Standardized Cost Structure for the Environmental Industry

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ABSTRACT

The underlying key to developing successful estimates, tracking project costs, and utilizing historical project cost information is the development of standardized and well-defined hierarchical listing of cost categories. Committees within the U.S. Federal agencies have pioneered efforts toward developing the Environmental Cost Element Structure (ECES), which is key in achieving these goals. The ECES was developed using an iterative process with input from federal agencies and industry. Experts from several disciplines participated including engineers, cost estimators, project/program managers, and contract personnel. The ECES benefits from an intense analytical effort, the knowledge gained from the maturation of the environmental industry, and incorporation of past user's experiences. Building upon this foundation, the E06 committee of the ASTM International has now fully developed and published a standard (ASTM 2150-04) that provides standardized cost categories with complete cost category definitions.

This standard affords environmental and nuclear D&D project mangers the opportunity to have a well defined hierarchical listing of their estimates and actual costs, readily adapted to performing summations and roll-ups, supported by a multi-level dictionary specifically defining the content of the cost elements as well as the summations. Owing to the dynamic nature of the environmental technologies, efforts need to be made to continue to update this standard by adding new technologies and methods as they are developed and employed in the field.

Lastly, the Environmental Cost Element Structure that is embodied in this standard also presents opportunities to develop historical cost databases and comprehensive life cycle cost estimates and standardized cost estimating tools.

INTRODUCTION

Environmental cleanup work is an industry that involves billions of dollars of annual expenditures, is spread over many Federal, State and local agencies, and the private sector and is accomplished by a range of contractors all the way from small businesses to the world's top-ranking construction and environmental remediation companies. Federal organizations involved in environmental remediation work include the Department of Energy (DOE), Environmental Protection Agency (EPA), Department of the Navy, U.S. Army, U.S. Air Force, Department of the Interior, and the National Aeronautics and Space Administration (NASA) to name a few. Many state environmental agencies are also involved in environmental cleanup at a significant scale. In addition to the federal agencies and state agencies corporations in the petrochemical, manufacturing, electric power generation, mining and other industries perform a substantial amount of environmental remediation work. These organizations manage billions of dollars worth of environmental remediation work performed each year. The large size and importance of this work indicates a strong need for a standardized way to identify and organize environmental cost information. If the standardized cost information could be arranged in a structure that would allow roll-ups and summaries at various levels, it would serve as an effective cost management tool. A uniform cost structure would be instrumental in developing accurate and traceable cost estimates, establishing industry benchmarks, determining the best remediation practices, and providing a consistent basis for effective communication concerning similar remediation project costs. This paper discusses the development and status of the Environmental Cost Element Structure (ECES), which is a comprehensive, hierarchical list of cost elements (tasks, items, or products) and associated activities conducted throughout the life-cycle of an environmental remediation program or project.

DEVELOPMENT OF THE ECES

ECES was first developed by the Interagency Environmental Cost Engineering Committee $(EC)^2$ whose members include U.S. EPA, Air Force, Army and Army Corps of Engineers, Navy, Coast Guard, Department of the Interior, DOE, and NASA. ECES is an enhancement to the previously developed Hazardous, Toxic, and Radioactive Waste Work Breakdown Structure (HTRW WBS). The ECES enhancements include adding the different phases of an environmental project, adding new technologies, and consolidating cost elements. In developing the ECES, inputs and comments were received from the Navy, Air Force, EPA, Army Corps of Engineers, private industry and the Association for Advancement of Cost Engineering International (AACEI). This completed draft document formed the starting point for submission to ASTM International and initiation of the process of formulating it as an ASTM standard.

To ensure that both public and private sector stakeholders would have access to the ECES, and that everyone would be using the same cost element structure, the ECES was submitted to the ASTM International[1] E06.81 Subcommittee on Building Economics to be considered for

[1] ASTM International, 100 Bar Harbor Drive, West Conshohocken, PA 19428

promulgation as an ASTM Standard Classification. The ECES document, titled *Classification for Life-Cycle Environmental Work Elements—Environmental Cost Element Structure*, was put in ASTM format and completed balloting through the consensus process 10 May 2001 as ASTM Standard E 2150, and was since revised on 2 October 2002 and 1 October 2004. The standard establishes a classification of the comprehensive hierarchical list of elements for life-cycle environmental work. The elements represent the life-cycle activities for environmental projects regardless of the project design specification, construction method, technology type, or materials used. The standard classification serves as a consistent reference for cost estimating, analysis, and monitoring during the various phases of the project life cycle, and applies to all environmental work, including environmental restoration, waste management, decontamination and decommissioning, surveillance and long-term monitoring, and technology development. Standard E 2150 establishes the first two levels of the cost structure. Yet some users require more details on environmental costs than two levels provide. Thus an ASTM Adjunct to support Standard E-2150, titled the *Environmental Cost Element Structure*, was originally approved 2 October 2002, and then revised on 1 October 2004 with the new stock number ADJE2150A. It provides three additional, complementary levels (Levels 3, 4, and 5) of cost structure to the ECES classification's Levels 1 and 2.

CURRENT ECES WBS STRUCTURE

ECES consists of a comprehensive list of elements (tasks, items, or products) required to accomplish an environmental project. ECES is organized in hierarchical levels where the lower level detailed data are summarized to upper, higher levels. As the Level numbers increase, the more the details are included at each level. In general detailed ECES elements do not need to be developed for each of the phases: Planning, Pesign, Construction, Operations and Maintenance, and Environmental Monitoring because the ECES uses a matrix approach and the same title, is used for all phases for each environmental technology (ECES components) but with different phase-specific meaning, e.g., excavation (planning), excavation (design), excavation (construction), etc. Fig. 1 illustrates the hierarchical nature of the ECES cost structure, which allows detailed cost data at Level 3 to be summarized into higher level cost elements in a standardized fashion

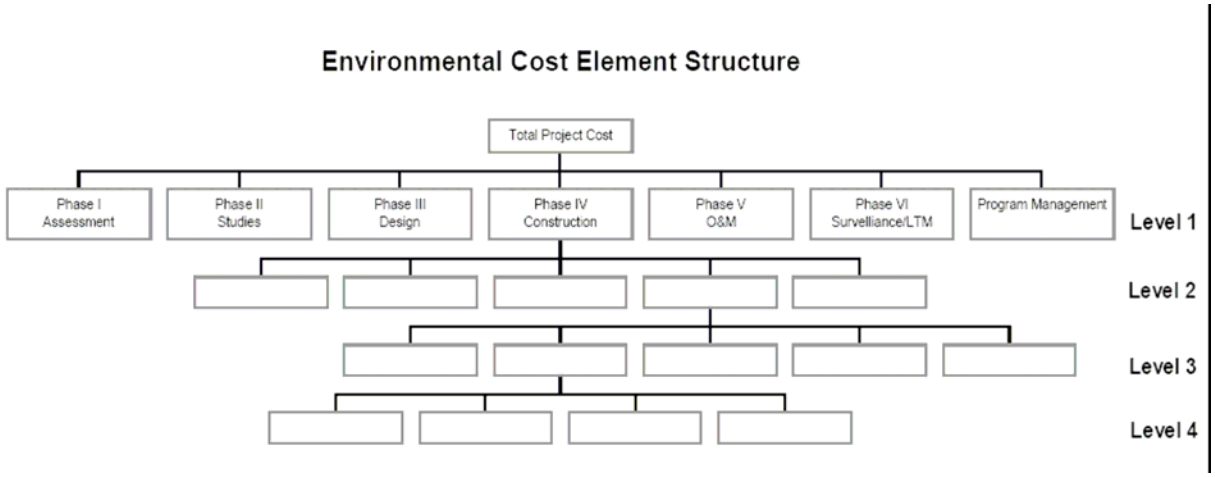

Fig. 1. Hierarchical structure of the environmental cost element structure

To limit the number of cost elements in the ECES, units of measure (or metrics) which affect cost are included (e.g., data on extraction wells such as diameter, depth, and flow rate for each well in addition to the total number of wells). The ECES is listed as a common standard through its top two levels in ASTM Standard 2150-04. The use of levels three through five is contained in the Adjunct to the standard dated October 2002.

Each level of the ECES is briefly described in the following sections.

Level 1

Level 1 of the structure includes seven cost categories. The first six categories represent the six life-cycle phases of an environmental project. The final category, Program Management, support and infrastructure or crosscutting activities, is included to address costs that are not attributable to a distinct phase or are attributable to all phases, such as program/project management costs. Throughout the document, the Level 1 cost element for cross cutting or multiphase costs such as Program Management, Support and Infrastructure are referred to as Phase 8 or by the use of the letter "X" in the phase column. This method simplifies references to multiphase Level 1 cost elements. Phase 7 is reserved for future use. With minor variations in the definitions, these project life-cycle categories apply to all environmental projects and programs including environmental remediation, waste management, decontamination and decommissioning, ordnance and explosive retrievals, underground and above ground storage tanks, and other environmental work.

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Phase 1: **Assessment** - Assess and inspect site, prepare site inspection

Phase 2: **Studies** - Risk assessment, characterization and investigations, reports, development and analysis of treatment or remediation options, and treatability studies.

Phase 3: Design -Engineering design and pre-construction activities of treatment or remediation alternatives. **Phase 4: Construction** - Construction of selected treatment or remediation alternatives. Includes start-up, but excludes all operations.

Phase 5: Operations and Maintenance (O&M) - Includes all operations and maintenance for the selected treatment or remediation alternatives. Phase ends when clean up or waste treatment goals are met.

Phase 6: Surveillance and Long-Term Maintenance (SLTM) - Operations have ceased or were not integral to selected treatment or remediation alternatives.

Phase 7: Reserved

Phase 8 (or the letter "X") : Crosscutting or Program Management, Support and Infrastructure -Program wide activities that are required, but cost is not specific to a single or distinct project.

The seven level one cost elements are illustrated in Fig. 2.

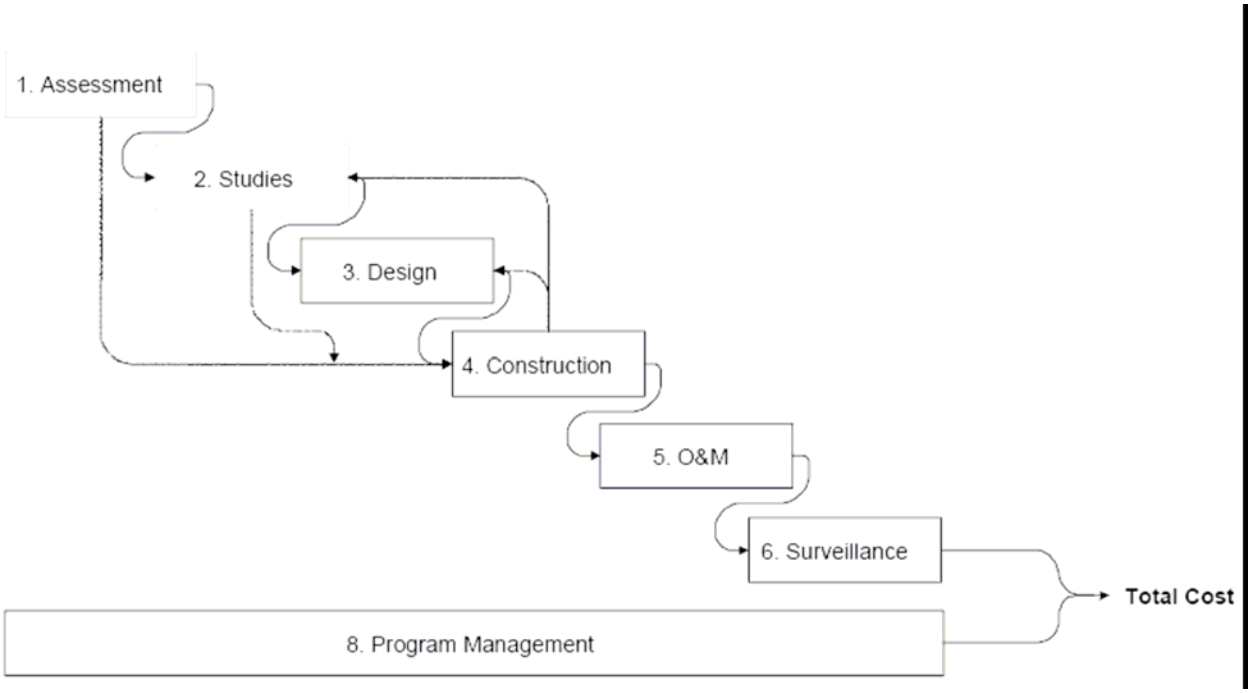

Fig. 2. Level 1 cost categories

Level 2

Level 2 of the ECES represents major elements necessary to perform work in an environmental project. There are 34 elements included in this structure, shown in Table I. Whereas Level 1 represents timeframe of when the activity is occurring, Level 2 and lower levels show what tasks or activities are being conducted. Level 2 elements are identified in the second column or the second set of numbers in the ECES number system. It should be noted that in the Level 2 structure, Level 2 elements are marked with life-cycle phase numbers in the left columns. These numbers represent the general applicability of that phase to that element. This is not necessarily all inclusive. There may be cases where that element may be applicable for a phase that is not marked. This structure is flexible, and the user can use other phases even though they are not marked in the columns.

Level 3

Level 3 of the structure consists of more detailed elements required to perform the tasks at the Level 2 of the ECES.

Level 4

The use of the Level 4 ECES elements is generally optional for most environmental cleanup technologies except decontamination and decommissioning (D&D). The very technology of D&D itself resides at Level 3; therefore at Level 4 and below it is required to define the actual work. To aid users to define Level 4 or whatever the lowest cost element selected, a standard generic lowest level breakdown is included.

Table I. ECES Levels 1 and 2

Level 1								Level 2	
Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Cross Cut (8)	Sub Proj.	Major Work Elements	
1	2	3	4	5	6	8		.01	PROGRAM MANAGEMENT, SUPPORT & INFRASTRUCTURE (OPTIONAL)
1	2	3	4	5	6	8		.02	PROJECT MANAGEMENT & SUPPORT (Operable Unit/Solid Waste Management Unit)
1	2	3	4	5	6	8		.03	PREPARATION OF PLANS
1	2	3	4	5	6			.04	STUDIES/DESIGN & DOCUMENTATION
1	2	3	4	5	6	8		.05	SITE WORK
1	2	3	4	5	6	8		.06	SURVEILLANCE & MAINTENANCE
1	2	3	4	5	6			.07	INVESTIGATIONS & MONITORING/SAMPLE COLLECTION
1	2	3	4	5	6			.08	SAMPLE ANALYSIS
1	2	3	4	5	6			.09	SAMPLE MANAGEMENT/DATA VALIDATION/DATA EVALUATION
	2	3						.10	TREATABILITY/RESEARCH & DEVELOPMENT
			4	5				.11	TREATMENT PLANT FACILITY/PROCESS
			4	5	6			.12	STORAGE FACILITY/PROCESS
			4	5	6			.13	DISPOSAL FACILITY/PROCESS
			4					.14	ORDNANCE & EXPLOSIVES REMOVAL & DESTRUCTION (CWM is in X.11 & X.20-X.30)
			4					.15	DRUMS/TANKS/STRUCTURES/MISC. & REMOVAL
			4		6			.16	AIR POLLUTION/GAS COLLECTION & CONTROL
			4	5	6			.17	SURFACE WATER/SEDIMENTS CONTAINMENT, COLLECTION, OR CONTROL
			4	5	6			.18	GROUNDWATER CONTAINMENT, COLLECTION, OR CONTROL
			4	5	6			.19	SOLIDS/SOILS CONTAINMENT (e.g., CAPPING/BARRIER), COLLECTION, OR CONTROL
			4	5	6			.20	LIQUIDS WASTE/SLUDGES CONTAINMENT (e.g., UST/AST), COLLECTION OR CONTROL
			4	5				.21	IN SITU BIOLOGICAL TREATMENT
			4	5				.22	EX SITU BIOLOGICAL TREATMENT
			4	5				.23	IN SITU CHEMICAL TREATMENT
			4	5				.24	EX SITU CHEMICAL TREATMENT
			4	5	6			.25	IN SITU PHYSICAL TREATMENT
			4	5				.26	EX SITU PHYSICAL TREATMENT
			4	5				.27	IN SITU THERMAL TREATMENT
			4	5				.28	EX SITU THERMAL TREATMENT
			4	5				.29	IN SITU STABILIZATION/FIXATION/ENCAPSULATION
			4	5				.30	EX SITU STABILIZATION/FIXATION/ENCAPSULATION
			4	5				.31	FACILITY DECOMMISSIONING & DISMANTLEMENT
1	2	3	4	5				.32	MATERIAL HANDLING/TRANSPORTATION
1	2	3	4	5				.33	DISPOSAL
			4	5				.34	AIR EMISSION AND OFF-GAS TREATMENT
1	2	3	4	5	6	8		.9x	OTHER

PROPOSED ENHANCEMENTS TO THE ECES WBS STRUCTURE

An extensive review was recently conducted of the cost elements (i.e., work items performed) of a major DOE site remediation project completed in October 2005, and those cost elements were compared to the elements contained in the ECES. The project was characterized by great scope and complexity. An immediate conclusion was that while the ECES would certainly be applicable to projects of that nature, the substantial project planning and cost management advantages of the ECES could be materially enhanced through the incorporation of certain additions and changes. Although relatively few in number, these additions and changes will increase the definition of project scope that can be readily encompassed by the ECES, and will also increase the flexibility of the ECES in accommodating a variety of desired project elements, whether the contemplated project be large or small. Several suggested areas for enhancement are discussed below.

Removal Actions

The ECES is adequate with respect to removal actions related to buildings, equipment and utility systems. It is, however, deficient regarding removal actions involving "in-ground" facilities and structures, i.e., waste pits, ponds, trenches, drains, pipelines, concrete/asphalt pads, and contaminated soil.

Waste Management

In many cases, the waste generated in an environmental remediation project contains contaminants that are highly toxic, highly reactive, highly corrosive, radioactive, or some combination thereof, and require special inspection, handling, packaging, staging, storage, and transport methods. It is believed that the ECES currently accommodates these requirements only in a very general way and is in need of greater levels of detail. Further, the whole subject of waste management could possibly be separated from transportation, a move that would require some restructuring of the pertinent ECES sections.

Amendment of Official Regulatory Documents

All environmental remediation projects performed under Federal law require certain prescribed documents (e.g., RI/FS, Proposed Plan, ROD), and the governing agencies frequently require modification and amendment prior to final approval. On occasion, such changes can consume significant resources to complete; thus the ECES needs to provide for the change process.

Instrumentation

The vast amount of surveying, sampling and testing inherent in environmental remediation projects, particularly in the field, has given rise to use of a wide variety of instrumentation, some of which can add significant costs. Elements may need to be added that will allow identification of various types of instrumentation applicable to the project's environmental costs.

Baseline Development and Management

Baseline documents describing project scope, cost and schedule are standard documents used in planning and managing some environmental remediation projects. They are not currently included in the ECES. Thus, additional elements may be needed in the ECES structure to accommodate these activities and costs.

In contemplating the ECES changes discussed above, it is unlikely that Level 2 would be affected, i.e., they would generally require changes (addition or modification) at Level 3 or below. Also, some changes and additions have been suggested that could, in various sections of the ECES, enhance its utility by increasing and clarifying the project cost detail available. These types of changes would typically involve the adding new elements at Levels 4 and/or 5.

BENEFITS TO ADOPTING THE ECES AS A UNIFORM COST STRUCTURE

Any professional who is involved in environmental remediation projects, either in the day- to-day operations or looking at the projects from management perspective, can readily attest to the value of having a uniform code of accounts/structure. The benefits can be realized throughout a project's life cycle, from preliminary planning and estimating to the final close out. A uniform structure will provide the basis for more accurate and defensible cost estimates in the initial phases of the project, will provide the base for performance measurement during the execution phase and, at project close-out, provide a basis for future planning and cost estimating in similar types of projects. Some of the specific benefits that can be achieved by adopting a uniform project cost structure are listed below.

- Incorporating the ECES Work Breakdown Structure (WBS) into the site-specific WBS will ensure that site-level scope and cost data can be captured, organized, analyzed, and exchanged using a consistent format
- The ECES WBS can be used as a checklist of activities to be performed in a project.
- Contractors' cost estimates submitted in the ECES WBS framework will facilitate validation of cost and scope proposals by the owners
- A consistent framework will provide environmental remediation professionals with the capability to review and assess costs for similar work at the same or at other sites
- Improved performance measurement is accomplished when both the initial estimate and the actual costs incurred utilize a consistent format
- A consistent framework facilitates meaningful and easy roll-up of cost information

NEW CHALLENGES – A HISTORICAL COST DATABASE

Cost estimating is a critical business decision element that plays an important role in several key areas: development and award of new contracts, managing existing contracts, independent estimates, ongoing project management, and cleanup alternative selections. Quality, accuracy, and timeliness of cost estimating are all vital to the successful accomplishment of these key business areas.

Currently, DOE is housing its cost-data for completed projects into a historical database: the Environmental Cost Analysis System (ECAS). The ECAS system breaks down the completed-cost financial data into standardized and comparable environmental cost categories, accomplished by using the Environmental Cost Element Structure, as the basis for the system content.

Potential Benefits to an Environmental Cost Database

A good knowledge of historical costs is central to any cost estimating process. Environmental cleanup activities are relatively new when compared to traditional cost estimating activities. For the Department of Energy, a database of past environmental projects is important for both preparing DOE estimates and for evaluating a contractor's cost estimate. However, when using historical costs, care must be taken; superficially similar environmental projects can have unique drivers that could dramatically affect costs.

The ECAS financial data should prove useful in preparing estimates for the acquisition process, as benchmark data to manage ongoing project costs, and providing baseline cost data to compare cleanup technology alternatives. Potential results from the use of the ECAS cost database are summarized below:

- More accurate cost estimates for future projects and planned technologies
- Bids and contracted costs for environmental work can be validated with the best possible cost information
- Determine the estimates of cost savings for deployment of new technologies
- New baselines and technologies can be applied to the field with better cost information.

CONCLUSION

We have outlined the current status of development of the ECES, a standardized and well defined hierarchical listing of cost categories. This system is currently mature and is readily available as an ASTM standard. It readily offers applications for preparing and comparing estimates as well as the new potential as the backbone for a historical environmental cost database.

However, this system is not static. In order to best serve its intended purposes in this dynamic industry there is a need to apply this system and make changes as new technologies and methodologies arise. Your participation and comments with respect to changes and additions to the ECES are requested at this session or at any time in the future to discuss any omissions and better determine the strengths and weaknesses of the ECES in a variety of applications. This can be accomplished by participation in the ASTM Building Economics Subcommittee (E06.81) or by directly contacting any of the authors of this paper[2] during the upcoming year.

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