and/or impact of deployments through qualitative descriptions rather than relying on simply the number of deployments.

Using site needs to target investments and evaluate the results

Science and technology needs have been available from the sites for four years; each year these needs statements have improved in quality. In 1999 we will baseline the needs as they relate to the cleanup activities and the current S&T investments. For the first time, we will have comprehensively integrated the cleanup projects with specific needs and Focus Area work packages. That is, we will have a good understanding of the relationship between the 350+ cleanup projects, the 500+ site needs, and the 40+ Focus Area work packages or investments. This relationship serves as the baseline from which to measure progress. Focus Area efforts to meet or address EM's highest priority needs will be evaluated starting in 1999. Progress toward elimination of those needs will be measured starting in 2000. This data is reported by the cleanup project managers through the Project Baseline Summary structure established in *Paths to Closure*.

Making the reduction of programmatic risk a priority for successful investing

EM conducted an initial baseline of programmatic risk in 1998. This was done through two methods: the pathways and events associated with the site critical closure paths and the contaminated media, waste streams, and materials identified in the disposition maps. In 1999, we will baseline how EM's investments in S&T correlate to those risk levels. In a manner similar to the site needs, as described above, we are mapping specific Focus Area work packages or investments, to specific critical pathways and events and particular streams on the disposition maps. This relationship between those elements and the risks associated with the elements provide us with our starting point or baseline from which to measure the effectiveness of the S&T investments. That is, are our investments reducing programmatic risk and is the programmatic risk being reduced in those areas that are most important to the cleanup effort. This measure is also extremely effective in helping OST to target the investments; we now know the critical path and how we relate to it and by waste stream which problems we are trying to solve. In 2000, we will be able to start to measure changes in the risk levels, for pathways, events, and disposition maps, that are due to S&T investments.

Improved focus on the highest cost projects and documentation of the resulting savings

In 1998 EM's cleanup projects were baselined and accelerated cleanup goals were established. However, systematic tracking of S&T based cost savings relies on EM's ability to document detailed, project-level progress towards accelerated cleanup goals. The Fiscal Year 1999 *Paths to Closure* guidance starts to do exactly that. This year through a Project Baseline Summary Cost

Variance Analysis Report we are requesting each of the projects to identify changes in projected life-cycle cost. This analysis looks at the life-cycle cost from the previous year and provides an explanation of whether the life-cycle cost for the project has gone up or down and why. One of the reasons for the decrease in life-cycle cost is the application of science and technology to change or improve the technical approach to the cleanup activity. Initial life-cycle cost savings information will be available in April 1999. Using this data, life-cycle cost calculations, and estimated S&T costs, we will be able to set metrics for targets starting in 2000. This data will be reported annually through the Project Baseline Summary structure.

In 2000, EM will be able to measure progress towards the four measures proposed in 1999. In addition to the financial and program indicators previously discussed OST will continue to use the performance measures established in 1997, as well as those approved for use in 1999, to evaluate its investments and impacts.

CONSIDERATIONS FOR METRICS DEVELOPMENT

While the EMAB identified the critical attributes of successful performance measures, they did not outline the process for developing those measures nor the metrics associated with them. We believe we have the right measures in terms of driving the program to achieve certain goals, but have had difficulty in establishing the right metrics. When implementing a new set of measures the availability of solid baseline data is critical to setting realistic but challenging metrics. The corporate measures we are implementing are based on data that was first available, in any form, in January 1998. The data will be available in a more useable form in April 1999. Metrics development is a challenging task as is evident from our early efforts to pick a corporate level metric for deployment. We are considering the following factors in the development of metrics:

- numerical goals versus percentage goals to drive and evaluate performance;
- use of complete data sets or subsets of the data, e.g., technological risk of all the waste streams or just the high risk waste streams;
- annual goals versus life-cycle goals, e.g., should we analyze historical cost savings only or life-cycle cost savings; and,
- data collection methods available through *Paths to Closure*.

We believe these corporate measures are sound in terms of focusing the program and as tools for improved management. However, to allow proper analysis, that is, to successfully acquire the data for the measures and conduct evaluate performance, the metrics must be correctly crafted. This is a challenging task that we are still working on and each of these factors must be taken into consideration as we develop the specific metrics.

STATISTICAL VIEW OF EM'S S&T PERFORMANCE MEASURES: CURRENT, AND FUTURE

The majority of this paper has focused on the types of measures, why they were developed, and how they have evolved over time as an important management tool. The next two sections of the paper address the metrics themselves and highlight some of the current and future outcomes of these measures in quantifiable terms.

Table I provides the metrics for the three performance measures currently associated with EM's investments in science and technology: number of demonstrations, number of technologies available for transfer, and number of technology deployments. EM has usually exceeded the metric associated with demonstrations. This metric, typically established a year or more in advance, is based on several factors. These factors include: the level of actual funding, the availability of personnel and equipment, the availability of certain test beds and access to cleanup sites and facilities, and the rate of developmental progress achieved on a given project.

Table I. Current Performance Measure Metrics

	Demonstrations		Available for Transfer		Deployments	
	Planned	Actual	Planned	Actual	Planned	Actual
FY97	20	56	40	51	—	—
FY98	35	40	40	42	49	122

EM has struggled to meet the metric associated with making technologies available for transfer. In 1998, to improve the consistency of reporting on technologies available for transfer, EM decided that an Innovative Technology Summary Report would be required for each technology made available. These reports are also highly dependent on the factors outlined for the number of demonstrations.

The third metric, associated with deployment, has only been reported as a corporate measure for 1998. The deployment metric can be impacted by a large number of external forces including: regulatory acceptance, stakeholder acceptance, changes in site priorities, vendor availability, changes in contracting strategies, and changes in the management contractor at the site, to name a few. These forces have very little to do with OST as a funding agency and hence deployment is a corporate measure reported by the Field Offices. Trends associated with these metrics are discussed in the next section of this paper.

SHIFT IN INVESTMENT STRATEGY IS REFLECTED IN THE METRICS TREND ANALYSIS

EM's vision of accelerated site cleanup is described in *Paths to Closure*. The emphasis is on accelerating schedules, wherever possible, to get the vast majority of sites closed prior to 2006. Supporting this vision required a change in the way EM managed its science and technology investments. In the past, EM had focused investments primarily in the applied research through engineering development sections of the R&D spectrum. As noted earlier, there was a conscious

shift in 1996-98 to add science and deployment as key components of the investment strategy. With the release of *Paths to Closure* in June 1998, EM took additional steps to strengthen its investments at the ends of the R&D spectrum, i.e., continued investments in science and additional investments to increase the deployment of new technology. That investment strategy is shown in Figure 4.

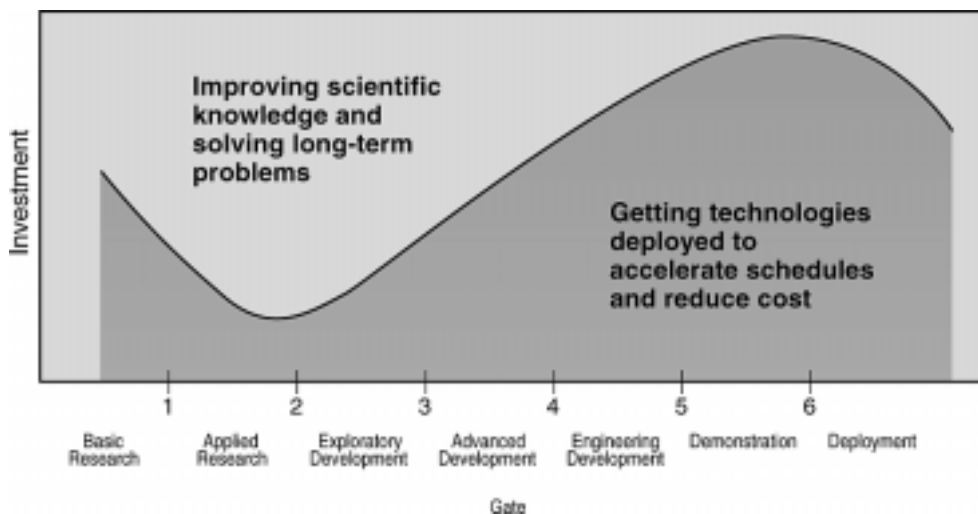


Fig.4. EM Investment Strategy

This shift in emphasis from technology development to a broader investment strategy is reflected in the changes to the metrics associated with the current measures. The changing investment strategy has reduced funding for applied research through engineering development and increased funding for deployment. These funding changes are driving down the metrics for the number of demonstrations and the number of technologies available for transfer, while increasing the expectations associated with deployment. It must be noted that these changes do not occur immediately and are not due simply to changes in performance measures. They are also impacted by past investment strategies, the overall funding level for the program, and the point we are currently at within the cleanup effort. The current investment strategy can only be used for two or three years. At that point the pipeline of technologies will be on the verge of depletion and we must start preparing the second wave of technologies for cleanup needed post 2006.

CONCLUSIONS

EM's performance measures associated with science and technology investments have evolved with the EM program and improvements in our understanding of how to most effectively use performance measures to achieve program goals. We have used performance measures to improve the efficiency of the technology development process, to increase our industry partnerships, and to accelerate the deployment of new technologies. Our new corporate measures are sound, balanced, complement each other, meet the EMAB recommendations, and are reported by our customers through *Paths to Closure*. They provide a broader base, than simply the number of deployments, to evaluate our investments and we have started the implementation process necessary to ensure their future use.

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