EM U.S. Department of Energy Office Of Environmental Management

Technology Development & Deployment

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(EM-20)

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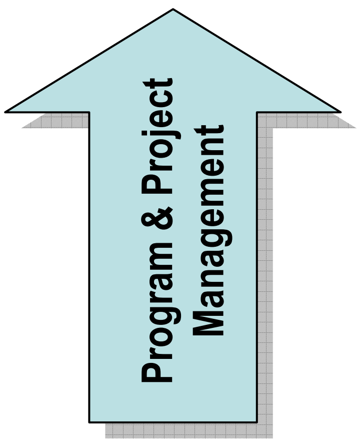
Our priorities . . .

#1 Priority: Safety

Reduce risk while maximizing regulatory compliance

- Construct **waste treatment facilities** to clean up tank wastes
- Consolidate and prepare for disposal of **surplus plutonium** and **spent nuclear fuel**
- Continue disposal of **transuranic and low-level waste**
- Continue **soil and groundwater remediation**
- Continue decontamination and decommissioning of **unneeded facilities**



Strengthen program and project management

- Implement **National Academy of Public Administration** recommendations
- Independently verify **project baselines** – scope, cost, schedules
- Strive for **"Best in Class"** capability
- Assure effective identification and **management of risk**
- Implement more effective **acquisition process**
- Develop and deploy needed **technologies**
- Focus on **project execution** through enhanced use of
  - Earned Value Management Systems and
  - Ongoing performance reviews by project and senior EM managers

Engineering and Technology Program

Mission

- To Identify Vulnerabilities and to Reduce the Technical Risk and Uncertainty of EM Programs and Projects

Vision

- Engineering and technology initiatives will provide the engineering foundation, technical assistance, new approaches, and new technologies that contribute to significant reductions in risk (technology, environmental, safety, and health), cost, and schedule for completion of the EM mission.

EM Office of Engineering and Technology

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Engineering and Technology

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Director

Office of Waste Processing

Dr. Vince Adams
Director

Groundwater & Soil Remediation Office

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D&D and Facility Engineering Office

Established to Reduce Technical Risk and Uncertainty in the EM Program

Functions

- Develop policy and guidance
- Assess projects and programs through technical reviews and oversight
- Provide technical assistance and support to the field and other Headquarters offices
- Manage the EM Technology, Development and Deployment Program

Strategic Planning for Engineering and Technology Program Activities

- Strategic Planning Approach
  - Implement Roadmap Initiatives
  - Select Critical, High-Risk, High-Payoff Projects
  - Conduct Technical Workshops and Exchanges
  - Complete External Technical Reviews
  - Review Risk Management Plans
  - Complete Technology Readiness Assessments

- Collaboration with National Laboratories, Private Sector, and Universities for innovative technologies and technical exchanges

- Work with Federal Project Directors

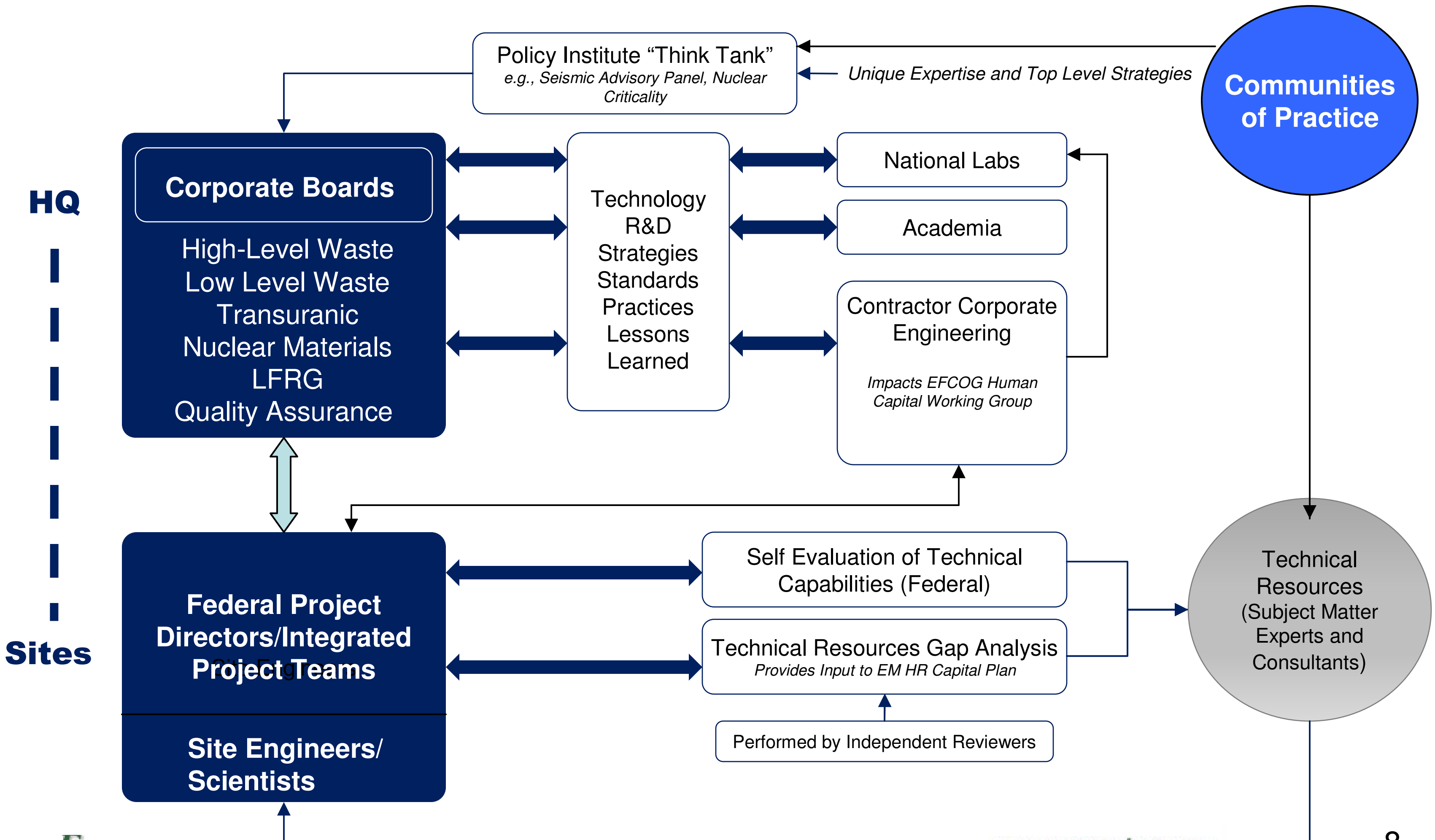
Engineering & Technology FY 2008 Management Initiatives

- Best-in-Class Program
- Technology Readiness Assessment Policy and Guidance
- Secretary's (TEAM) Transformational Energy Action Management Initiative
- Real Property Management Process

Best-In-Class Engineering and Technology Initiative

- Current Implementation Activities include:
  - Integrated Project Team (IPT) Self Assessment – Technical Capabilities
  - IPT External Assessment – Technical Capabilities
    - Results from self and external assessments will feed into EM Human Capital Management Plan and Technical Qualifications Program
  - Enhance technical capability at Headquarters through use of national laboratory intergovernmental personnel act assignments (IPA)
  - Explore other human resource options, including Professional Development Corps, Florida International University Intern Program, International secondments, Vanderbilt training program, NRC grant program, etc.
  - Benchmarking [Federal and private organizations; International – United Kingdom Nuclear Decommissioning Authority]
  - Establishment of EM Corporate Boards [new Boards include HLW and QA]
  - Finalization of EM Cleanup Technology Roadmap and strengthening of associated Communities of Practice
  - Continued utilization of External Technical Reviews and Technology Readiness Assessments

Striving for EM Program Engineering and Technology Excellence



LFRG – Low Level Waste Disposal Facility Federal Review Group
EFCOG – Energy Facilities Contractors Group

Technology Development and Deployment

- Much progress made in Environmental Management cleanup mission, e.g., completion at Fernald and Rocky Flats; more expected over next few years
- Major uncertainties/risks across the Complex must be addressed through innovative technologies and approaches
- Technologies have been inserted to reduce risk through accelerated schedules, cost savings, reduction in worker risk, and solving intractable problems
- Solutions have made a difference in waste processing, soils and groundwater treatment, and deactivation and decommissioning
- Presenting some examples of success over last 5 years

Technology Development and Deployment Strategic Initiatives laid out in the Environmental Management Engineering and Technology Roadmap (March 2008)

Waste Processing

- Improved Waste Storage
- Reliable and Efficient Waste Retrieval
- Enhance Tank Closure Processes
- Next-Generation Pretreatment Solutions
- Enhanced Stabilization
- Spent Nuclear Fuel: Improved Storage, Stabilization and Disposal preparation
- Challenging Materials: Enhanced Storage, Monitoring and Stabilization Systems

•Groundwater and Soil

- Improved Sampling and Characterization Strategies
- Advanced Predictive Capabilities
- Enhanced Remediation Methods

•Deactivation and Decommissioning (D&D)

- Characterization
- Deactivation, Decontamination, and Demolition
- Closure

Strategic Planning Approach for Engineering and Technology Program Activities

- Implementation of Roadmap Initiatives
- Critical, High-Risk, High-Payoff Projects that address needs identified by Federal Project Directors
- Technical Workshops and Exchanges to share information and lessons learned
- External Technical Reviews and Site Risk Management Plans to develop technical solutions
- Technology Readiness Assessments to focus investments in technologies to support first-of-a kind applications
- Coordination across Complex via HLW Corporate Board
- Competitive solicitations to private sector, universities, and national laboratories.
- Peer reviews and/or project reviews for new and ongoing projects prior to selection and at key points in the project development.

Leverage Research Investments

- Leverage investments made within the Department by Office of Science, Office of Nuclear Energy, National Nuclear Security Administration, and Office of Civilian and Radioactive Waste, especially in the areas of predicting high level waste performance and characterization of radiological waste.

- Leverage investments made by other federal agencies such as Department of Defense (e.g., Strategic Environmental Research and Development Program), Department of Homeland Security (e.g., radiation detection) and National Institute of Standards and Technology.

- Continue to work cooperatively with Nuclear Regulatory Commission on issues such as long term performance of cementitious materials.

- Continue to work cooperatively with the United Kingdom Nuclear Decommissioning Authority to share lessons learned for cleanup activities and to conduct joint Technology Readiness Assessments to evaluate technologies being developed and implemented in the United Kingdom.

National Research Council of the National Academy of Sciences' Interim Report: Technical and Strategic Advice on Office of Environmental Management's Development of a Cleanup Engineering and Technology Roadmap

Observations

- The complexity and enormity of EM's cleanup task require the results from a significant, ongoing R&D program so that EM can complete its cleanup mission safely, cost effectively, and expeditiously.
- By identifying the highest cost and/or risk aspects of the site cleanup program, the EM roadmap can be an important tool for guiding DOE headquarters investments in longer term R&D to support efficient and safe cleanup.
- The national laboratories at each site have special capabilities and infrastructure in science and technology that are needed to address EM's longer-term site cleanup needs. The EM roadmap can help establish a more direct coupling of the national laboratories' capabilities and infrastructure with EM's needs.

Conclusions

- The committee generally agrees with the five program areas for strategic R&D presented in EM's draft Cleanup Technology Roadmap.
- According to the range of technology needs presented to the committee and the committee's initial observations, the committee judges that existing knowledge and technologies are inadequate for EM to meet all of its cleanup responsibilities in a safe, timely, and cost-effective way. Meeting current and future EM challenges will require the results of a significant, ongoing R&D program.
- The committee is concerned that the medium- and long-term research component of EM's program has largely disappeared. Implementing the roadmap will require substantial and continuing federal support for medium- and long-term R&D for technologies focused on high priority cleanup problems.

Roadmap Development

- Input provided by EM Federal Project Directors, Stakeholders, Contractors, National Laboratories, and the National Academy of Science

- Identified technology risks in Waste Processing, Groundwater and Soil Remediation, and Deactivation & Decommissioning/Facility Engineering, Spent Nuclear Fuel, Roadmap identifies technical risks and uncertainties in EM program over next ten years
- Challenging Materials, and Integration

- Establishes strategic initiatives to address technical risks and identifies expected outcomes when implemented

Waste Processing
Risks & Strategic Initiatives

Technical Risk and Uncertainty

Waste Storage

- Existing tanks provide limited storage and processing capacity, have exceeded their original design life, and will likely be in service for extended periods of time.
- Conservative assumptions regarding behavior of waste during storage, such as flammable gas generation, restrict operations and increase costs.

Waste Retrieval

- Current waste removal and retrieval operations and monitoring technologies are costly, sometimes inefficient, and are limited by complicated internal tank design (e.g., obstructions) and conditions (e.g., past leak sites).

Tank Closure

- Achieving lower levels of residual radioactivity and improving immobilization of residual materials might be possible if there were more cost-effective and efficient closure methods for some tanks.
- Final closure of some waste management areas, including closure of ancillary equipment such as underground transfer lines and valve boxes, would be facilitated by improved closure methods that would make the process more cost-effective and efficient.

Waste Pretreatment

- Achieving effective separation of low- and high-level wastes (HLW) prior to stabilization requires improved, engineered waste processes and a more thorough understanding of chemical behavior.

Stabilization

- Waste loading (i.e., the amount of waste concentrated in waste containers) constraints limit the rate that HLW can be vitrified and the tanks can be closed.
- Current vitrification techniques may require supplemental pretreatment to meet facility constraints.

Strategic Initiatives

Improved Waste Storage Technology

- Develop cost-effective, real-time monitoring of tank integrity and waste volumes to ensure safe storage and maximum storage capacity.
- Improve understanding of corrosion and changing waste chemistry, including flammable gas generation, retention, release, and behavior to establish appropriate assumptions in safety analyses.

Reliable & Efficient Waste Retrieval Technologies

- Develop optimization strategies and technologies for waste retrieval that lead to successful processing and tank closure.
- Develop a suite of demonstrated cleaning technologies that can be readily deployed throughout the complex to achieve required levels of removal.

Enhanced Tank Closure Processes

- Improve methods for characterization and stabilization of residual materials.
- Develop cost-effective and improved materials (i.e., grouts) and technologies to efficiently close complicated ancillary systems.
- Perform integrated cleaning, closure, and capping demonstrations.

Next-Generation Pretreatment Solutions

- Develop in- or at-tank separations solutions for varying tank compositions and configurations.
- Improve methods for separation to minimize the amount of waste processed as HLW.

Enhanced Stabilization Technologies

- Develop next-generation stabilization technologies to facilitate improved operations and cost.
- Develop advanced glass formulations that simultaneously maximize loading and throughput.
- Develop supplemental treatment technologies.

Groundwater & Soil Remediation Risks & Strategic Initiatives

Technical Risk and Uncertainty

Sampling and Characterization

- Current sampling techniques and characterization technologies result in costly, time-consuming characterization programs, may leave large gaps in plume delineation, and may lead to uncertainty in the selection of cleanup strategies.
- Incomplete understanding of contaminant subsurface behavior results in long-term uncertainty regarding risks to human health and the environment.

Modeling to Guide Cleanup

- Existing models provided limited capability to represent complex hydrogeology, biogeochemistry, chemical reactions, and transport. Improved models are needed to reduce risk and uncertainty in predicting contaminant fate and transport and to provide an improved technical basis for optimizing the selection, design and implementation of remedies.

Treatment and Remediation

- In-situ treatment and stabilization technologies provide cost, human health and ecological benefits, but require additional development and demonstration to realize their full potential and to be accepted by the regulatory community.
- Ex-situ technologies may be necessary to remove, treat, isolate and dispose of contaminants in certain situations, but current ex-situ treatment technologies may result in high cleanup costs and unacceptable risks to workers.

Strategic Initiatives

Improved Sampling and Characterization Strategies

- Develop advanced sampling and characterization technologies and strategies for multiple contaminants (organics, metals and radionuclides) in challenging environments (e.g., around subsurface interferences, at intermediate and great depths, and in low and high permeability zones.
- Use basic and applied research to gain a better understanding of contaminant behavior in the subsurface and to provide defensible prediction of risk.

Advanced Predictive Capabilities

- Develop advanced models that incorporate chemical reactions, complex geologic features, and/or multiphase transport for multiple contaminants (organics, metals and radionuclides) in challenging environments to provide an improved technical basis for selecting and implementing remedies.
- Determine mechanisms and rates of release of contaminants from low porosity/permeability zones.
- Develop models that integrate data from various monitoring forms to design long-term effective monitoring systems.

Enhanced Remediation Methods

- Develop, demonstrate and implement advanced in-situ and ex-situ methods which reduce costs, increase effectiveness and reduce risks to human health and the environment.
- Improve understanding of in-situ degradation of chlorinated organics and immobilization of radionuclides and metals to facilitate development and use of advanced, cost-effective in-situ technologies and use of natural processes.
- Provide the technical basis for use of monitored natural attenuation (MNA) of organics, radionuclides, and metals in the subsurface, including use of MNA in conjunction with other methods (e.g., barrier technology).
- Develop safe, cost-effective strategies to treat and remediate legacy materials in historical waste sites, as appropriate.

D&D/Facility Engineering
Risks and Strategic Initiatives

Technical Risk and Uncertainty

Characterization

- Limited techniques for detection, quantification and localization of penetrating radiation, radioactive contamination (e.g., Pu, U, tritium), chemicals (asbestos, beryllium, metals, organics, caustic and acidic solutions, lead paint), and biological contaminants (mold, dead birds and rodents, and animal feces) increase the risk of personnel exposure to hazardous conditions.

Deactivation, Decontamination, and Demolition

- Hazardous conditions involving radionuclides, heavy metals, and organic contaminants result in worker safety issues and lead to use of cumbersome personal protective equipment and D&D approaches.
- Inadequate historical knowledge of past operations and contamination (and other hazards) drive conservative and costly D&D approaches.

Closure

- End-state requirements for D&D of process facilities are not adequately defined.

Strategic Initiatives

Adapted Technologies for Site-Specific and Complex-Wide D&D Applications

- Develop and deploy improved characterization and monitoring technologies for detecting and quantifying penetrating radiation, radioactive, and biological contaminants.
- Develop and deploy improved deactivation, retrieval, size-reduction, and stabilization technologies that provide adequate personal protection and effectively achieve end-state requirements.
- Develop and deploy advanced remote and robotic methods to rapidly access and assay facilities to determine optimal D&D approach.
- Establish the scientific and technical basis for end-state conditions to satisfy federal, state, and local stakeholders.

DOE Spent Nuclear Fuel (SNF) Risks and Strategic Initiatives

Technical Risk and Uncertainty

Spent Fuel Storage

- Storage of vulnerable SNF types (e.g., aluminum-clad) and conditions (SNF and basins) are subject to continued deterioration, and may impact repository acceptance.

Spent Fuel Stabilization

- Present facilities and methods are not designed for processing all SNF types.

Disposal Packaging Preparation

- Geologic disposal of SNF requires assurance of criticality control over long timeframes.
- Current plans identify the need for a canister closure weld in a high radiation environment for which commercial systems do not exist.

Strategic Initiatives

Improved SNF Storage, Stabilization and Disposal Preparation

- Improve monitoring of fuel condition, cladding integrity, and basin integrity.
- Develop efficient, cost-effective stabilization technologies and processes based on spent fuel types.
- Develop advanced neutron absorber materials for use inside disposal packages to meet long-term criticality control needs.

Challenging Materials
Risks and Strategic Initiatives

Technical Risk and Uncertainty

Storage

- Improved inventory analyses, monitoring and storage systems are needed for unique TRU wastes and special nuclear materials.

Stabilization and Disposition

- Some materials have no defined path for disposal in their current condition.

Strategic Initiatives

Enhanced Storage, Monitoring and Stabilization Systems

- Develop advanced characterization, monitoring, and inventory analysis methods; and improved storage systems for multiple material forms including contaminants.
- Develop advanced processes for stabilization and waste form qualification.

Integration & Cross-Cutting Risks and Strategic Initiatives

Technical Risk and Uncertainty

Assessing Long-Term Performance

- Inadequate fundamental understanding of wasteform performance and contaminant release, transport, and transformation processes result in inadequate conceptual models potentially leading to selection and design of non-optimal remedial actions.
- Inadequate long-term monitoring and maintenance strategies and technologies to verify cleanup performance could potentially invalidate the selected remedy and escalate cleanup costs.

Transportation and Disposal Packaging

- Disposal and transportation restrictions include flammable gas limitations, material characteristics and configuration. Existing data is insufficient to quantify the effects of potential sources of hydrogen, deflagration events, degraded fuel, impurities, and other conditions for challenging materials.

Strategic Initiatives

Enhanced Long-Term Performance Evaluation and Monitoring

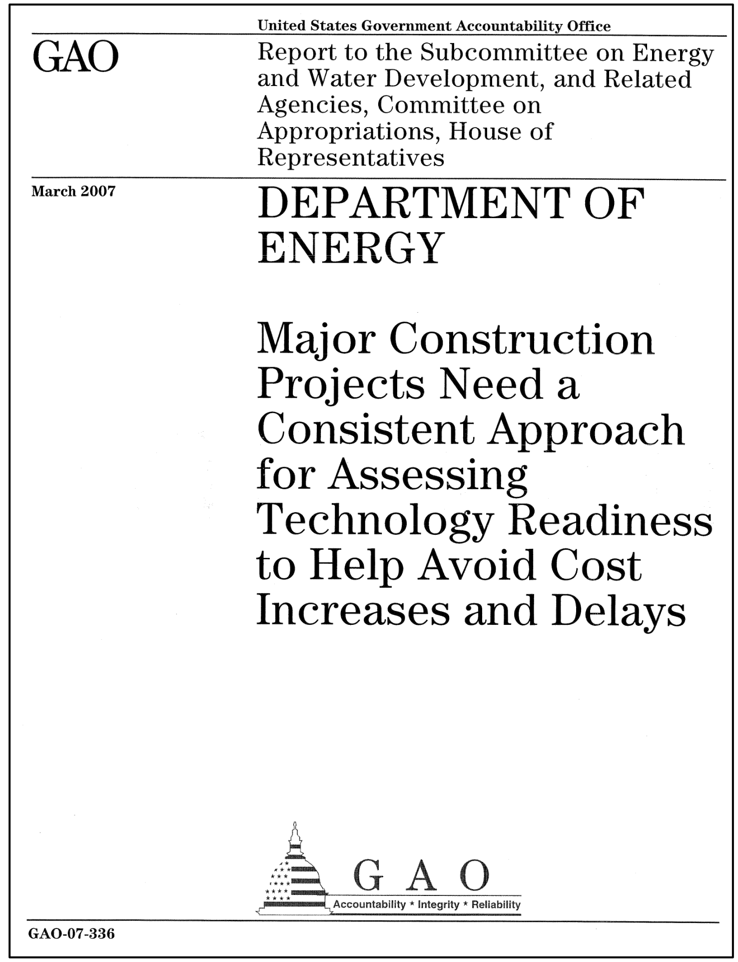
- Develop increased understanding of long-term wasteform performance integrated with transport of contaminants to support broad remedial action decisions and cost-effective design and operation strategies.
- Develop and deploy cost-effective long-term strategies and technologies to monitor closure sites (including soil, groundwater, and surface water) with multiple contaminants (organics, metals and radionuclides) to verify integrated long-term cleanup performance.

Improved Packaging of SNF, TRU Waste and Nuclear Materials

- Develop improved packaging and conduct tests and/or analyses to meet regulatory requirements.
- Improve inventory and characterization data.

Background for DOE TRAs

- **GAO initiated review of DOE projects in 2006 to assess relationship between technology maturity and project cost growth and schedule extension**
  - 12 DOE projects reviewed-WTP included
  - Concluded that implementing immature technology in design was part of the reason for cost growth
  - Recommended that DOE use a consistent process for measuring readiness of critical technologies
  - DOE supports GAO's recommendation and suggested a pilot application to understand process
- **In late 2006 DOE initiated 3 TRAs**
  - WTP Used as Pilot Case


United States Government Accountability Office

GAO

Report to the Subcommittee on Energy and Water Development, and Related Agencies, Committee on Appropriations, House of Representatives

March 2007

DEPARTMENT OF ENERGY

Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays

G A O
Accountability * Integrity * Reliability

GAO-07-336

Technology Readiness Assessments (TRAs)

- **A description of what has been done to develop a technology at a given point in time (i.e., not a "grade").**
- **An systematic evaluation of a technology in terms of Technology Readiness Levels (1-9).**
- **For a given system, subsystem or element, the TRL for the whole equals the lowest TRL of its components.**

Why Conduct a TRA?

- A useful project management tool to support design/ construction project management decisions, reduce technical risk—and thereby—limit costs and schedule overruns
- A consistent, systematic and structured process to evaluate & communicate the status of technology development
- An emerging standard for Federal Projects
  - Originally developed by NASA
  - Congressionally mandated for DoD
  - Recommended for DOE use by GAO (GAO-07-336)
- International use - U. K. Nuclear Decommissioning Authority, Australian Defense Department

TRA Methodology

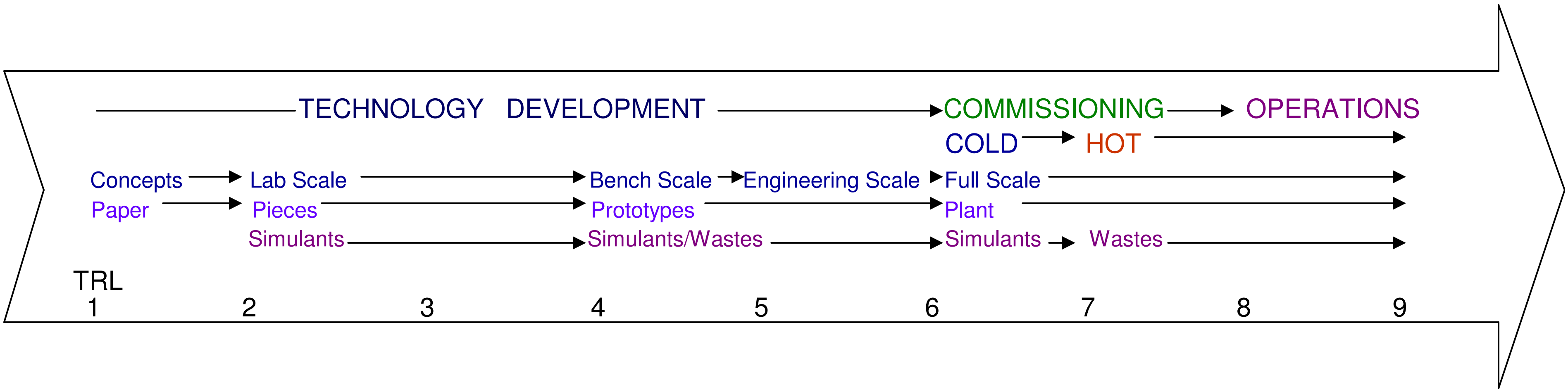
- **Based upon *Department of Defense, Technology Readiness Assessment (TRA) Handbook*, May 2005**
- **TRA Steps**
  1. **Identify Critical Technology Elements (CTEs)**
  2. **Determine TRL for each CTE**
  3. **Prepare a Technology Maturation Plan (TMP) for technologies with TRLs below desired level**
- **Incorporation of TRA/TMP insights into project plans and schedules**

Technology Readiness Level Scale

Phase	Level	Description
System Operations	TRL 9	Actual equipment/process successfully operated in the operational environment (Hot Operations)
System Commissioning	TRL 8	Actual equipment/process successfully operated in a limited operational environment (Hot Commissioning)
	TRL 7	Actual equipment system/process system successfully operated in the expected operational environment (Cold Commissioning)
Technology Demonstration	TRL 6	*Prototypical equipment/process system demonstrated in a relevant environment (Cold Engineering Scale Pilot Plant)*
Technology Development	TRL 5	Bench scale equipment/process system demonstrated in a relevant environment
	TRL 4	Laboratory testing of similar equipment systems completed in a simulated environment.
Research to Prove Feasibility	TRL 3	Equipment and Process analysis and proof of concept demonstrated in a simulated environment
	TRL 2	Equipment and process concept formulated
Basic Technology Research	TRL 1	Basic process technology principles observed and reported

TRL 6 normally required for incorporation of technology into design

DOE Technology Readiness Levels



Pilot TRAs

DOE-EM has conducted 8 pilot TRAs

- **Hanford Waste Treatment and Immobilization Plant (WTP) Laboratory, Low Activity Waste (LAW) Facility and Balance of Facilities (BOF)**
- **Hanford WTP High-Level Waste (HLW) Facility**
- **Hanford WTP Pre-Treatment (PT) Facility**
- **Hanford Study of LAW Treatment Alternatives**
- **Hanford K Basins Sludge Treatment**
- **Savannah River Tank 48H Waste Treatment Technologies**

Conclusions

- Roadmap identifies strategies to reduce risks and improve technologies and processes at EM sites.
- External Technical Reviews have been proven useful in supporting critical project management decisions.
- Project Risk Management Plans should be used to help resolve technical risks and uncertainties.
- Technology Readiness Assessments are a promising tool to delineate technical risk. Technology Maturity Plans are key to reducing project risk.
- Better communication is needed to ensure project success.