

15 Years of Environmental Sensors
Development by DOE:
Changing Strategies, Technologies and Programs

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Background of Presenter



Research Chronology: 29 Years. Academia, DoD and DOE national labs, Director of a small, high-tech, sensor development co., DOE EM (HQ and NV), back to academia

DOE EM Support:

- Recruited by DOE and contractors to support newly formed Office of Technology Development in the Office of Environmental Restoration and Waste Management in 1990.
- Supported 6 DOE Program Managers in administrative and technical management of over \$120M of R&D projects in the Characterization, Monitoring and Sensor Technology (CMST) Program (1991-1999)
- Provided Technical Expert Support to other DOE EM R&D Programs which developed over \$120M of CMST not under the CMST Program

Environmental CMST Development 1999-Present: Have been Principal Investigator on over 40 projects delivering many solutions to 9 major DOE sites.

- Sensors have included: video cameras; infrared imaging; seismic; radiation; pressure; moisture; chemical; proximity; liquid level; passive electromagnetic; radar and more
- Several consulting efforts to identify improved characterization processes, deploy innovative monitoring technologies, and to improve the site conceptual modeling.
- In FY2006 ARC is developing two innovative monitoring systems to be placed in-tank and in-line at Hanford high-level waste facilities.
- Also in FY2006 ARC is helping Hanford make radiation survey more robust for surveying desert acreage for surface radiation and in developing a groundwater monitoring system for tracer pump tests.



Environment CMST



CMST Application Areas:

- **Soil & Groundwater⁺**
- High-level Waste Retrieval and Processing
- Decontamination and Dismantlement of Facilities
- Mixed/TRU Waste Characterization & Treatment
- Nuclear Materials Focus Area (very small, late effort)

⁺soil & groundwater CMST will be focus of this presentation and had total funding larger than all others combined



Environmental Soil & Groundwater CMST - Circa 1991



- Site Characterization was rigid, prescriptive, inefficient, and extremely expensive consisting of multiple sampling campaigns and analyses in analytical laboratories
- New analytical labs were planned, projections of env. samples needing analysis were astronomical
- Few env. technologies available were not used. Characterization methods were inefficient.
 - CMST Program was critically needed



CMST Program 1992



Numerous experts from across many disciplines were engaged to bring dozens of available technologies for other applications to use for environmental characterization & monitoring

- Remote sensing technologies from DoD and NASA
- Surface and Borehole Geophysical techniques from the oil and mineral exploration field
- Ground-penetrating radar from DoD
- And many others

Most technologies needed development specifically for environmental applications, e.g., characterization of subsurface soils 0-50 ft deep versus square miles (remote sensing) or cubic miles (exploration)



CMST Program 1992 (continued)



Organized several workshops with multiple government agencies and world experts to identify state of the art of several technology areas and 5 year R&D plan for needed development. Examples include:

- Classified and unclassified remote sensing workshops with support of ERIM, DOE Nat'l Labs, Universities, NASA, etc.
- Geophysical Techniques workshop with LANL as lead support
- Borehole Geophysics for Environmental Applications (1993)
- All DOE EM conferences (Spectrum '92,'94,... and Env. Restoration '91,'93, ... Technology Information Exchange 1990-2003)

Expert guidance from these workshops, new national technical conferences sponsored by DOE EM led to calls for R&D.



Environmental Soil & Groundwater CMST - Circa 1995



Many technologies have now been developed but most are not being deployed, analysis reveals that technologies cannot simply be cheaper, faster, safer, better, and safer (CFBS - old slogan) but must be tied to realistic solutions

Barriers to technology deployment include:

- Contractors have no incentive to doing work CFBS
- DOE sites continue to spend billions on characterization, many times higher than other federal sites and MUCH larger than industry (cannot grasp concept of DQOs)
- Analysis shows that improved methods such as for expedited site characterization greatly exceed savings from individual technologies
- Technologies need a customer and a driver
- Technologies are not solutions but part of a solution. Method for replacing old technology with new one is not always simple and may require new method



Environmental Soil & Groundwater CMST - Circa 1995



Barriers to technology deployment also include:

- Lack of defined baseline environmental operations and lack of component costs do not allow even rough cost benefit analyses
- One must work with contractors, public, local regulator at each site to get them to deploy a technology – no tops down requirement for accepting a new BDAT
- Industry cannot understand and market their products to every site effectively.
- Most technology development was done by DOE laboratories based upon generic need statements with solutions that are not user-friendly
- Enabling technologies are needed to support the implementation of new technologies or processes
- Local regulators are risk adverse and generally against new ideas and technologies [this is beginning to change with the re-emergence of field screening technologies being promoted by EPA HQ programs (ORD/TIO, Eric Koglin, EPA Las Vegas, etc.)]



CMST Program 1995



- Annual Program R&D over \$20M
- Major effort on getting Expedited Site Characterization Method deployed at key DOE sites (SLAP site, Pantex, etc.) and accepted as ASTM standard
- CMST Program Team (13 PhD experts travel to DOE sites to work with Site Technology Coordination Groups (STCGs) in defining their 134 CMST needs
- Working with over a dozen other programs in CMST area including EPA ORD/TIO, EPA Las Vegas (Eric Koglin), newly formed Interstate Technology & Regulatory Council
- Strong push for improved project management (cost and sched variance reductions)
- EM performs BEMR and BEMR-II and then Ten Year Plans for every DOE site.
- Post-closure monitoring and its possible, enormous costs becomes a new focus
- Program begins close work through newly formed 5 Focus Areas for DOE EM R&D: Subsurface Contaminants (SRS); Mixed Waste & Nuclear Materials (INEL); High-level Waste (RL/ORP/PNL); D&D (NETL)



CMST Program 1995 (continued)



- Program began working directly with DOE site restoration managers in developing technologies that were suitable for their deployment
 - Reviewed site plans to identify existing technologies that can solve some of their needs;
 - Identified technology performance specifications for unmet needs and dates when technology were required to plan R&D; and
 - Identified multiple DOE users and estimated potential cost savings for deployment across DOE sites.



CMST Program 1995 (continued)



Soil & Groundwater CMST R&D areas:

- Subsurface site characterization systems;
- DNAPL location
- Flow & transport modeling
- Buried Waste retrieval and characterization
- Barrier integrity and emplacement
- Subsurface contaminant monitors



CMST Program 1995 (continued)



Peer Review of proposals and on-going R&D projects

NAS Committee on Env. Management Technologies reviewed DOE/EM/OST and cited several problems including with peer review that was not expert, external, open and truly “peer”

- CMST Program was cited an one positive example for their review process that included: DOE customers, independent experts, balanced portfolio of technology maturation stages.



CMST Program 1999



- Annual budget down to \$8M and 24 projects
- All 11 Soil & Groundwater (S&GW) projects were completing development or deploying technologies/solutions
- There were many CMST critical needs at DOE sites but much fewer were in S&GW area
- Time was correct for DOE EM R&D down-sizing
 - TIE conferences were now very effective at transferring technology deployment information and lessons learned across DOE
 - Industry was now fully engaged in S&GW technology development with and without DOE funding and were now driving new developments
 - More acceptance of technologies by local regulators, lack of new regulatory acts as technology drivers, ITRC, more experienced gained by those executing EM at DOE sites led by decreasing need.
 - Post-Closure monitoring was big S&GW focus



Soil & GW CMST R&D Completed



- DNAPL location technologies * Buried waste location technologies
- CPT in situ sensors & samplers * Improved GW and transport models
- Over 20 Geophysical techniques* Landfill cover performance monitoring
- 3M sampling disks * several remote sensing technologies
- Monitoring barrier emplacement* Data Fusion
- Liner leak location * Buried tank leak location
- Improved site characterization method (ESC, TRIAD)
- Over 20 field-deployed chemical analysis instruments & methods
- Limited success with down-well chemical sensors (acoustic wave) led to realization that these sensors did not work for years in GW and provided no cost savings – led to Flow Probe and then to Burge sampling/analysis
- Improvements to several lab chemical analysis instruments (e.g., ICP-MS)
- And others EM applications!



FLUTe with hydrophobic sorbent







DOE EM S&GW CMST R&D Needed



Is there a need for new S&GW CMST R&D?

YES – there is an enormous, changed need!

Does new R&D need to be coordinated by DOE EM?

YES – along with FRTR, ITRC, TIE conferences,
EPA/ORD, International DNAPL consortium, etc.



DOE EM S&GW CMST R&D Needed



What are the reasons for the new, enormous need for S&GW R&D?

1. Landfill cover performance is poorly understood and overestimates performance.

DOE (CMST Program, SCFA, EPA) and many others worked to approve alternative cover designs that were much more effective and yet much less costly than the earlier required designs (e.g., RCRA subtitle C & D). The A-CAP program has been collecting performance data from these covers for a few years and by the 3rd year, the performance fell way below anything expected or modeled.

2. Remediation technologies have been deployed and accepted based upon only a few years of performance data. In some cases these have ultimately failed.

Soil & GW parameters will change significantly over decades and centuries in ways not understood today. With no systematic study of possible future conditions and periodic (5 yr) reviews of sites with residual contamination, failure and subsequent DOE liability are all but certain.



DOE EM S&GW CMST R&D Needed



3. Long-term performance assessments (EAs, EISs) for landfill liners, caps, engineered disposal facilities, etc. all make many assumptions in order to reach acceptable performance over centuries and may greatly overestimate performance.
4. As DOE sites transition out of EM to other landlords, there is need for transfer of knowledge and a periodic review of any change in conditions such as increased contaminant transport.



Precautions for Current R&D Programs



- Technology development programs are most effective when driven by customer needs (cost savings, difficult to meet env. regulations, no existing technology available, etc.)
 - many current CMST R&D programs do not have drivers and are back to making things CFBS
- Science (more basic R&D) is less driven by performance requirements and should be more exploratory and less constrained
 - Programs to make basic R&D field-deployable (e.g., nanotechnology-based sensors) generally fail by not emphasizing exploration of multiple possibilities and applying arbitrary performance constraints
- An effective R&D program should have outside peer review, prioritized needs, performance metrics, and a balanced portfolio of technologies at various maturation levels



Precautions for Current R&D Programs



- Many proposed new areas for R&D look very similar to the research interests of academics identifying these needs
- Most problems at environmental sites do not require a technology solution
- Most problems at environmental sites that do require a technological solution do not require a new technology development
- The most effective new technology development is:
 - Guided by performance specifications and clients at multiple sites
 - Performed by industry
 - Led by government planning – e.g., huge cost benefits, future needs



Conclusions?



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- Technology development in many fields continue to reinvent the wheel
 - Where are the Lessons Learned? The DOE environmental technology deployment forums?
 - Is there a venue to pull together clients (gov. environmental management managers), technology developers, and expert analysts for “big picture” current and future R&D needs?
 - Is anyone looking at the liability of deployed solutions that may under-perform or completely fail?