

Science and Technology Roadmap (Draft)



The Department of Energy (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”¹. According to its latest published estimate, DOE will be responsible for LTS at approximately 129 sites. 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) fulfills 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 over tens to thousands of years. 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 successfully with regulators, stakeholders, and others that influence decisions in exploring whether a new approach may work better than an accepted, or even prescribed, technology.

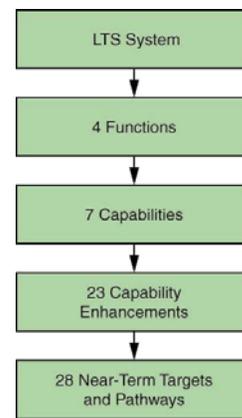
¹ U.S. Department of Energy, *Long-Term Stewardship Study: Volume I—Report*, Washington, D.C.: DOE-Office of Environmental Management, Office of Long-Term Stewardship, 2001, p. 1.

The Draft LTS S&T Roadmap has been developed to aid DOE in identifying and cost effectively implementing knowledge and tools at DOE LTS sites. The draft 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 the Draft LTS S&T 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 draft Roadmap, this effort targeted the FY2003–FY2008 planning cycles, with some recommended pathways extending to FY2012.

The draft Roadmap was compiled by an interdisciplinary team of subject matter experts from industry and 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.

LTS as a System

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 (see Figure 1):



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- 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.

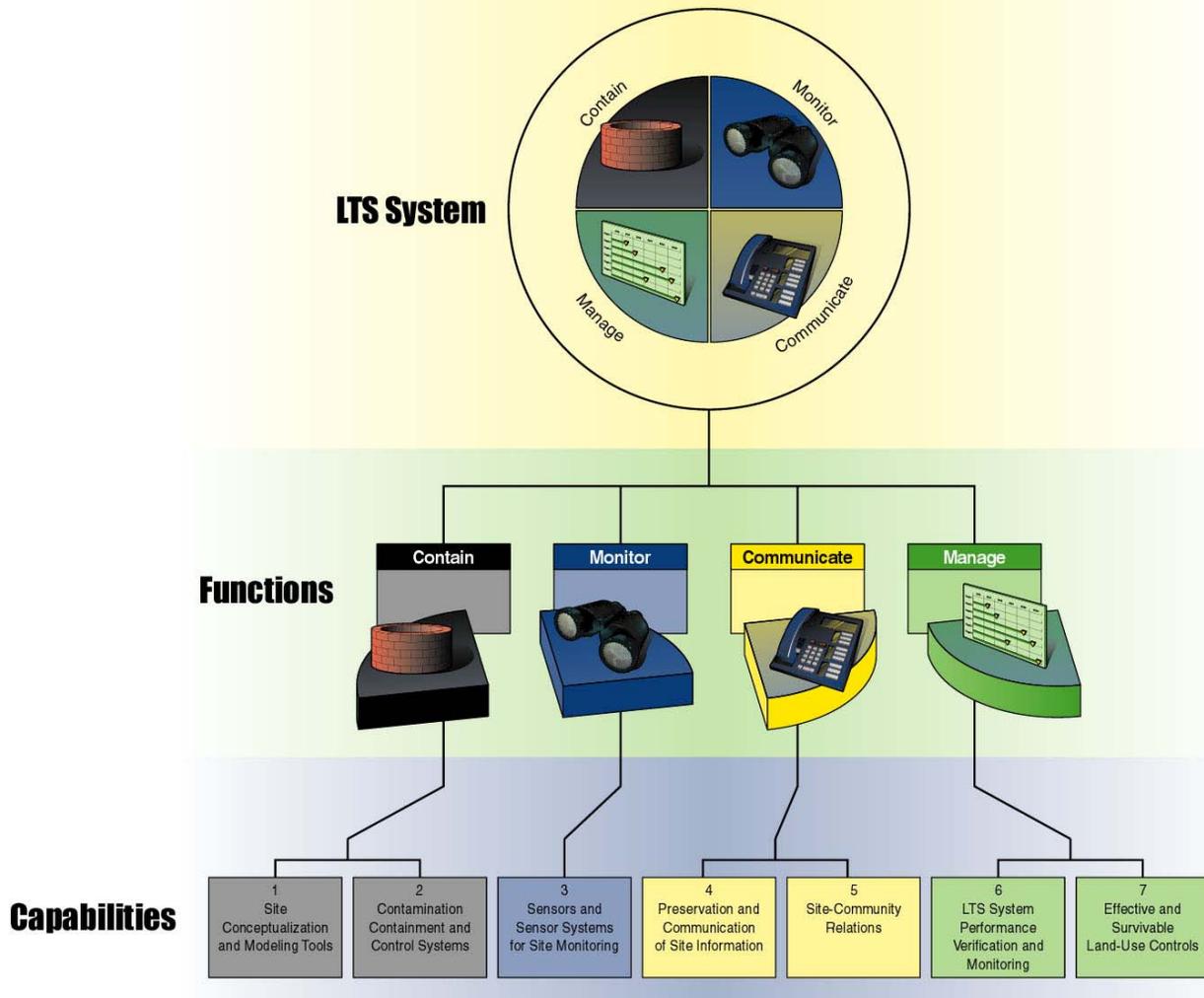


Figure 1. Flowdown of System Functions and Key Capabilities.

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 draft 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.

The LTS system to be developed by implementation of the draft Roadmap will provide a strong foundation for continued improvement of LTS capabilities. The integrated Roadmap schedule provides a pathway to develop the components of the overall system. Figure 2 shows the recommended annual investment and the cumulative completion of capability enhancement targets under the investment scenario. It should be recognized that for many of the targets, significant practical value will be realized prior to completion of the target.

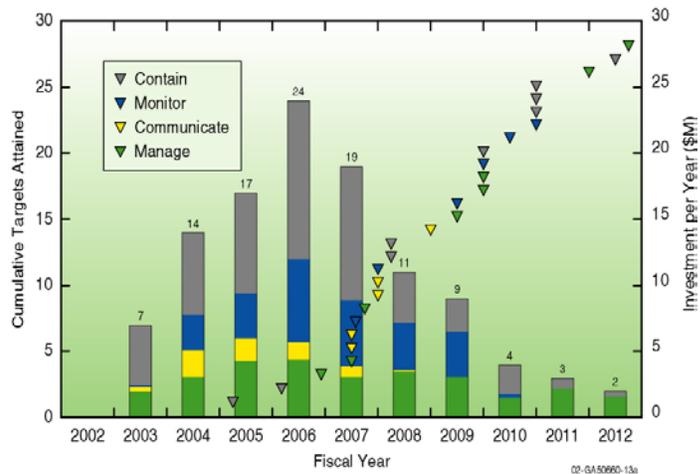


Figure 2. Projected Investments and Cumulative Targets Attained through FY 2012 (total cost: \$110M in FY03 dollars).

Table 1. Capability Enhancements Necessary for a Long-Term Stewardship System

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 demonstrate, verify, and monitor long-term performance and management of contamination containment and control 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

Benefits and Critical Messages

The Draft LTS S&T Roadmap recommends R&D pathways that will provide a system of integrated LTS capabilities needed for DOE to influence LTS policy and best manage investments (see Figure 3). Implementing this Draft LTS S&T Roadmap will provide several near-term programmatic benefits for DOE:

1. The draft Roadmap presents a vision for a full suite of LTS capabilities and identifies near-term enhancement opportunities that provide for step-change improvements in risk reduction, cost reduction, and assuring timely schedule completion.
2. The draft Roadmap identifies a broad spectrum of tools needed to fill an LTS Technology Toolbox that will link state-of-the-art technologies with the state-of-the-practice for LTS planning and operations to enhance DOE's ability to cost effectively meet closure schedules and keep LTS commitments to local communities and other stakeholders.
3. The draft Roadmap is a catalyst for coordinating and integrating dispersed efforts within DOE and with other federal agencies in developing technology to improve cleanup and stewardship.

The Draft LTS S&T Roadmap team learned a great deal from the roadmapping effort. Two specific messages need to be stated explicitly:

- **Message 1: A Strategic Plan for LTS Science and Technology Will Help DOE with Site Closure Decisions.** DOE has invested significant resources in S&T to address technical issues raised in the course of environmental management of its sites. However, DOE has not yet developed a strategic vision and plan encompassing all of the S&T required to assure regulators, stakeholders, and potential stewards that LTS will be effective for the considerable periods of time during which residual contamination will present risks. DOE should use the draft Roadmap to establish the strategic vision for LTS S&T and develop an LTS S&T Strategic Plan.
- **Message 2: To Be Effective in the Long Term, Stewardship Must Be Approached as a System.** The integrated schedule presented in the draft Roadmap provides a pathway to develop the components of the overall system in a manner that allows early implementation of portions of the system while other portions are still under development. As such, capability enhancements can, and should, be implemented as sites gain experience with their particular stewardship requirements. Each capability within the LTS system adds intrinsic value toward meeting LTS objectives, but the greatest benefit will be realized only when those capabilities and associated tools are employed as an integrated system.

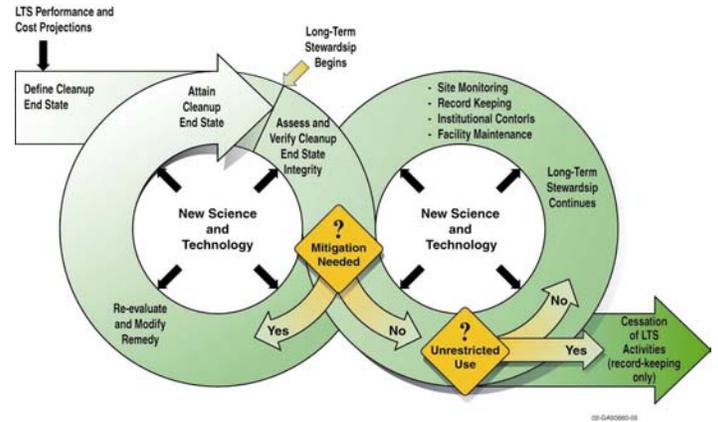


Figure 3. Changing Knowledge and Technology Will Continue to Affect LTS. (Source: U.S. Department of Energy, Long-Term Stewardship Study: Volume I—Report, Exhibit 10-3, p. 127.)

The benefits provided by the Draft LTS S&T Roadmap can be expanded and improved with the participation of other state and federal agencies and non-governmental organizations with recognized expertise and the willingness to participate. A cooperative and coordinated effort between DOE and other agencies is needed, and the draft Roadmap can play an important role in that effort. DOE can learn from others, just as others can benefit from DOE efforts and lessons learned. Additionally, because the time frame of the draft Roadmap was restricted to the near term, some important capability enhancements were not identified nor were related enhancement pathways developed. To provide a more comprehensive, long-term view, the draft Roadmap should be expanded to provide needed longer-term benefits. The result of these broader efforts would be a follow-on S&T Roadmap providing for LTS capabilities and technologies applicable to a wider range of sites and situations.

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LTS S&T Roadmap Website

<http://lts.inel.gov/st-roadmap/>