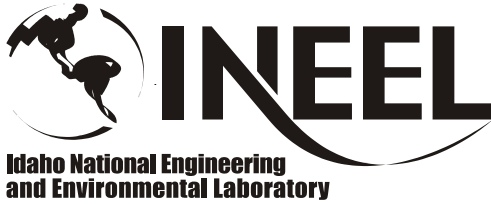


INEEL/CON-03-00538
PREPRINT



**Strategic Program Planning Lessons Learned In
Developing The Long-Term Stewardship
Science and Technology Roadmap**

**B. Dixon
D. Hanson
G. Matthern**

July 20, 2003 – July 24, 2003

**Portland International Conference on
Management of Engineering and Technology**

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint should not be cited or reproduced without permission of the author.

This document was prepared as a account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights. The views expressed in this paper are not necessarily those of the U.S. Government or the sponsoring agency.

Strategic Program Planning Lessons Learned In Developing The Long-Term Stewardship Science and Technology Roadmap

Brent Dixon, Duane Hanson, Gretchen Matthern
Idaho National Engineering & Environmental Laboratory (INEEL)
2525 Fremont Ave. Idaho Falls, ID 83415

Abstract

Technology roadmapping is a strategic planning method used by companies to identify and plan the development of technologies necessary for new products. The U.S. Department of Energy's Office of Environmental Management has used this same method to refine requirements and identify knowledge and tools needed for completion of defined missions.

This paper describes the process of applying roadmapping to clarify mission requirements and identify enhancing technologies for the Long-Term Stewardship (LTS) of polluted sites after site cleanup has been completed. The nature of some contamination problems is such that full cleanup is not achievable with current technologies and some residual hazards remain. LTS maintains engineered contaminant barriers and land use restriction controls, and monitors residual contaminants until they no longer pose a risk to the public or the environment. Roadmapping was used to clarify the breadth of the LTS mission, to identify capability enhancements needed to improve mission effectiveness and efficiency, and to chart out the research and development efforts to provide those enhancements.

This paper is a case study of the application of roadmapping for program planning and technical risk management. Differences between the planned and actual application of the roadmapping process are presented along with lessons learned. Both the process used and lessons learned should be of interest for anyone contemplating a similar technology based planning effort.

1. INTRODUCTION

A major mission of the U.S. Department of Energy (DOE) is the disposition of legacy waste and cleanup of contaminated sites resulting from over 40 years of nuclear research and weapons production. DOE defines long-term stewardship (LTS) as "the physical controls, institutions, information, and other mechanisms needed to ensure protection of people and the environment at sites where DOE has completed or plans to complete 'cleanup' (e.g., landfill closures, remedial actions, removal actions, and facility stabilization). This concept of long-term stewardship includes, [among other things], land-use controls, monitoring, maintenance, and information management" [DOE 2001a, Vol. I, p. 1]. According to its latest published estimate, DOE will be responsible for LTS at approximately 129 sites [DOE 20001b]. The residual hazards at some of those sites—notably those from radioactive materials and toxic metals—will remain as potential threats to health and the environment for tens to thousands of years. This means that LTS must continue long after the current plans for site cleanup or closure are completed.

Science and Technology (S&T) has a critical LTS role in that DOE needs knowledge (science) and tools (technology) beyond what it already has to ensure that planning and

implementation will result in efficient and effective LTS for decades into the future. In general, this means moving the LTS state-of-the-art in S&T into the state-of-the-practice at DOE sites. Site stewards also need better information and resources to work more effectively with regulators, stakeholders, and others that influence decisions in exploring whether a new approach may work better than an accepted, or even prescribed, technology.

Science and technology roadmapping is a disciplined analysis, solution development and decision-making methodology that supports strategic, programmatic, and/or project planning. Roadmapping organizes and focuses technology planning for a specific mission, culminating in an integrated path forward (the roadmap) designed to provide needed capabilities consistent with the mission schedule. The roadmapping effort identifies what research and development to do, when to do it, and why it needs to be done.

Application of roadmapping within the DOE cleanup program requires significant flexibility to accommodate the variations between different projects and programs and the different levels of roadmapping application. Program-level roadmaps are generally used to develop a shared vision of the future and direction on how to prepare for that future. Thus a program-level roadmap is less about how to accomplish a mission and more about how to define the mission.

A program level Long-Term Stewardship Science and Technology Roadmap was recently developed for the DOE. This Roadmap was developed to clarify the LTS mission and to identify the knowledge and technologies needed to effectively and efficiently accomplish that mission.

An important consideration in the development of the LTS roadmap was the inclusion of a number of people from outside the DOE. General roadmapping guidance encourages the inclusion of a number of points of view to help ensure comprehensive coverage of the topic area. This was one reason for the inclusion of outside experts. The other reason was that other federal and state agencies also have stewardship responsibilities and it was hoped that working together on the roadmap would transition into working together on its implementation.

This paper describes the design considerations and process used to develop the LTS S&T roadmap and the lessons learned in each stage of development. LTS roadmap lessons learned have broad application because LTS affects many interest groups (government agencies, regulators, local communities, broad stakeholders, etc.) and LTS requires the integration of a wide range of scientific disciplines to be successfully planned, implemented and completed. In addition to the specific value to people involved with stewardship, both the process and the lessons learned in application of the roadmapping process have generic value for anyone contemplating a similar strategic planning effort.

2. LTS ROADMAP OVERVIEW

The LTS S&T Roadmap [DOE 2002] has been developed to aid DOE in identifying and cost effectively implementing knowledge and tools at DOE LTS sites. The Roadmap recommends research and development (R&D) pathways to provide a system of integrated capabilities needed for DOE to influence LTS policy and best manage investments to implement an effective LTS program. The areas of R&D covered in this roadmap offer possibilities to realize significant performance improvements and cost savings in the near term (within the next 2 to 10 years). For

purposes of developing the Roadmap, this effort targeted the FY 2003–FY 2008 planning cycles, with some recommended pathways extending to FY-2012.

The Roadmap was compiled by an interdisciplinary team of subject matter experts from industry, academia, federal and state regulators, stakeholder groups, DOE national laboratories, DOE site contractors (end users), and other federal agencies. This Roadmap team was directed to concentrate its efforts on meeting immediate LTS needs by (1) identifying gaps in existing LTS capabilities; (2) seeking near-term opportunities to perform essential LTS functions at lower risk to human health and the environment, at lower cost (especially at lower life-cycle cost), or with less technical uncertainty; and (3) applying the results of research or transferring promising technology possibilities into implementable systems for LTS sites.

Long-term stewardship of a site with residual contamination must be viewed as a system made up of many interrelated and interacting components and activities. The essential functions this system must perform are to **contain** the residual contaminants, **monitor** the site and the entire LTS system, **communicate** within and beyond the LTS system, and **manage** the system. By applying this system perspective, the Roadmap team identified seven capabilities essential to fulfilling these four functions:

- Key Capability 1.Site Conceptualization and Modeling Tools
- Key Capability 2.Contamination Containment and Control Systems
- Key Capability 3.Sensors and Sensor Systems for Site Monitoring
- Key Capability 4.Preservation and Communication of Site Information
- Key Capability 5.Site–Community Relations
- Key Capability 6.LTS System Performance Verification and Monitoring
- Key Capability 7.Effective and Survivable Land-Use Controls.

Under each key capability, the team listed one or more enhancements with associated near-term R&D targets that, if achieved, would address deficiencies in existing LTS capabilities or substantially improve a capability to reduce risk, cost, or uncertainty (see Table 1). The 23 capability enhancements and 28 associated R&D targets identified in the Roadmap will focus LTS S&T efforts and provide an LTS system that is resilient to human and natural forces, effective in protecting human and environmental health, and efficient in its use of national and local resources.

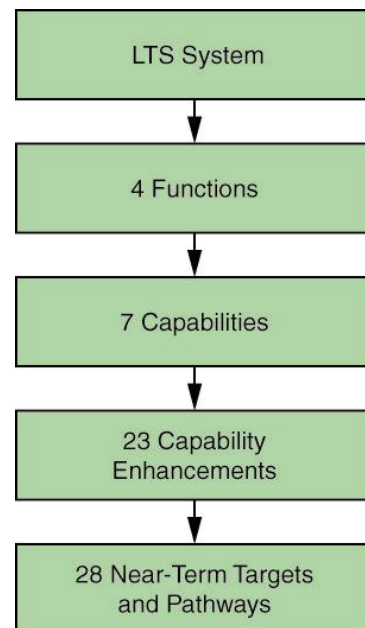


Table 1 - LTS Roadmap Capabilities and Enhancements

CONTAIN Residual Contaminants

Key Capability 1. Site Conceptualization and Modeling Tools

- Enhancement 1.1 Improve geologic-hydrologic-biological-chemical-thermal conceptual modeling for long-term forecasting
- Enhancement 1.2 Provide tools for long-term forecasting of environmental conditions relevant to predicted end states
- Enhancement 1.3 Provide tools for modeling the community at risk
- Enhancement 1.4 Conceptualize and predict containment/control system performance, including potential failure modes and levels of failure

Key Capability 2. Contamination Containment and Control Systems

- Enhancement 2.1 Engineer the geologic-hydrologic-biological-chemical-thermal environment to limit contaminant toxicity and mobility
- Enhancement 2.2 Design, build, and operate alternative (next-generation) containment and control systems

MONITOR the Site and the LTS System

Key Capability 3. Sensors and Sensor Systems for Site Monitoring

- Enhancement 3.1 Identify contaminant monitoring needs for all media of potential transport or exposure and fill sensor technology gaps where monitoring solutions are needed
- Enhancement 3.2 Establish site-specific parameters for environmental exposure routes and for both occupational (on-site) and non-occupational (community at risk) human routes of exposure
- Enhancement 3.3 Improve sensors and sensor systems for monitoring active and passive safety systems

COMMUNICATE Within and Beyond the LTS System

Key Capability 4. Preservation and Communication of Site Information

- Enhancement 4.1 Provide components for an integrated information visualization and display system
- Enhancement 4.2 Provide an information system module for communicating system performance data
- Enhancement 4.3 Provide options for intergenerational information archiving

Key Capability 5. Site-Community Relations

- Enhancement 5.1 Improve understanding of what affects public trust and confidence
- Enhancement 5.2 Involve the community in the conduct of site stewardship
- Enhancement 5.3 Identify and solve problems that can undermine reliability and constancy in LTS institutions

MANAGE the LTS System

Key Capability 6. LTS System Performance Verification and Monitoring

- Enhancement 6.1 Provide techniques and technologies to improve planning, design, implementation, and decision-support capabilities of Contamination Containment and Control systems and their associated monitoring systems
- Enhancement 6.2 Improve tools to verify performance of contamination containment and control and monitoring subsystems
- Enhancement 6.3 Provide tools to verify and monitor the overall (technical and non-technical) performance of the LTS system
- Enhancement 6.4 Integrate preventive maintenance requirements into site subsystems
- Enhancement 6.5 Improve tools for collecting, analyzing, evaluating, and disseminating performance data
- Enhancement 6.6 Develop science to ensure continuous improvement in stewardship implementation

Key Capability 7. Effective and Survivable Land-Use Controls

- Enhancement 7.1 Develop legal pathway modules to help identify potential legal strategies, assess established agreements, and develop draft alternative legal instruments
- Enhancement 7.2 Provide intergenerational archive options for maintaining land-use control information.

3. ROADMAP ORGANIZATION AND DEVELOPMENT

The Roadmap focused on near-term compliance improvements that would not alter currently established DOE closure end-states. Follow-on roadmaps will expand the horizon past 2012, integrate S&T initiatives by other federal agencies, incorporate technologies that could result in improved remediation designs, and coordinate S&T initiatives identified in the Vadose Zone S&T Roadmap [DOE 2001c].

A collaborative, multi-step approach was implemented for developing the LTS S&T Roadmap to integrate DOE's current end-state operational plans, S&T needs, and ongoing R&D. The process consisted of four major tasks: Roadmap Initiation, Technical Needs Assessment, Roadmap Development, and Roadmap Review and Implementation.

Roadmap Initiation Task

The Roadmap Initiation task focused on preparation for Roadmap development and included obtaining agreement on the Roadmap's scope, team structure, participants (including stakeholders), and deliverables. Figure 1 outlines the Roadmap Initiation process and planned timing. Actual timing of process steps changed due to external events discussed later under roadmap initiation lessons learned.

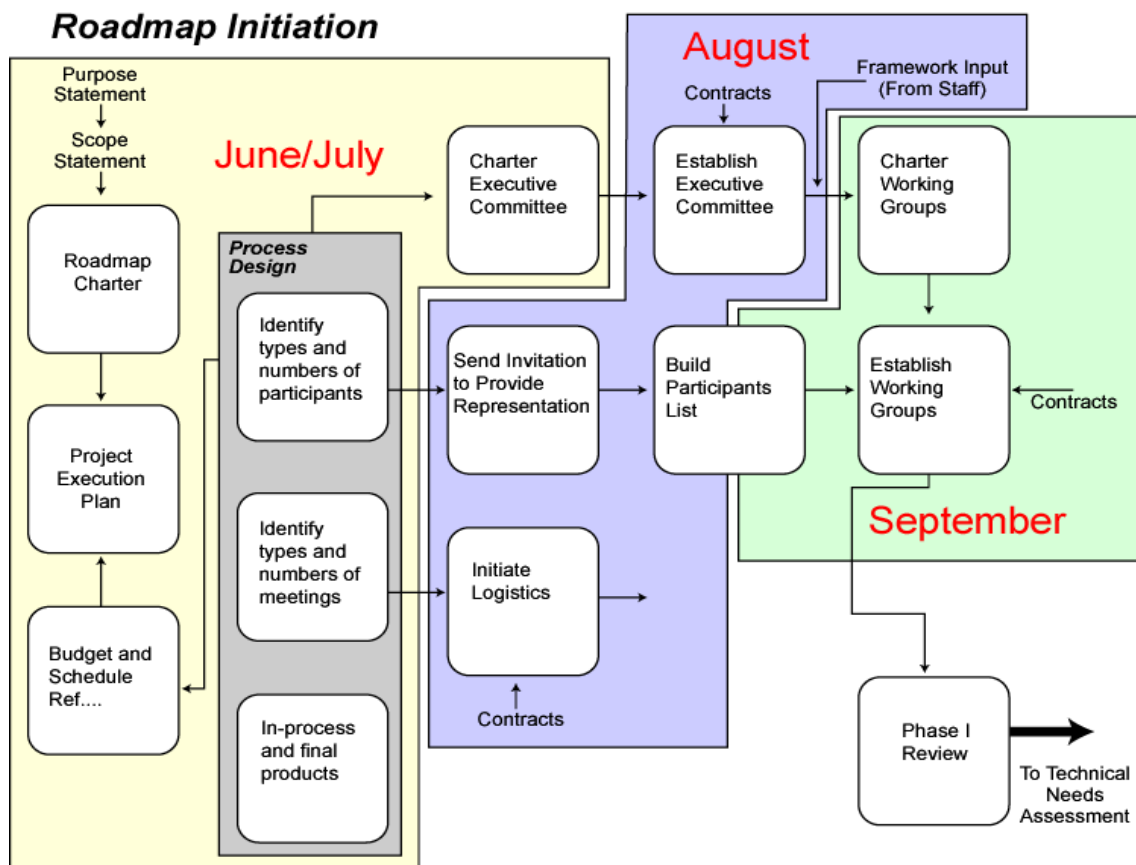
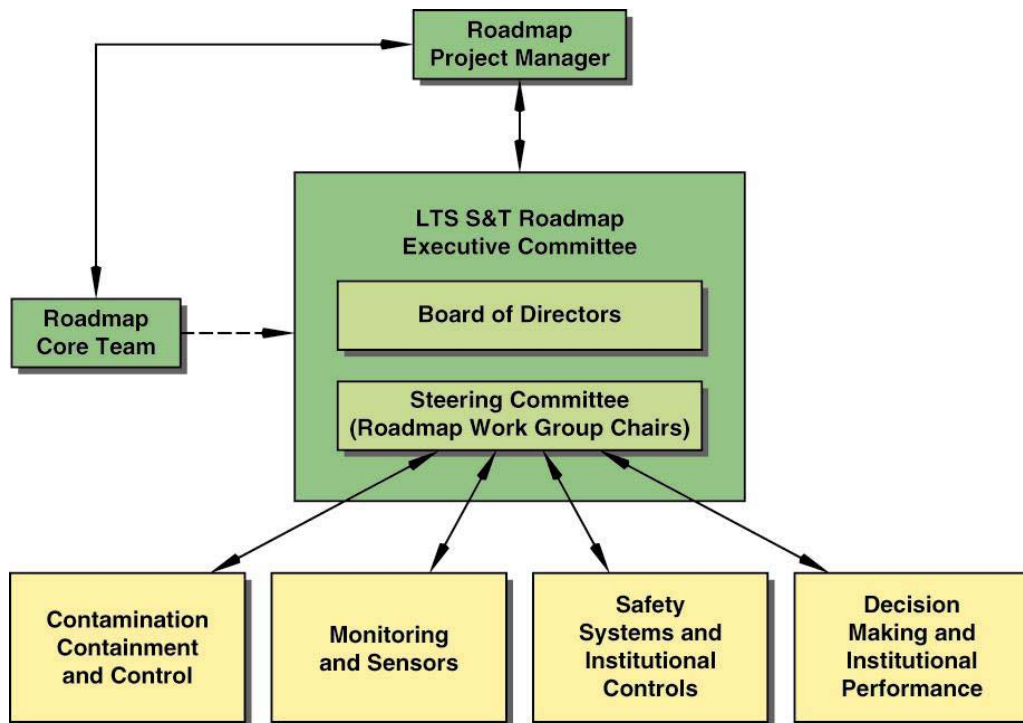


Figure 1 - Roadmap Initiation Process and Timing

Specific elements key to the success of the Roadmap Project include the team structure and composition (including the Roadmap Executive Committee and Workgroups), as well as the workshops necessary to develop a sound S&T investment strategy for the DOE.

Team Structure

Based on the objectives of the Roadmap, EM draft roadmapping guidance, and lessons learned from previous roadmapping efforts, a team structure was established to promote the broad participation and collaboration of interested and affected parties. The Roadmap Executive Committee (Figure 2) was delegated leadership of the Roadmap effort as defined and bounded by DOE. A Roadmap Core Team, composed of INEEL staff reporting to the Roadmap Manager, supported the Roadmap Executive Committee. Roadmap Workgroups were responsible for investigating various S&T issues associated with the Roadmap and for developing the Roadmap text for their respective topical area.



02-GA50660-11

Figure 2 - Organization of LTS Roadmap Teams

Roadmap Project Manager

The Roadmap Project Manager was responsible for the quality of the Roadmap products and for delivery of the Roadmap to DOE. As such, the Roadmap Project Manager reviewed the technical, administrative, managerial, and budgetary targets of the roadmapping effort and took appropriate actions to ensure progress toward achieving them. The Roadmap Project Manager and the Roadmap Executive Committee provided a communication channel with DOE and INEEL management, regulators, site contractors, and other stakeholders.

Roadmap Executive Committee

The Roadmap Executive Committee was delegated leadership of the Roadmap effort as defined and bounded by DOE. DOE defined the primary topic - science and technology for long term stewardship, the time frame – short term needs of 2 – 10 years, and the primary beneficiary – DOE sites scheduled to close within 8 years. The Roadmap Executive Committee was composed of a Board of Directors and a Steering Committee of Roadmap Workgroup Chairs, as described below.

Roadmap Board of Directors

The Board of Directors directed the roadmapping process, defined the overall technical scope of the roadmapping effort based on collaboration from the Roadmap Manager, and ensured that the Roadmap Workgroups covered all technical topics required for an integrated roadmap. The Board of Directors reviewed participants selected by the Steering Committee and provided suggestions to ensure that overall work group membership reflected the broad perspectives that needed to be incorporated in this effort. The Board of Directors reviewed and commented on the major S&T objectives identified by the Roadmap Workgroups through interaction with participants during and between Roadmap meetings and workshops.

The Board of Directors was chaired by the President of the BWXT Savannah River Company, having relevant DOE site and end-user experience. The remaining directors included a site contractor operations manager, recognized S&T R&D specialists, a recognized scientist from academia, a national Environmental Protection Agency manager, a representative of the Department of Defense, and a representative from a stakeholder organization. Other members included the Chief Scientist and Assistant Manager for R&D at DOE Idaho Operations Office and the INEEL Roadmap Project Manager, who served as liaisons between the Roadmap Executive Committee and the DOE LTS Program Management and INEEL LTS Program, respectively.

Roadmap Steering Committee

The Steering Committee managed the Roadmap development process and ensured that schedules were met and issues resolved that arose within and between the Roadmap Workgroups. The Steering Committee was composed of the Chairs of the Roadmap Workgroups. The Chair of each Roadmap Workgroup was a recognized authority in a respective S&T topical area with experience in the application of R&D to cleanup issues.

Roadmap Workgroups

The Roadmap Workgroups defined the overall technical scope of the roadmapping effort for their respective S&T topical areas. The Roadmap Workgroups drafted the major technical objectives for the Roadmap, refined objectives through interaction with the other Roadmap Workgroups, and coordinated with other Roadmap Workgroups to ensure a coherent, consistent, and reasonable Roadmap for this phase of the effort. Roadmap Workgroups were comprised of end-users from DOE field contractor organizations and industry; S&T developers from DOE national laboratories, industry, and academia; national and state regulatory agencies; and national and site stakeholder groups.

Lessons Learned During Roadmap Initiation

While the process and timing outlined in Figure 1 was followed as closely as possible, the “as built” was somewhat different. Some of these differences were due to external events, such as the terrorist attacks in September 2001, which impacted travel to meetings. However, most of the differences were due to internal events that form the basis for the following lessons learned.

Filling Team Leadership Positions Requires Substantial Time. An important lesson learned is the higher the level of the desired leadership candidate; the higher the level of approval required for their participation and the longer the lead-time. Identification of the executive committee members was initiated before identification of the working group members, but the working groups were finalized before the executive committee. The last person on board was the executive committee chairman, due primarily to the high level of reviews and approvals needed. Thus the order of finalization of roadmap participants was backward from what was intended.

Extensive Expert Participation Stretches Schedules. The level and numbers of experts required for a programmatic level roadmap can result in significant scheduling problems. Nationally known experts are busy, and can't easily change their schedules even months in advance. Initial scheduling of meetings was not too difficult, but there was very little flexibility to adjust the schedules based on new information or a timing change. While the LTS roadmap needed to adjust schedules for the external event of 9/11, many roadmap processes can identify the need for additional meetings, etc. The LTS roadmap added one meeting toward the end of the process to help finalize the roadmap report; fortunately that meeting involved only a subset of the experts and did not extend the schedule.

Roadmapping Must Be A Collaborative Process. To achieve full collaboration and a balanced product, a roadmap should strive for the full spectrum of perspectives of the topical area. Involving a diverse group in a programmatic roadmap broadens perspectives, expands the extent of the shared vision, and more clearly defines the future. This was achieved in the LTS roadmap by designing participation to include all important stakeholder groups. Previous DOE roadmaps had included both developers and users of technology. The LTS roadmap extended this concept to also include federal and state regulators, other agencies, and a tribal representative. The results were very positive, with the representatives of these additional perspectives turning out to be not just appreciative of their inclusion but also strong participants and some of the strongest proponents of the results.

Roadmap Teams Must Be Structured To Cover Required Technical Scope. Structuring the groups to cover the desired roadmap technical areas can be difficult. Budgetary constraints and insufficient understanding of team capabilities can limit the breadth of technical areas covered. Eleven different technical areas were originally identified for inclusion in the roadmap based on review of other stewardship documents. The roadmap budget limited the number of working groups to four, requiring grouping of the eleven areas. The twin objectives of broad technical coverage and broad organizational representation had to be balanced, and some technical areas ended up with less coverage than others. This problem was mitigated somewhat by the involvement of highly experienced people in the roadmap teams. However, in hindsight, the LTS roadmap did not provide as much detail on, information technologies as that area warranted.

Seek Diversity In The Background of Experts To Balances The Product. The method used to identify individual participants was observed to affect team results. The roadmap organizers identified the desired composition for each group, while the work group chairs were given significant latitude to identify and recruit the individual members. Per human nature, the chairs tended to identify people they worked with successfully in the past. This allowed the groups to form more quickly, which was helpful with our compressed schedule and limited budget, but this approach could limit the range of perspectives available to a team. The work group teams for this roadmap accepted the responsibility to reach out to additional resources when needed. The overall diversity across the work groups was good, but all of the desired perspectives were not covered in every team. This may have contributed to the variation in emphasis on individual aspects of the roadmapping process observed across the work groups. In contrast, the executive committee was both designed and populated according to initial guidelines. This committee took longer to function as a team but exhibited good balance in their discussions and products.

Roadmap Leaders Need Strong Technical and Administrative Support. While roadmap participants are key to a successful effort, so is a strong support staff. The staff performs most of the organizational efforts, usually behind the scenes. One key “support” position that evolved during the LTS roadmap provided direct assistance to the executive committee chair. The executive chair position turned out to be more than a full time job but, as president of a large company, the chairman had only a limited amount of time to devote to this effort. A member of the roadmap core team became a de facto chief of staff for the chairman, helping to keep people on task and schedule and facilitating integration efforts. Future roadmaps should include this position explicitly in their organizational structure.

Technical Needs Assessment Task

The Technical Needs Assessment task assessed the technical capabilities needed to achieve LTS Program goals and objectives and was a critical part of the roadmapping effort. Initial needs were based on two reports - the end-state driven technologies identified as part of a Technology Profile of current DOE LTS related S&T investments for FY 2001 [INEEL 2001a] and a Technical Baseline [INEEL 2001b] of information compiled from many DOE sites. These reports were provided to all participants for review. Representatives from LTS operations were also part of the Roadmap team, briefed the Roadmap team, and reviewed the Roadmap drafts.

This task included a structured, systematic approach to identify technical issues and LTS Program functions, assess those issues and functions to identify capability and usage gaps (i.e., areas where S&T is needed to address technical issues and satisfy program functions), and establish associated program goals for S&T. The Roadmap Executive Committee directed the efforts of several workgroups in accomplishing this task (see Figure 2). A needs workshop was held to (1) define technical and programmatic needs and functions as a result of anticipated end-states and available technologies defined in the LTS Technical Baseline and Technology Profile reports, respectively, and (2) finalize objectives for the Roadmap. The workshop involved all four working groups in both separate and joint sessions. The workshop included participants from regulatory agencies; state, and tribal governments; other stakeholder groups; multiple DOE sites and laboratories; other government agencies; academia; and industry. The workshops transformed issues and concerns from the participants into programmatic and technical S&T requirements.

This task was completed when a consensus was reached by the Roadmap Executive Committee on the programmatic and technical needs and the overall direction for the Roadmap. Figure 3 displays the overall Technical Needs Assessment process and planned timing.

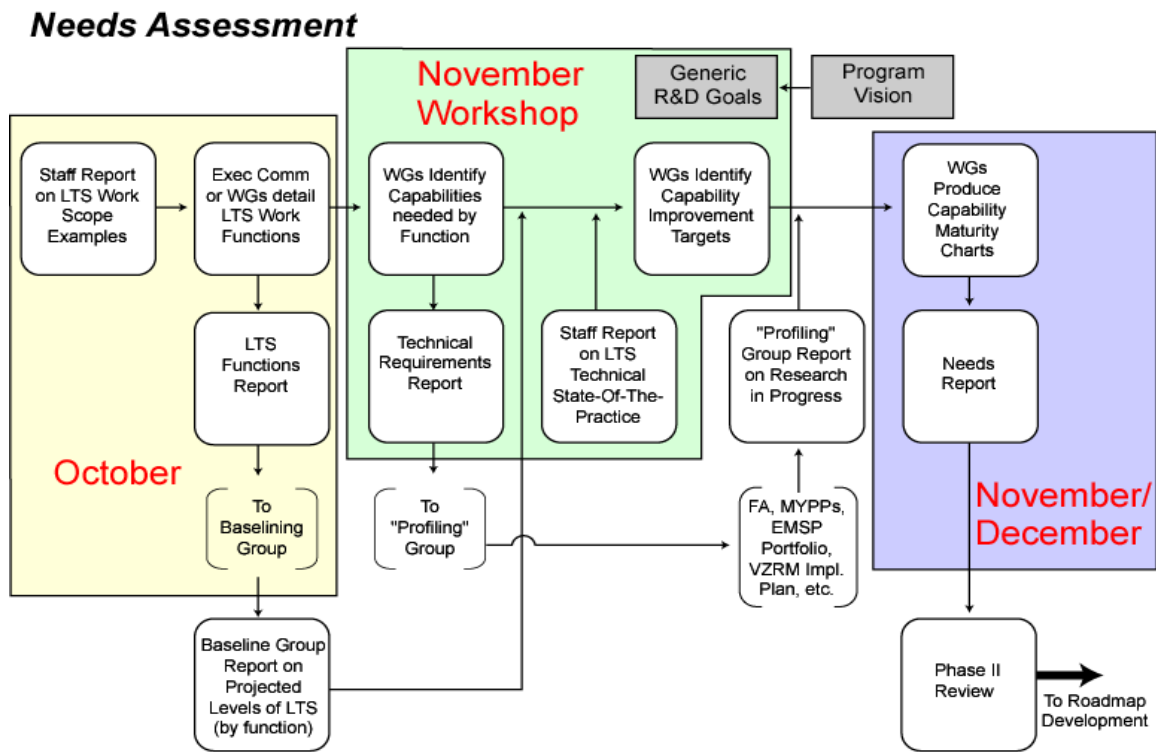


Figure 3 - Technical Needs Assessment Process and Timing

Lessons Learned During Technical Needs Assessment

For a programmatic roadmap, such as the LTS roadmap, a major task in roadmap development is to identify and define the system that is relevant to the roadmap objective. Defining this system for the LTS roadmap was challenging because it has a policy component as well as a technical component. The LTS roadmap defined science and technology to include social, behavioral, and economics, several of the participants wanted to include in the roadmap topics such as funding mechanisms and defining of responsibilities. However, DOE considered these topics to be addressed by policy rather than science and technology. In addition, some participants believed that LTS didn't just need "hard science" technologies such as sensors and simulation models but also needed technologies from the social sciences to improve public interaction and participation in LTS programs. Defining the LTS system showed the importance of "social science and technology in developing and maintaining adequate Long-Term Stewardship.

Plan Meetings That Enhance Product Quality. Experience gained through organizing and conducting meetings intended to develop technical information showed that product quality was improved when a small team was allowed to develop an intermediate product follow by a larger group review to refine it. Initial separation is necessary to focus the groups and refinement by the whole group is necessary to maintain an expansive perspective. Experience from previous roadmapping and related planning efforts had been used in the design of the LTS process, with

efforts made to streamline parts of the process. Previous planning efforts had used full-week workshops with initial drafts due at mid-week and the remainder of the week used to improve, prioritize, and integrate results. For the LTS roadmap, the workshops were shortened to 2 ½ days in length. In hindsight this was a mistake. Many of the participants felt they were just starting to make real progress when everyone had to leave to catch planes and the workshop products were still in draft form.

Provide Product Guidelines And Examples To Enhance Productivity. Specific guidelines on approach and example of needed products are necessary to help the diverse groups develop uniform roadmap products. Guidance must be balanced so creativity is not limited, but standards must be maintained to facilitate integration of results. In the Needs Assessment workshop, the groups and their facilitators worked too independently, and there was difficulty in combining results. While a longer meeting with comparison of intermediate drafts may have helped, better communication between facilitators and the use of “floaters” would also have helped.

Everyone Should Be Involved In The Process. The executive committee didn’t participate directly in several of the workshops, but instead came in on the last day to be briefed on the results. The roadmapping activity would probably have been improved if the executive committee had been more directly involved in the process. They could have been floating help to provide perspective and direct and immediate assistance for the work groups.

Leaders Should Take Charge by Integrating Within. Two styles of group leaders were noted. The more effective style was the leader who worked with the team as a facilitator and integrator. The less effective style was the more autocratic, up front leader. Differences in effectiveness likely resulted from the desire of all participants to easily get their ideas included – the more autocratic leadership was possibly too controlling for the expert-level participants who were used to having more individual control.

Roadmap Development Task

The Roadmap Development task involved identifying and documenting approaches to respond to the targets identified during the Technical Needs Assessment task and developing the draft Roadmap. Roadmap Development utilized current technology development data obtained from DOE Office of Science and Technology (OST) Focus Areas, Environmental Management Science Program (EMSP), and Crosscut Programs, and from other government agencies to further analyze the current DOE S&T portfolio (including identified technology gaps) to aid in the development of response plans.

During the Roadmap Development Workshop, the Roadmap Workgroups validated the gaps and targets from the Technical Needs Assessment task, identified and investigated response alternatives, and drafted response. This information was discussed by the Executive Committee at additional meetings, after which the response plans were sequenced and their associated response schedules integrated. The response plans and schedules guide S&T development such that sound investment decisions can be made.

This task interfaced with other LTS teams (e.g., Information Management, Technical Baseline, Technology Profile, and Performance Assessment and Decision Analysis) and used information developed by those teams to assess the value of making various technology investments. Figure 4 illustrates the overall Roadmap Development Process.

Roadmap Development

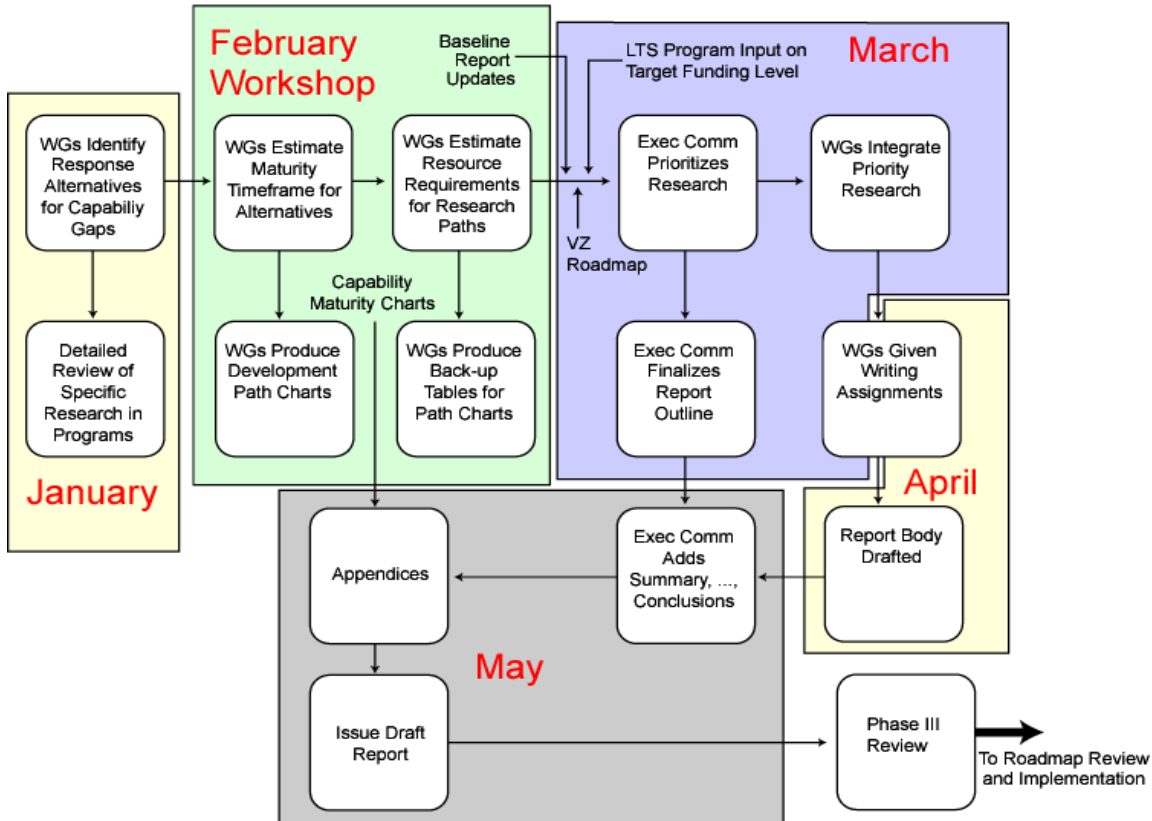


Figure 4. Lessons Learned During Roadmap Development

Don't Ignore The Contribution Of The Social Sciences. Social sciences can have an important role in programmatic roadmap development, especially when there is a regulatory or policy component. Initial investigations during planning of the LTS roadmap indicated a role for the social sciences and two of the four working groups were focused on communications and management issues. When needs were prioritized and response integrated across all four working groups, many of the social issues and their resolution came out as top priorities – more important to mission accomplishment than improved monitoring hardware or engineered barrier maintenance.

Surprisingly the strongest proponents for resolution of social issues were the cleanup and stewardship operations personnel. They felt that their existing hardware tools and engineering methods were sufficient to perform the technical aspects of the LTS mission (though enhancements would greatly improve their effectiveness and reduce operational costs). However, they felt that some tools for community interaction, communication, legal controls, and other social issues were not sufficient. In particular, the potential inability to achieve local community acceptance of LTS goals could completely block progress.

Quantification at a Program Level May be Impractical. During roadmap design, the prioritization process was envisioned to be part qualitative and part quantitative. Updates to the baseline reports on LTS operations were to be the basis for quantitative analyses of return on investment, especially for hardware improvements (see top center portion of Figure 4).

Difficulties in data gathering for the baseline prevented the use of quantitative methods. While the participating experts had first-hand knowledge of a number of specific field problems, there was no way to quantitatively evaluate the impact of their solution across all LTS sites. Quantitative evaluation of alternatives requires a significant amount of detailed data so defensible projections can be made from it. During the program formation stage, such as where LTS is, the quantitative data may be hard to access because it has not been systematically gathered and organized. When faced with insufficient quantitative data, expert opinion, as was used in the LTS roadmap, is a viable method to develop good qualitative rankings of alternatives.

Maintain Focus On The Purpose Of The Roadmap. The use of roadmapping as a strategic tool and not a tactical tool was reemphasized on the participants by the process itself. There was a desire and some effort made to develop more detailed evaluations, down to the level of individual technologies. However, efforts to work at that level quickly bogged down and the group returned to technology-independent planning. It was generally recognized that identifying the enhancement target was a prerequisite to identifying technologies to develop to meet that target and the roadmap should concentrate on the former. There would be plenty of time later for the implementation managers to worry about technology-specific tactical planning.

Roadmap Review and Implementation

During the Roadmap Review and Implementation task (in progress), the Roadmap will be reviewed, released, implemented, and updated as necessary. This task will include management briefings on the Roadmap findings, independent technical and stakeholder reviews, and Roadmap finalization. After release of the Roadmap, implementation plans will be developed by the INEEL core and Roadmap Executive Committee. R&D plans will be developed in cooperation with the appropriate DOE offices (such as the Office of Science), site LTS work managers, and other federal agencies. Implementation progress will be tracked and the Roadmap and associated implementation plans periodically revised and updated to support sound decision-making and ensure the timely and cost-efficient availability of S&T needs for program success. Figure 5 shows the overall Roadmap Review and Implementation process and timing.

Lessons Learned During Roadmap Review and Implementation. The roadmap has not progressed far enough into this phase to provide meaningful lessons learned. A formal review of the report, including public comment, is expected to occur in February and March of 2003. The final report is expected to be completed in late spring after comments are resolved and report approvals obtained.

General LTS Roadmap Lessons Learned

In hindsight a general lesson learned about a program level roadmap concerns the relationship between the roadmap and the participants. Effective implementation of the LTS roadmap will require collaboration of a number of organizations, both inside and outside of DOE. The process of roadmapping creates a community of experts and managers that can provide that collaboration [Dixon, 2003]. Thus “roadmapping” is not just about creating a plan, but also creating the network of professionals necessary to execute that plan. To provide breadth of perspective, the LTS roadmap included managers and experts from operations, labs, universities, other government agencies, and regulatory bodies. All will be key in developing and fielding the knowledge and technology improvements recommended by the roadmap - both for DOE and other LTS efforts.

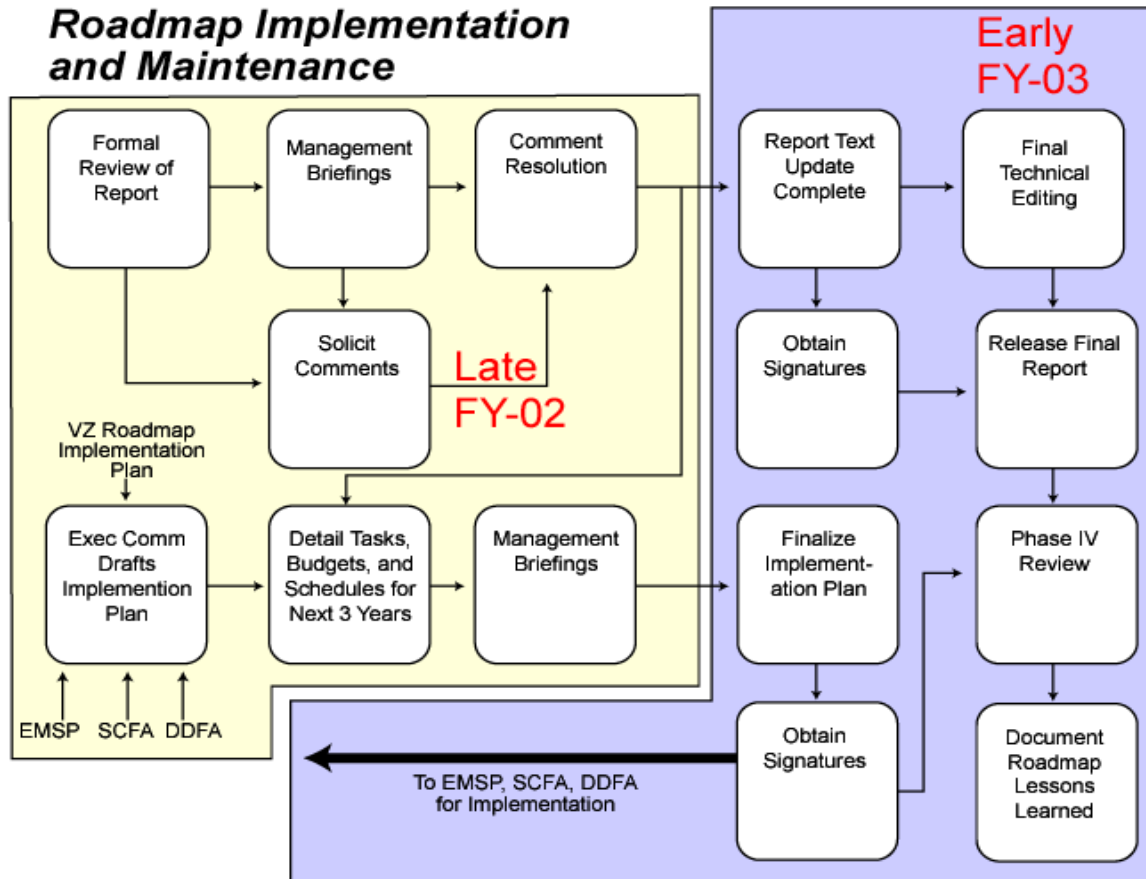


Figure 5 - Roadmap Review and Implementation Process and Timing

4. CONCLUSIONS

This paper has described the process of applying roadmapping to clarify mission requirements and enhance technologies for the DOE Long-Term Stewardship (LTS) program. Roadmapping was used to clarify the breadth of the LTS mission, to identify capability enhancements needed to improve mission effectiveness and efficiency, and to chart out the research and development efforts to provide those enhancements.

While development of the LTS roadmap was successful and has produced a comprehensive draft report ready for broader review, in the process a number of lessons were learned. Both the roadmapping process used and lessons learned should be considered by anyone contemplating a similar programmatic planning effort.

5. REFERENCES

- DOE 2001a. Long-Term Stewardship Study. Volume I—Report and Volume 2—Response to Public Comments. Final Study. October. Office of Long-Term Stewardship, Office of Environmental Management, U.S. Department of Energy, Washington, D.C. Available from the DOE Center for Environmental Management Information, Washington, D.C., (1-800-736-3282 or on the Internet at <http://lts.apps.em.doe.gov/center/stewstudy.html>).
- DOE 2001b. A Report to Congress on Long-Term Stewardship. Volume I—Summary Report. Office of Long-Term Stewardship, Office of Environmental Management, U.S. Department of Energy, Washington, D.C. Available from the DOE Center for Environmental Management Information, Washington, D.C., (1-800-736-3282).
- INEEL 2001a. Long-Term Stewardship Technology Analysis of the Office of Science and Technology Profile, INEEL/EXT-01-01248. Idaho Falls, ID: Idaho National Engineering and Environmental Laboratory, September 2001.
- INEEL 2001b. Technical Baseline for the Long-Term Stewardship Program (Revision C), INEEL/EXT-01-01133. Idaho Falls, ID: Idaho National Engineering and Environmental Laboratory, September 2001.
- DOE 2002. DRAFT: Long-Term Stewardship Science and Technology Roadmap, DOE/ID-10926, U.S. Department of Energy, Idaho Operations Office, Idaho Falls, Idaho, 2002.
- DOE 2001c. A National Roadmap for Vadose Zone Science and Technology, DOE/ID-10871, U.S. Department of Energy, Idaho Operations Office, Idaho Falls, Idaho, 2001
- Dixon 2003. Designing Program Roadmaps to Catalyze Community Formation: A Case Study of the Long-Term Stewardship Science and Technology Roadmap. Brent Dixon, Duane Hanson, and Gretchen Matthern. Waste Management 2003, Tucson, AZ, February 23-27, 2003.