08:15:59 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 10/10/94

Active

Project #: E-20-W22 Cost share #: Rev #: 1
Center # : 10/24-6-R8249-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: S5301.003 Mod #: 1 Document : CONT
Prime #: F08635-93-C-0068 Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: CIVIL ENGR Unit code: 02.010.116
Project director(s):
FROST J D CIVIL ENGR
VANEGAS J A CIVIL ENGR (404)-

Sponsor/division names: DELTA RESEARCH CORPORATION / NICEVILLE, FLA
Sponsor/division codes: 203 / 055

Award period: 940301 to 941231 (performance) 941231 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	27,327.00
Funded	0.00	27,327.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: ENVIROMENTAL LIFE CYCLE COST ESTIMATING FOR WEAPONS SYSTEMS

PROJECT ADMINISTRATION DATA

OCA contact: Brian J. Lindberg 894-4820

Sponsor technical contact

STEVE TOWER
(904)897-5380

DELTA RESEARCH CORPORATION
1501 WILSON BLVD.
ARLINGTON, VA 22209

Sponsor issuing office

PAMELA CARRINGER
(703)247-8329

CONTROLLER
DELTA RESEARCH CORPORATION
1501 WILSON BLVD., SUITE 1200
ARLINGTON, VA 22209

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A N/A supplemental sheet
Equipment title vests with: Sponsor GIT
NONE PROPOSED OR ANTICIPATED.
Administrative comments -
AMENDMENT NO. 1 EXTENDS PERIOD OF PERFORMANCE THROUGH DECEMBER 31, 1994.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 04/26/95

Project No. E-20-W22 Center No. 10/24-6-R8249-0A0

Project Director FROST J D School/Lab CIVIL ENGR

Sponsor DELTA RESEARCH CORPORATION/NICEVILLE, FLA

Contract/Grant No. S5301.003 Contract Entity GTRC

Prime Contract No. F08635-93-C-0068

Title ENVIROMENTAL LIFE CYCLE COST ESTIMATING FOR WEAPONS SYSTEMS

Effective Completion Date 941231 (Performance) 941231 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	
Other	N	

Comments

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

NOTE: Final Patent Questionnaire sent to PDPI.

Georgia Tech

School of Civil & Environmental Engineering

Georgia Institute of Technology
Geotechnical Engineering Program
Atlanta, Georgia 30332-0355
USA
404•894•2282
404•894•2281 FAX

June 1, 1994

E 20 - W 22
1

Mr. Marland Thurston,
Delta Research Corporation
1501 Merchants Way
Niceville
Florida 32578

Dear Marland,

Please find attached the final copy of our report describing the activities and findings of the workshop on **"Environmental Life Cycle Cost Estimating for Weapons Systems"** was held from April 19 to 22 at Callaway Gardens near Atlanta, Georgia. We have enjoyed working with you and your colleagues on this project and look forward to continuing our association with you on other projects.

Sincerely,

J. David Frost, PhD, PE, PEng
Associate Professor of Civil Engineering
Geotechnical Program Coordinator

Final Report

Workshop on

Environmental Life Cycle Cost Estimating for Weapons Systems

Submitted to

Headquarters Air Force Civil Engineering Support Agency
Tyndall AFB, Florida 32403-5319

through

Delta Research Corporation
Niceville, Florida 32578

Prepared by

The Center for Sustainable Technology and the
School of Civil and Environmental Engineering
at the Georgia Institute of Technology
Atlanta, Georgia 30332-0355

June, 1994

Principal Investigators:

J. David Frost
Associate Professor of Civil Engineering
Georgia Institute of Technology
Atlanta, GA. 30332-0355

Jorge A. Vanegas
Associate Professor of Civil Engineering
Georgia Institute of Technology
Atlanta, GA. 30332-0355

EXECUTIVE SUMMARY

A multi-perspective workshop on **"Environmental Life Cycle Cost Estimating for Weapons Systems"** was held from April 19 to 22 at Callaway Gardens near Atlanta, Georgia. The primary purpose of the workshop was to convene a selected group of experts from the Department of Defense, the regulatory community, other government agencies, industry, consultants and academia to provide input collectively in establishing a solid theoretical framework for a system specification for a life cycle environmental costing system. This report summarizes the activities and findings from the workshop.

A framework that allows for integration of an environmental cost element structure at any level within a weapons system work breakdown structure was proposed and endorsed by all participants. A general process was proposed for performing an environmental cost component analysis wherein a sequential procedure is followed depending on the amount of data/information available.

To assist in identifying a framework for an environmental cost component analysis for a specific weapons system, a methodology which uses a matrix approach to identify the relationships between the categories from the environmental cost element structure and the various phases of a weapons system development program was identified. Additional relationship tables allow for identification of existing models, costing methodologies and information/data requirements at each matrix cell.

A consensus was reached among the participants on a number of issues including broadly defining what are environmental costs and what information is currently available. An effort was also made to assess priorities for development and implementation based on an informal survey. The survey asked participants to assess the current ability to effectively cost each item on the component cost element structure, to indicate the importance of each item on the component cost element structure as a major environmental cost driver and to estimate what they considered the probability of success of developing a model and database to cost each item on the component cost element structure within a two year period. Given the subjective nature of the results of the survey conducted during the workshop, additional surveys of a more rigorous nature will be required to provide a more substantive data set on which to base future activities. The workshop concluded with all participants indicating the most important items they had learned as a result of attending the meeting.

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WORKSHOP DESCRIPTION

Overview

Over the past decade the Department of Defense (DoD) and the military services have recognized that protecting the environment is a critical element of national defense policy. Major programs have been initiated to remediate past environmental problems and to ensure that current and future defense programs and activities are performed in an environmentally sensitive manner. DoD and the services have recognized that environmental concerns need to be integrated into every facet of the military mission including base operations related to new weapons system development, logistics and disposal. OSD has initiated an approach to addressing environmental concerns called Conservation, Compliance, Cleanup, and Pollution Prevention (C^3P^2) based on the need for an integrated approach to environmental issues which recognizes that there are many ways for DoD to meet its environmental stewardship goals.

Recognizing that remedial environmental programs can be expensive, DoD is seeking to implement procedures to enable the planning and execution of environmental aspects of their activities in an economically prudent manner. Economic analysis methods can be used to help DoD and the services make fact based decisions that balance the need for life cycle costs and the value received from environmental programs. Independent reviews have indicated that there are no tools currently available to address this need in a comprehensive manner. Accordingly, the Air Force is in the process of developing a comprehensive economic analysis approach that can be used by them and the other services to support environmental decision making.

The Air Force development plan included the sponsorship of a workshop on environmental life cycle cost estimating so that a resource document of potential issues, problems and solutions would be available as a basis for future activities. As a result, a multi-perspective workshop on **Environmental Life Cycle Cost Estimating for Weapons Systems** was held from April 19 to 22 at Callaway Gardens near Atlanta, Georgia. This report is submitted to the Headquarters Air Force Civil Engineering Support Agency (HQ AFCESA) through Delta Research Corporation by the Center for Sustainable Technology and the School of Civil and Environmental Engineering at the Georgia Institute of Technology to summarize the activities of the workshop.

Workshop Approach

The primary purpose of the workshop was to convene a selected group of experts from the Department of Defense, the regulatory community, other government agencies, industry, consultants and academia to provide input collectively in establishing a solid theoretical framework for a system specification for a life cycle environmental costing system. A list of participants is given in Appendix I. The workshop was aimed at identifying environmental issues of specific

concern to DoD and the services. Participants who provided special expertise and perspective on issues of concern and the current state of the industry in each area were identified in advance of the meeting. The workshop attempted to identify technical and economic issues and, where possible, solutions or recommended approaches for economic evaluation were developed.

The workshop organization was led by Dr. J. David Frost and Dr. Jorge A. Vanegas of the School of Civil and Environmental Engineering at Georgia Tech and Dr. F. Michael Saunders, Director of the Office of Environmental Science, Technology and Policy at Georgia Tech. They worked closely with personnel from Delta Research Corporation and the Air Force in developing a comprehensive pre-workshop plan. Organizational meetings were held in advance involving individuals from these various groups as necessary. The agenda for the workshop is shown in Figure 1.

Description of Workshop Activities

A preliminary agenda was developed by the organizers in advance to the workshop that was, by design, somewhat broad in scope but intended to be flexible so that the participants from the different employment sectors (government, industry, consultants and academia) would be able to jointly contribute to its final structure. As a result, the opening half-day of the workshop was dedicated to a number of activities which were intended to stimulate ideas and promote participant input into better defining the workshop agenda. Keynote lectures were given as follows:

- Dr. Jean-Lou Chameau, Director of the Center for Sustainable Technology at the Georgia Institute of Technology made a presentation outlining the need for sustainable development and technology as illustrated in Figure 2. He illustrated his talk with examples of current activities from around the world ranging from integrated limestone injection systems that capture acid rain causing sulfur dioxide before it enters the atmosphere to automobile recycling programs wherein the manufacturer agrees at the time of purchase to buy-back an automobile when its useful life is spent. The philosophy embedded in the latter example was a frequent point of reference during the workshop.

- Dr. Earl Beaver, Director for Waste Minimization with Monsanto Corporation made a presentation describing the benefits of including environmental costs in life cycle estimates given the exponentially increasing amount of legislation. His succinct discussion of the benefits of self-enforcement and in particular, recognition of the trend and hence implications associated with the growth of environmental laws as depicted in Figure 3 had a significant impact on workshop discussions related to uncertainty and hence evaluating the risk component of environmental life cycle cost estimates.

- Dr. Rita Gregory, Director of the Construction Cost Management Group at the Headquarters Air Force Civil Engineering Support Agency gave a briefing outlining the initiatives and activities that had preceded the workshop. She discussed the distinction between detailed cost analyses and review cost estimating and explained the role of both in the development of a weapons system as illustrated in Figure 4. Dr. Gregory also spent a significant amount of time in clarifying the distinction between "the cost of doing business" environmental costs and environmental costs associated with a specific weapons system. While this distinction was clear conceptually as shown in Figure 5, it remained as a frequent point of discussion throughout the workshop because of different perspectives about what could be considered "the cost of doing business". In other words, participants recognized the two distinct cost categories, but remained uncertain as to how to assign costs in a number of cases.

Following the keynote lectures, the participants were assigned to one of four concurrent breakout groups, provided with a copy of the preliminary agenda and asked to critically evaluate it in light of their experiences and perspectives. The opening afternoon concluded with an hour long plenary session where the findings of these breakout groups was discussed and synthesized to define the structure for the breakout sessions during the following two days. Some additional minor changes in the breakout structure were implemented as the workshop progressed to reflect unanticipated issues and concerns as they were encountered. The complete structure of the breakout sessions included 4 sequential half day efforts as illustrated in Figures 1 and 6 as follows:

- Breakout Session 2A - Cost Universe and Bounds
- Breakout Session 2B - System Information Requirements
- Breakout Session 3A - Component Cost Analysis
- Breakout Session 3B - Environmental Costing Data and Methodologies

The schedule for the final half-day of the workshop was established at the end of the two days of breakout sessions and was aimed at developing a consensus among the participants on a number of key issues.

Workshop Results

The principal results of the workshop can be most succinctly presented with a number of figures and charts. They are presented here in the final format that was agreed to in principal by the workshop participants.

As a result of discussions in Breakout Session 2A, Cost Universe and Bounds, and Session 2B, System Information Requirements, an **Environmental Cost Element Structure (ECES)** as shown in Figure 7 was agreed to. While the three breakout groups in Session 2A were to examine

the session topic from the perspectives of (i) component cost analysis structure issues (CCA), (ii) conservation, compliance, cleanup, and pollution prevention issues (C^3P^2), and (iii) life cycle issues, and the three Session 2B groups were to look at system information requirements for the acquisition, operation and support (O&S) and disposal and demilitarization (D&D) phases respectively, all independently arrived at essentially the cost element categories listed in the table. Discussion in the plenary sessions following Breakout Sessions 2A and 2B resolved a few minor variations.

More importantly, a **framework for integrating this environmental cost element structure at any level of a weapons system Work Breakdown Structure (WBS),** as shown in Figure 8, was proposed by one of the breakout groups and following discussion was endorsed by all participants during the subsequent plenary session. As can be seen in the figure, the framework allows for integration of the ECES at any level within the WBS, depending on the level of detail required in a given cost estimate.

Having established the format for the ECES and identified the framework for integrating it into the WBS, the Breakout Groups in Session 3A, Data and Methodologies, and Session 3B, Environmental Costing Data and Methodologies, were asked to respond to a number of specific questions including:

- what cost analysis models are available ?
- what procedure should be used in selecting a cost analysis model ?
- what data exists ?
- what format is the data in ?

Following breakout group examination of these questions, a general process was proposed for performing an **environmental cost component analysis (ECCA)** as shown in Figure 9. Within this process, a sequential procedure is followed depending on the amount of data/information available. For example, if limited data is available, then it may be appropriate to use an analogy type costing method. On the other hand, if significant data is available, the use of a design/parametric model may be justified. It is noted that this process for performing an environmental cost component analysis can be performed for any item of the environmental cost element structure at any level within the work breakdown structure as shown in Figure 10.

To assist in identifying a framework for an environmental cost component analysis for a specific weapons system, the methodology shown in Figure 11 was proposed. Through the use of a matrix approach, the relationships between the categories from the environmental cost element structure for the various phases of a weapons system development program are identified. Additional

relationship tables allow for further identification of existing models, costing methodologies and information/data requirements at each matrix cell.

Given the framework for environmental cost component analysis as illustrated in Figure 10, the final half-day session focused on developing a consensus among the participants on a number of issues including:

- defining what are environmental costs
- identifying what information is currently available
- prioritizing development and implementation strategies
- summarizing participant perspectives as a result of the workshop

Breakout group and plenary session discussions led to the following points of agreement:

- Environmental cleanup and remediation of weapons related activities of the current and past decades indicate that all costs are not included in defense industry projects.
- Current and projected environmental regulations have created an apparent need to clearly and explicitly identify "environmental costs" of weapons systems.
- Requirements to identify costs reported separately from those of weapons systems as "environmental costs" are to be addressed as follows:

    - The weapon system cost analysis requirement document (CARD) must have all environmental (C^3P^2, etc.) requirements and environmental goals/directives stated explicitly. The goal of the component cost element structure and its integration into the CCA process is to examine environmental quality issues.
    - All environmentally-related costs are therefore fully integrated into the life-cycle cost of a weapons system, just as are other categories of costs (eg. weight limitations, radar avoidance requirements, target detection and combat maneuverability). Therefore, although environmental issues may stimulate process changes or system improvements in weapons systems, the costs for these changes and improvements inherent in the acquisition process are difficult and, in some cases, impractical to separate from other costs.
    - If required to identify "environmental costs" associated with the introduction of a weapons system, the consensus on which costs are to be specified as "environmental costs" are those costs directly associated with compliance-driven activities (eg. processes, equipment, fees, labor, materials). These costs are those that can be directly allocated to meeting specific regulations and directives imposing the limitation on environmental impacts.

- In some scenarios, separate reporting of "environmental costs" may be required or mandated. This approach is inappropriate given the above integration of these costs into the overall design and costing of the weapons system.

Given this consensus, an effort was made to assess priorities for development and implementation based on an informal survey. The survey asked participants to assess the following items:

- current ability to effectively cost each item on the component cost element structure
- importance of each item on the component cost element structure as a major environmental cost driver
- probability of success of developing a model and database to cost each item on the component cost element structure within a two year period.

Examples of the score sheets used to conduct this survey are shown in Figures 12 and 13. The summarized results of this survey are given in Figure 14. The results of this survey are highly subjective and as a result their significance will not be discussed in detail. They do provide an indicator of where efforts and resources might be allocated. For example, a high composite score reflects a line item where the current ability to effectively cost it is high, the item is considered to be of importance as a major environmental cost driver and the probability of success of developing a model and database to cost the item within a two year period is high. Clearly, additional surveys of this nature would be required to provide a more substantive data set on which to base future activities than the survey reported herein.

The final plenary session of the workshop involved all participants to identify what they considered was the most significant item they had come to realize as a result of their participation. The comments are summarized by participant affiliation (consultant, government, industry) in Appendix II.

Workshop on:

Environmental Life Cycle Cost Estimating for Weapons Systems

April 19–22, 1994

Callaway Gardens Resort
Atlanta, Georgia

Sponsored by:
U.S. Air Force

AGENDA

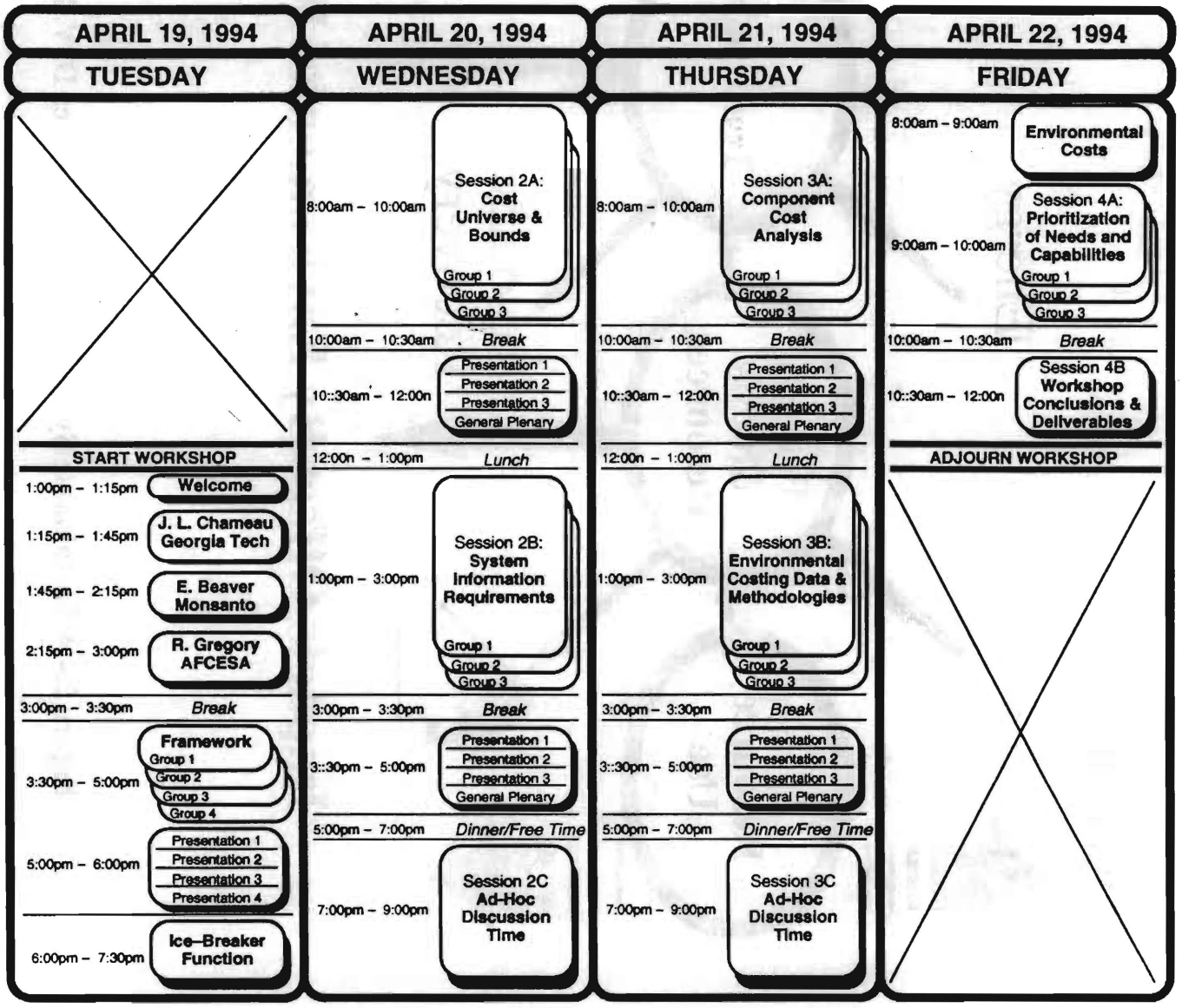

Figure 1.– Workshop Agenda

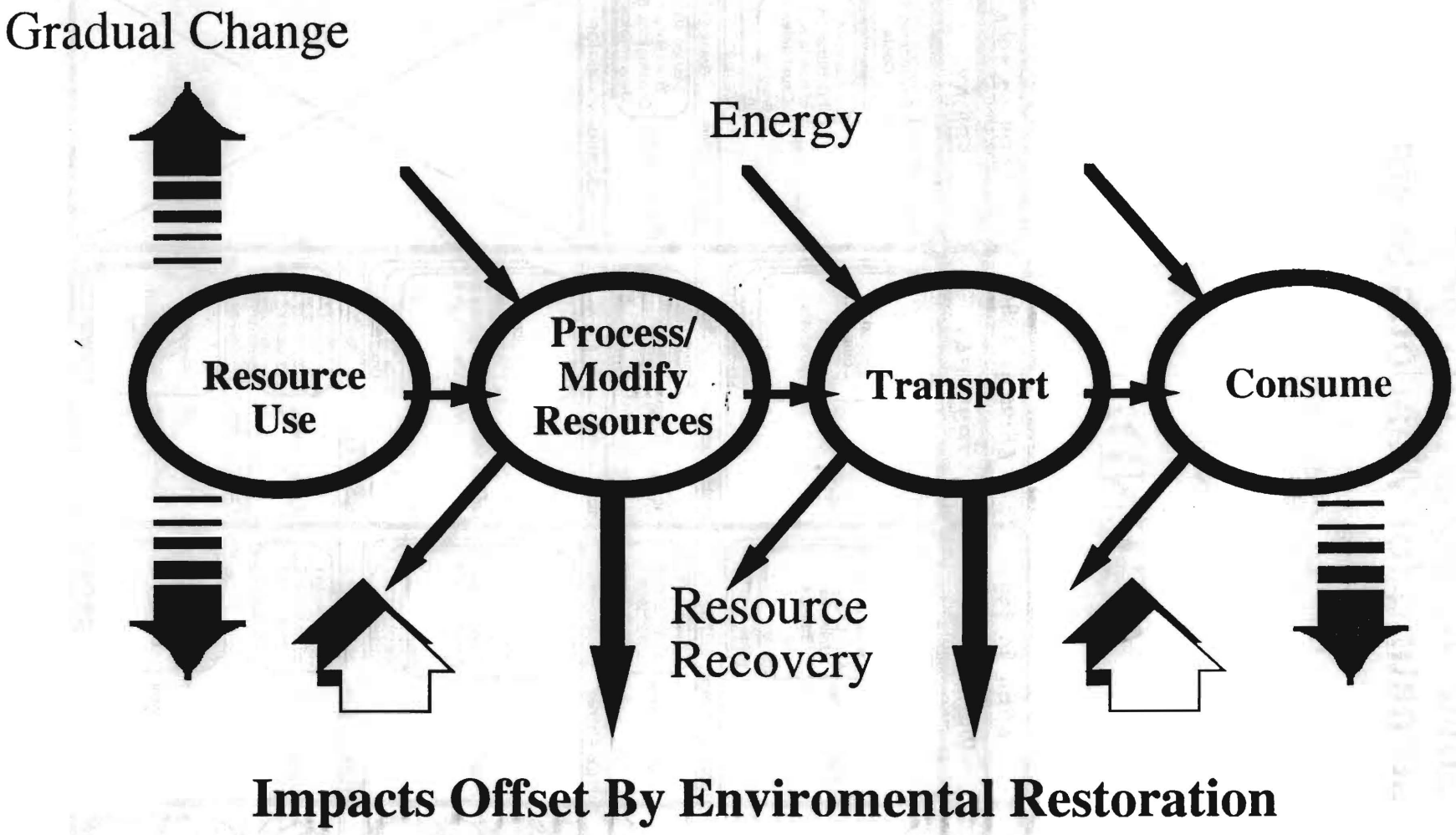

Figure 2.– A Sustainable System for Humans (after D. V. Roberts, 1990)

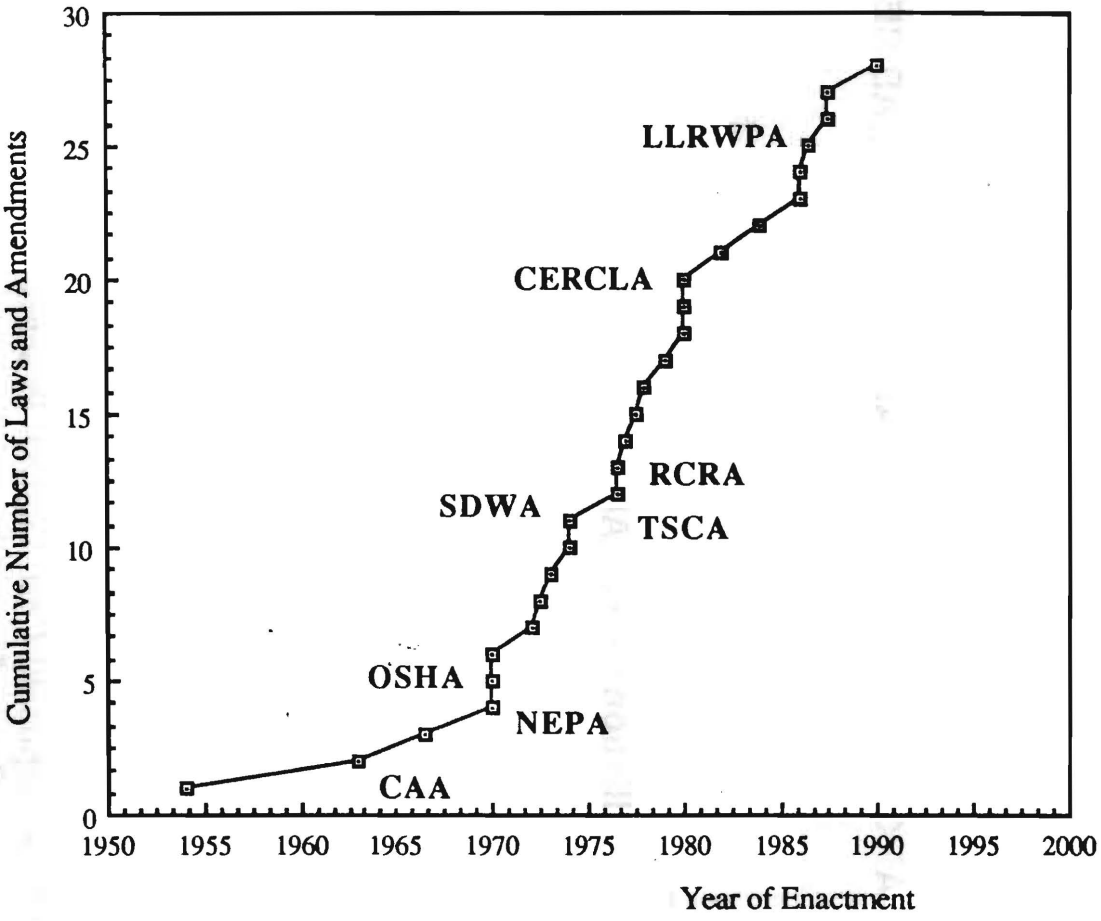

Figure 3.- Growth in Environmental Legislation

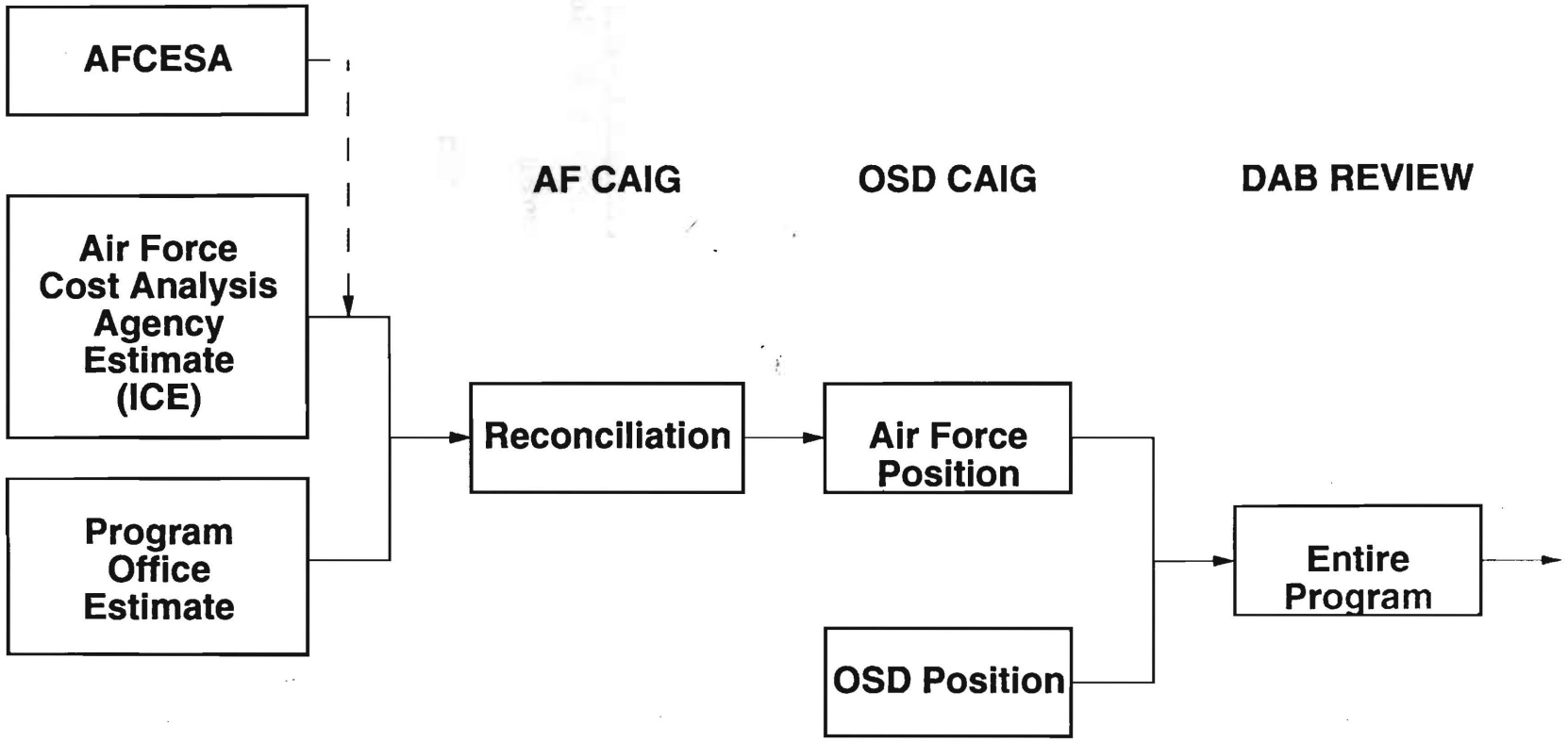

Figure 4.– Component Cost Analysis Process (after K. Held, 1994)

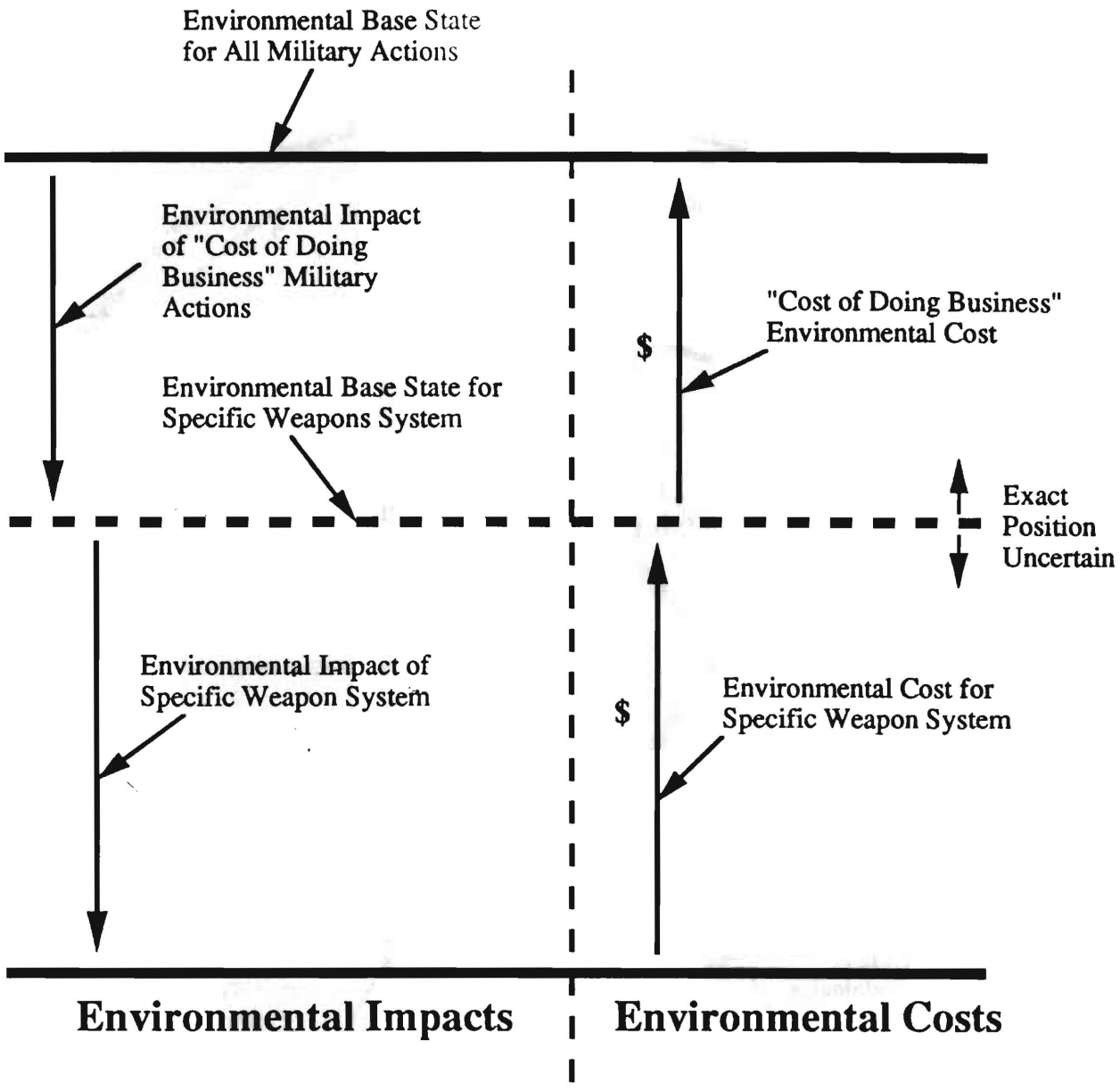

Figure 5.- Environmental Costs (adapted from A. Bennett, 1994)

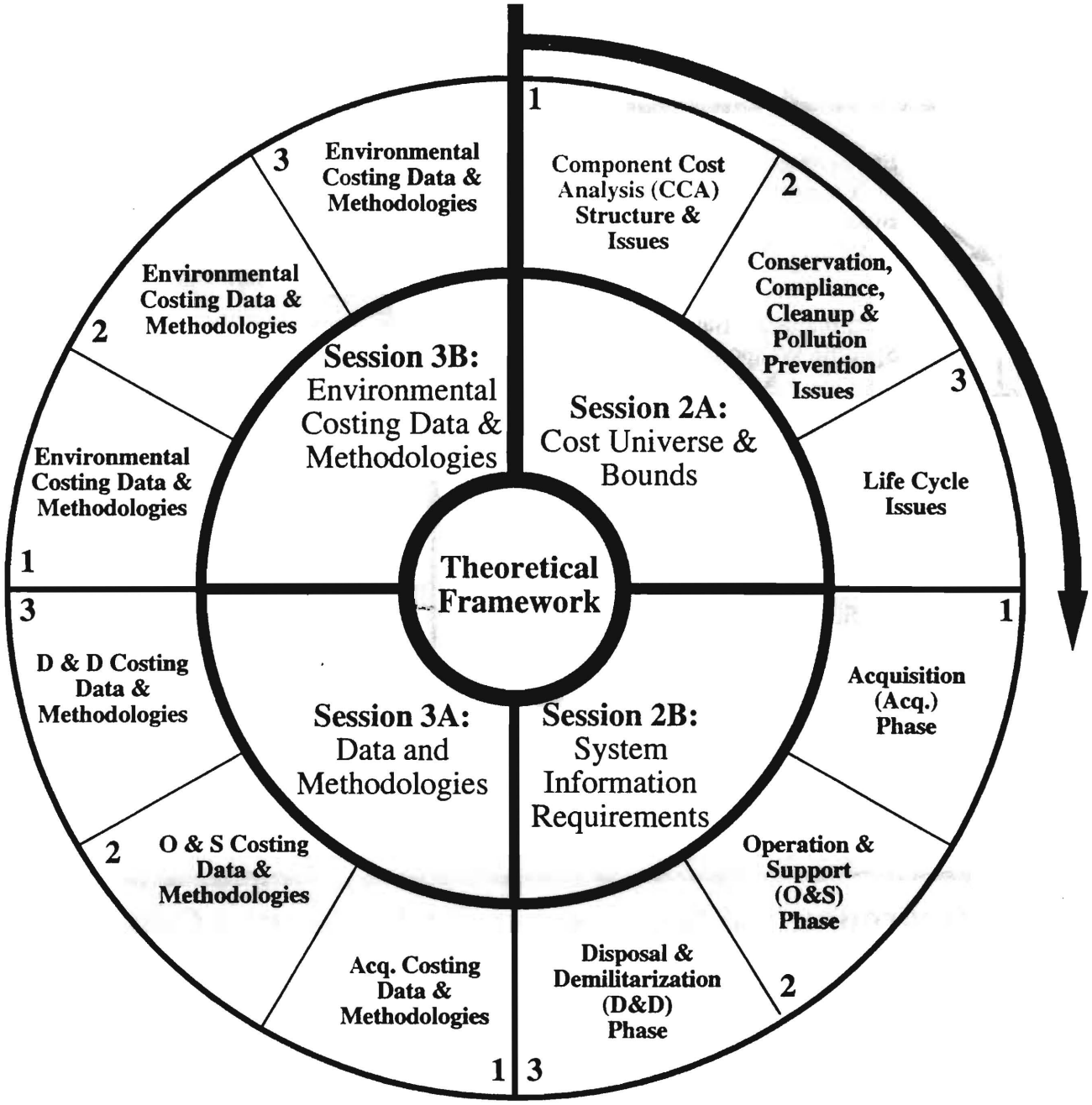

Figure 6.– Structure of Breakout Sessions

Categories	Principal Cost Areas
Compliance	• Air • Water • Solids (Non–Hazardous Materials & Waste) • Hazardous Materials • Hazardous Waste (Including Radioactive) • Noise • Special Compliance Reporting
Pollution Prevention	• Air • Water • Solids (Non–Hazardous Materials & Waste) • Hazardous Materials • Hazardous Waste (Including Radioactive) • Noise
Conservation	• Preservation of the Natural Habitat • Preservation of Cultural and Archeological Resources • EIS/EA
Restoration	• Water • Soil • Materials
Management	• Planning • Program Management • Program Support • Training/Certification • Auditing
Cost Risk	• Compliance • Pollution Prevention • Conservation • Restoration • Management • Unknowns

Figure 7.– Environmental Cost Element Structure (ECES)

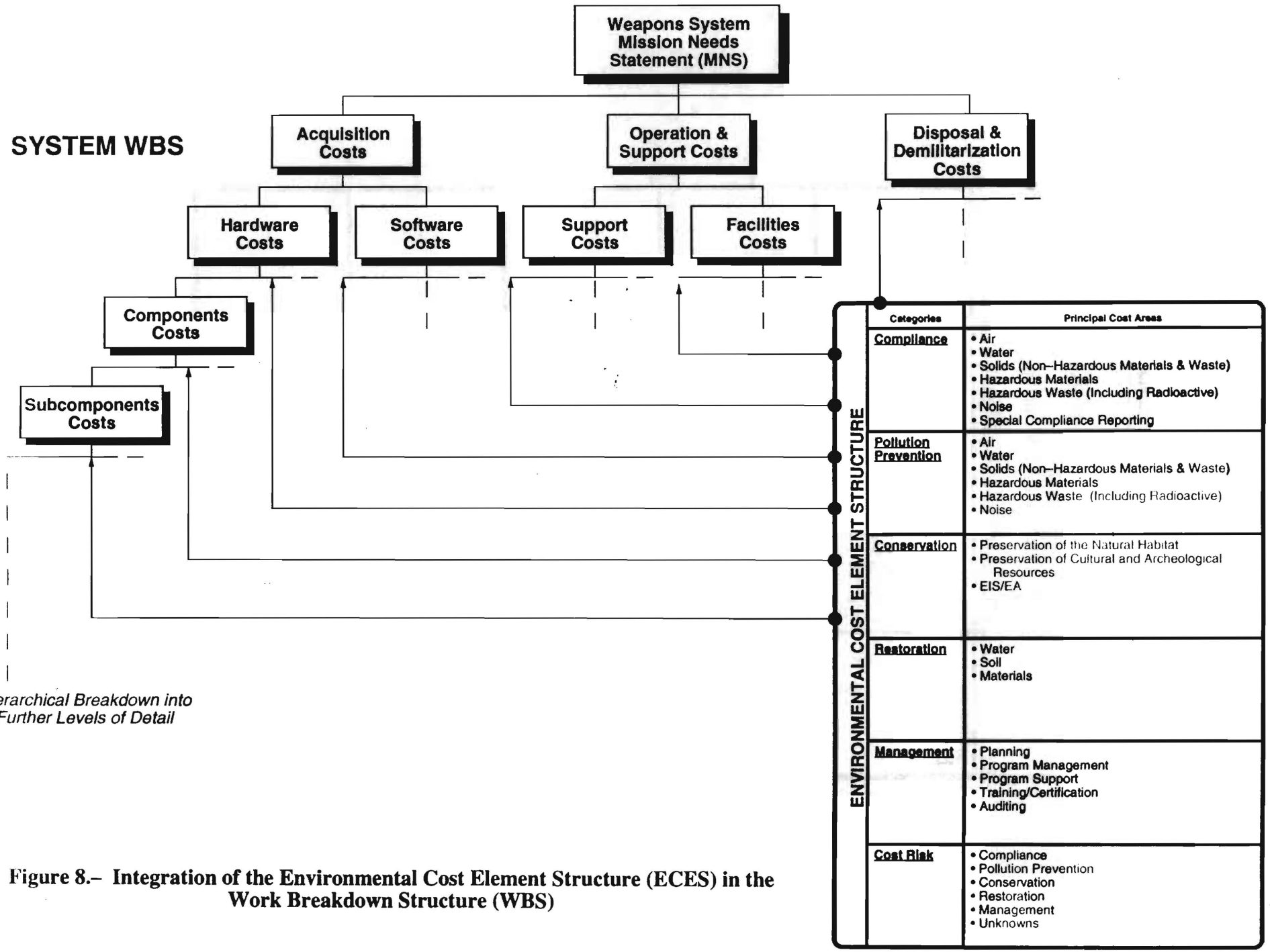

Figure 8.– Integration of the Environmental Cost Element Structure (ECES) in the Work Breakdown Structure (WBS)

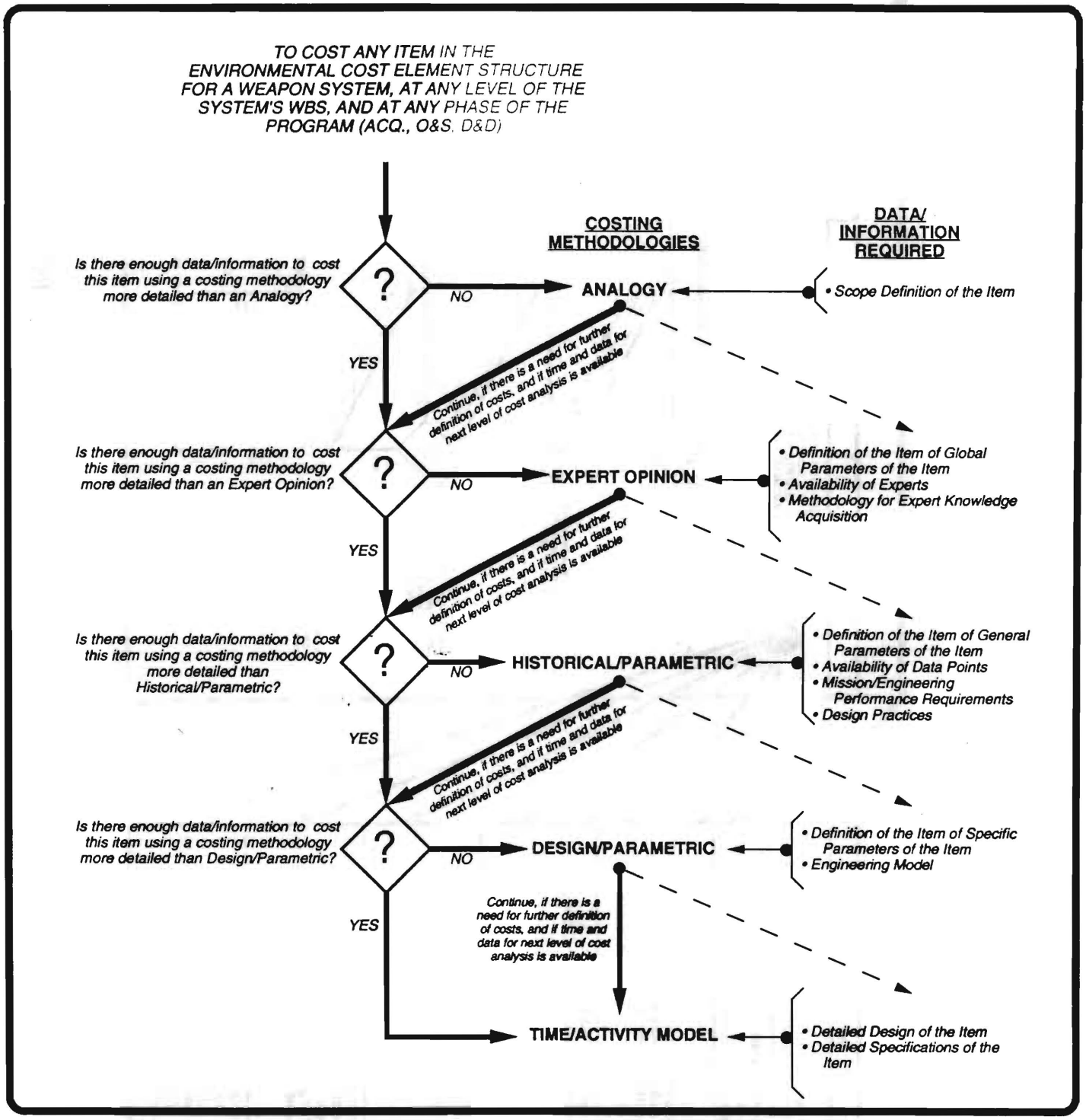

Figure 9.– General Process for an Environmental Cost Component Analysis (ECCA)

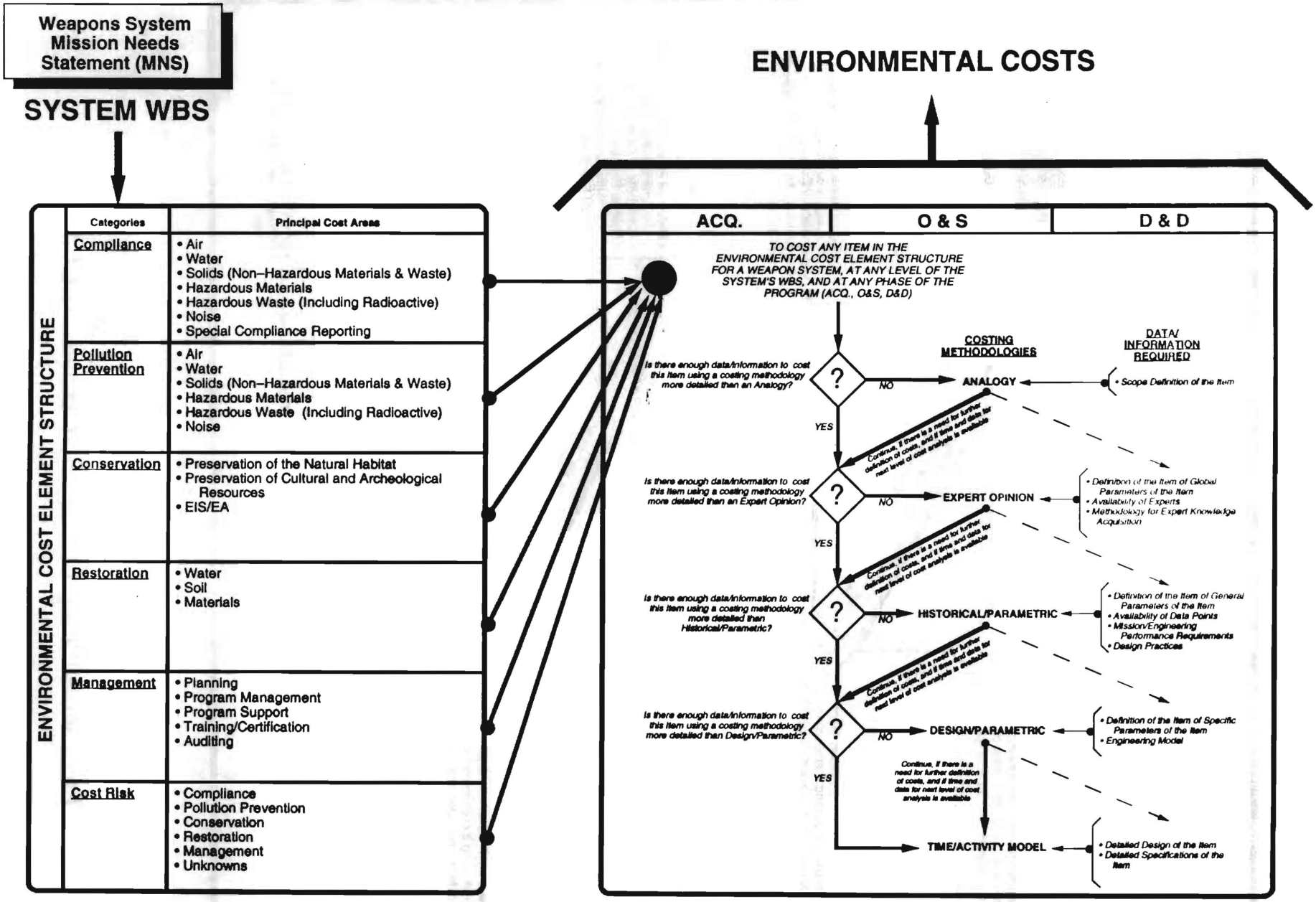

Figure 10.– Framework for an Environmental Cost Component Analysis (ECCA)

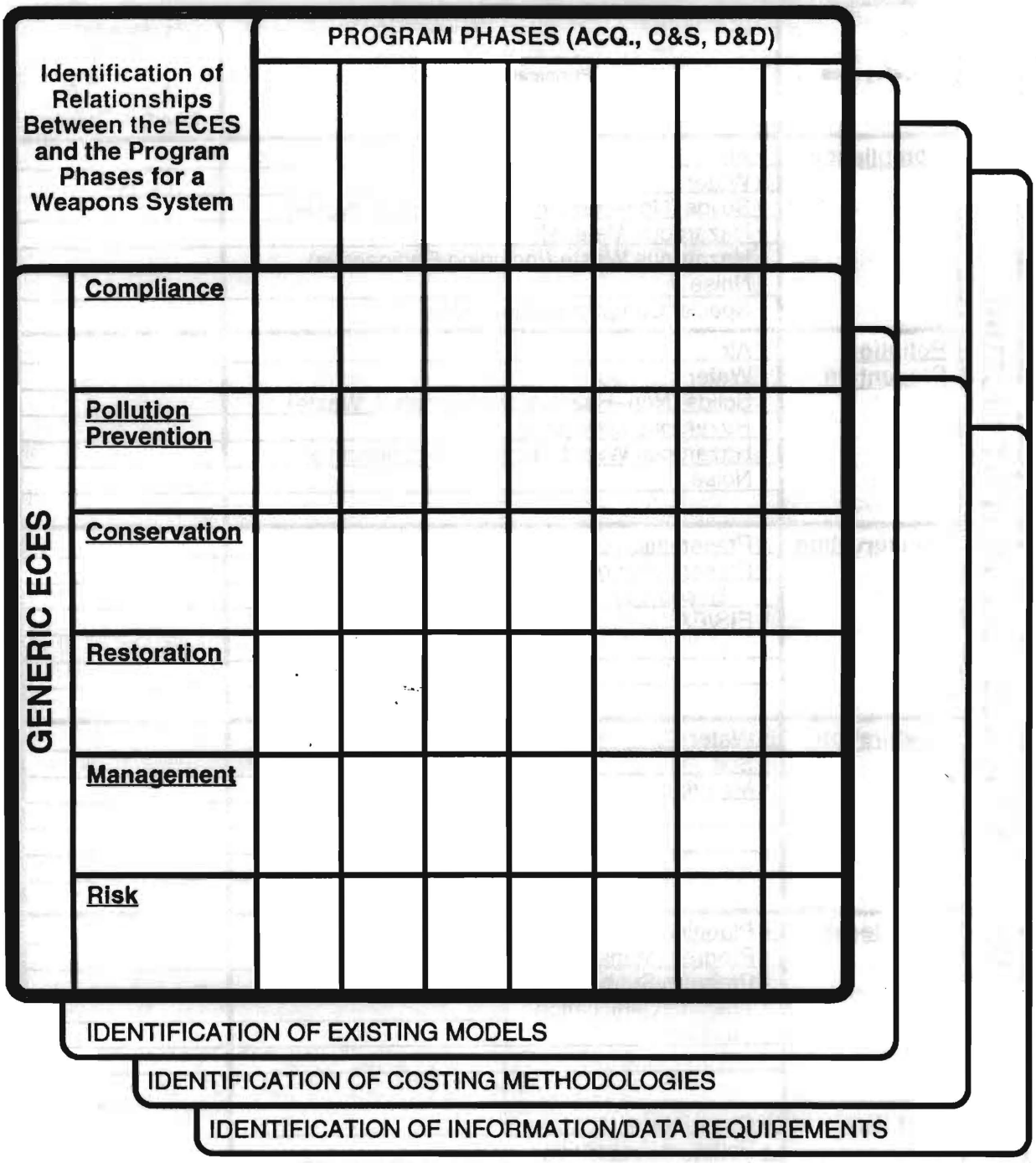

Figure 11.– Methodology for Developing an Environmental Component Cost Analysis (ECCA)

Please provide your assessment of our current ability to effectively cost each line item, both from a methodology and a data points of view.

ENVIRONMENTAL COST ELEMENT STRUCTURE

Categories	Principal Cost Areas	Assessment of Ability 1 – 5 (good) (poor)
Compliance	• Air	
	• Water	
	• Solids (Non–Hazardous Materials & Waste)	
	• Hazardous Materials	
	• Hazardous Waste (Including Radioactive)	
	• Noise	
	• Special Compliance Reporting	
Pollution Prevention	• Air	
	• Water	
	• Solids (Non–Hazardous Materials & Waste)	
	• Hazardous Materials	
	• Hazardous Waste (Including Radioactive)	
	• Noise	
Conservation	• Preservation of the Natural Habitat	
	• Preservation of Cultural and Archeological Resources	
	• EIS/EA	
Restoration	• Water	
	• Soil	
	• Materials	
Management	• Planning	
	• Program Management	
	• Program Support	
	• Training/Certification	
	• Auditing	
Cost Risk	• Compliance	
	• Pollution Prevention	
	• Conservation	
	• Restoration	
	• Management	
	• Unknowns	

Figure 12.– Assessment of Priorities for Development and Implementation – Part 1

*Please provide your **assessment of :***
***(1) the importance** of each line item as a major **environmental cost** driver, and*
***(2) the probability of success** of developing a model and a database **of the cost item** by the end of Fiscal Year 1995.*

ENVIRONMENTAL COST ELEMENT STRUCTURE

Categories	Principal Cost Areas	Assessment of Importance 1 – 10 (low) (high)	Assessment of Probability of Success 0.01 – 0.99 (low) (high)
Compliance	• Air		
	• Water		
	• Solids (Non–Hazardous Materials & Waste)		
	• Hazardous Materials		
	• Hazardous Waste (Including Radioactive)		
	• Noise		
	• Special Compliance Reporting		
Pollution Prevention	• Air		
	• Water		
	• Solids (Non–Hazardous Materials & Waste)		
	• Hazardous Materials		
	• Hazardous Waste (Including Radioactive)		
	• Noise		
Conservation	• Preservation of the Natural Habitat		
	• Preservation of Cultural and Archeological Resources		
	• EIS/EA		
Restoration	• Water		
	• Soil		
	• Materials		
Management	• Planning		
	• Program Management		
	• Program Support		
	• Training/Certification		
	• Auditing		
Cost Risk	• Compliance		
	• Pollution Prevention		
	• Conservation		
	• Restoration		
	• Management		
	• Unknowns		

Figure 13.– Assessment of Priorities for Development and Implementation – Part 2

ENVIRONMENTAL COST ELEMENT STRUCTURE

Categories	Principal Cost Areas	(1) Average Ability	(2) Average Importance	(3) Average [Importance x Probability]	(4) Composite Score: [(1)x(2)x(3)]	(5) Ranking
Compliance	• Air	2.72	7.83	4.96	13.50	1
	• Water	2.38	7.46	5.00	11.90	5
	• Solids (Non–Hazardous Materials & Waste)	2.41	5.75	3.84	9.24	
	• Hazardous Materials	2.55	7.88	4.85	12.40	3
	• Hazardous Waste (Including Radioactive)	2.66	8.46	4.92	13.10	2
	• Noise	3.14	3.83	1.74	5.46	
	• Special Compliance Reporting	2.55	5.38	3.29	8.39	
Pollution Prevention	• Air	3.45	6.67	3.23	11.10	8
	• Water	3.17	6.42	3.26	10.30	
	• Solids (Non–Hazardous Materials & Waste)	3.07	5.42	2.90	8.90	
	• Hazardous Materials	3.14	7.25	3.82	12.00	4
	• Hazardous Waste (Including Radioactive)	3.24	6.88	3.69	11.90	5
	• Noise	3.52	4.00	1.67	5.87	
Conservation	• Preservation of the Natural Habitat	3.41	4.88	2.00	6.82	
	• Preservation of Cultural and Archeological Resources	3.21	4.13	1.84	5.92	
	• EIS/EA	2.66	5.58	3.54	9.42	
Restoration	• Water	2.45	6.96	4.83	11.80	6
	• Soil	2.28	6.79	4.68	10.70	
	• Materials	2.55	6.29	4.31	11.00	9
Management	• Planning	2.93	5.54	3.63	10.60	
	• Program Management	2.69	6.13	4.38	11.80	6
	• Program Support	2.83	5.67	4.00	11.30	7
	• Training/Certification	2.76	5.58	4.00	11.00	9
	• Auditing	2.97	5.29	3.67	10.90	10
Cost Risk	• Compliance	3.76	6.71	2.89	10.90	10
	• Pollution Prevention	3.97	6.08	2.44	7.25	
	• Conservation	3.79	5.63	2.41	9.15	
	• Restoration	3.72	6.33	2.69	10.00	
	• Management	3.76	5.92	2.77	10.40	
	• Unknowns	4.62	6.21	1.87	3.82	

Figure 14.– Results of the Assessment of Priorities for Development and Implementation

(Based on Individual Assessments of Workshop Participants)

APPENDIX I - Workshop Participants

APPENDIX I

Workshop Participants
Environmental Life Cycle Cost Estimating for Weapons Systems

Callaway Gardens Resort
April 19-22, 1994

NAME	COMPANY	PHONE	FAX
John Barfield	Boeing Defense & Space Group P.O.Box 3999 MS 8A-53 Seattle, WA 98124-2499	(206) 773-8650	(206) 773-2787
Andrew Bennett	Lockheed Aeronautical Systems Co. D173-06, Zone 0685 86 South Cobb Drive Marietta, GA 30063	(404) 494-3762	(404) 494-6355
Earl Beaver	Monsanto Company 800 N. Lindbergh Blvd. St. Louis, MO 63167	(314) 694-6087	(314) 694-8425
Thomas Burns	HQ AFCESA/DC 139 Barnes Dr. Ste. 1 Tyndall AFB, FL 32403-5319	(904) 283-6230	(904) 283-6499
Jean-Lou Chameau	Georgia Tech School of Civil Engr. Atlanta, GA 30332-0355	(404) 894-2202	(404) 894-2278
Jacque Crenca	CH2M Hill 6060 S. Willow Drive Englewood, CO 80111-5142	(303) 771-0900	(303) 741-4623
John Dorsett	SAF/FMC 1111 Jefferson Davis Hwy. - Suite 403 Arlington, VA 22202	(703) 604-0387	(703) 604-6646

NAME	COMPANY	PHONE	FAX
Kevin Dykema	Martin-Marietta Astronautics P.O. Box 179 Crystal Gateway North Washington, DC 20330	(303) 971-7397	(303) 977-3844
Bob Errera	Harris Corporation P.O. Box 37 M/S 11-8420 Melbourne, FL 32951	(407) 729-2273	(407) 727-5339
Dick Fontaine	Anser Corporation Suite 800 1215 Jeff Davis Hwy. Arlington, VA 22202	(703) 416-3146	(703) 416-3225
David Frost	Georgia Tech School of Civil Engr. Atlanta, GA 30332-0355	(404) 894-2280	(404) 894-2281
Traci Green	USACEAC SFFM-CA-AM 5611 Columbia Pike Falls Church, VA 22041-5050	(703) 756-0326	(703) 756-2601
Rita Gregory	HQAFCESA/DC 139 Barnes Dr., Ste.1 Tyndall AFB, FL 32403-5319	(904) 283-6230	(904) 283-6499
Allyn Griffiths	Teledyne-Brown Engr. Cummins Research Park Mail Stop 34 Huntsville, AL 35807	(205) 726-1764	(205) 726-2423
Wes Hammond	AFCESA 139 Barnes Dr. Tyndall AFB, FL 32403-5319	(904) 283-6261	(904) 283-6499
Paul Hardin	US Navy - NCA 3312 Wyndham Circle Apt. 203 Alexandria, VA 22302	(703) 604-0290	(703) 604-0315

NAME	COMPANY	PHONE	FAX
Tom Harter	USAF/CEV 1260 Pentagon Washington, DC 20330-1260	(703) 697-3355	(703) 697-3378
Kurt Held	AFCAA/FMM 1111 Jefferson Davis Hwy. - Suite 403 Arlington, VA 22202	(703) 604-0930	(703) 604-6646
Bill Hombach	CTAC 20404 Altavista Way Ashburn, VA 22011	(703) 729-6777	(703) 729-6744
Mike Kabjian	Weston 1 Weston Way, Bldg. 91N West Chester, PA 19380	(610) 701-3170	(610) 701-7455
Tom Korzenowski	General Dynamics Dept. 442, Sta. J11-431 75 Eastern Point Rd. Groton, CT 06340	(203) 437-5307	(203) 437-5203
John Long	TASC 2555 University Blvd. Fairborn, OH 45324	(513) 426-1040	(513) 426-8888
Gary Lowe	HQAFCESA/DC 139 Barnes Dr., Ste. 2 Tyndall AFB, FL 32403-5319	(904) 283-6230	(904) 283-6499
Tom Meitzler	ASC/ALTE 2475 K St., Ste. 1 Wright-Patterson AFB, Ohio 45324	(513) 255-8578	(513) 476-4828
Guy Northcutt	Lockheed 86 South Cobb Drive Marietta, GA 30063-0160	(404) 494-5754	(404) 494-9610
Charles Outlaw	ASC/EML, Bldg. 8 1801 Tenth St., Ste. 2 Wright-Patterson AFB, Ohio 45433-7626	(513) 255-3059	(513) 255-4155

NAME	COMPANY	PHONE	FAX
Jane Penny	Rust Environmental 3980 DeKalb Technology Parkway Suite 700 Atlanta, GA 30340	(404) 458-9309	(404) 458-9438
Richard Rast	Delta Research 1501 Merchants Way Niceville, FL 32578	(904) 897-5380	(904) 897-5388
Mike Saunders	Georgia Tech School of Civil Engr. Atlanta, GA 30332-0355	(404) 894-7693	(404) 894-9724
James Schorie	SMC/MEE 180 Skynet, St. 1508 Los Angeles AFB, CA 90245-4690	(310) 363-5607	(310) 363-3734
John Slaughter	Thiokol Strategic Operations Mail Stop K00 P.O. Box 689 Brigham City, UT 84302-0689	(801) 863-5458	(801) 863-8806
Marland Thurston	Delta Research 1501 Merchants Way Niceville, FL 32578	(904) 897-5380	(904) 897-5388
Steve Tower	Delta Research 1501 Merchants Way Niceville, FL 32578	(904) 897-5380	(904) 897-5388
Jorge Vanegas	Georgia Tech School of Civil Engr. Atlanta, GA 30332-0355	(404) 894-9881	(404) 894-2278
Betty West	HSC/EM 8213 14th Street Brooks AFB, TX 78235- 5246	(210) 536-5121	(210) 536-3228
Bob Wright	CH2M Hill 800 Fairway Dr., #350 Deerfield Beach, FL 33441	(305) 426-4008	(305) 698-6010

APPENDIX II - Participant Perspectives on Workshop

APPENDIX II - PARTICIPANT PERSPECTIVES

The final plenary session of the workshop involved all participants identifying what they considered was the most significant item they had come to realize as a result of their participation. The comments are listed by participant affiliation (consultant, government, industry) below.

CONSULTANT PERSPECTIVES

- Be prepared to acknowledge the fact that when we have a system that gives us a "true" environmental answer, it may be so politically unfavorable that either it will affect the viability of the program, or will provoke a change in the problem statement such that the resulting answer is easier to accept.

- Development of an environmental cost element structure was an important first step. Data is biggest problem (as it is with any cost study). If data is to be collected by weapon system, then it becomes a problem of apportionment. Many "environmental" costs are buried in other costs and are not easily separated.

- Developing a working cost model for environmental weapons systems is going to be very difficult, and may not be necessary, since many existing models solve parts of the problem and can be used in combination to solve the larger problem.

- If environmental costs and impacts for a major weapon system must be reported, a standardized system and methodology are required to produce the result. The government should define and sponsor construction of such a system. A basic structure for the system was agreed upon.

- There is a need for identifying specific activities that may have environmental impacts. Other needs include: definition of environmental costs; ranking of environmental cost drivers; and ranking of the most important model development activities.

- It is not clear what environmental estimates are required for the CCA. The CCA may or may not require that the environmental costs be explicitly stated. It was stated that if the manufacturing and operational units are in compliance with Federal, State, and local regulations, then the currently estimated Life Cycle Cost (LCC) already includes the environmental costs. It was also stated that reporting the portion of the component price, for example, has little importance and will be very difficult (expensive) to report. If environmental costs are reported in the CCA, then there is a concern that estimates will not be consistent between programs. It may be that only the demilitarization and disposal activities will require environmental estimates in the CCA. Only a database and estimating tool for disposal will be required. Industry should estimate all environmental cost in order to achieve the P^2 requirement, however. The establishment of a cost category structure, the collection of data, and the development of tools will be required to achieve these trade studies.

- The participants at the workshop seem to believe that the estimating of environmental costs for weapon systems in the near term will be hampered by historical (known) data. Less concern was voiced on the tools, methodologies, and techniques to do the estimating. Considerable work is left to be done by the defense community on the development of standardized CWBS's to define the LCC models for environmental cost analysis.

• The concepts and methodologies behind life-cycle environmental cost assessment are very similar for both the private industry and government sectors. The differences arise in the drivers for performing cost allocations which affect specific costs to be included (i.e., private vs. social) and the way in which these costs are categorized (i.e., compliance, P^2, .. vs. ecological, H_2S, L_{eg}/P_{eg}, Stakeholder Perception). Therefore, there should be more concurrent development of the underlying concepts and methodologies of LCEC in order to account for the efforts and experiences of both sectors.

• The distinction between private industry and the government sector is the customers served. Private industry customers are assumed to be other companies or individual consumers.

GOVERNMENT PERSPECTIVES

• We have a solid and strong WBS to collect and allocate environmental costs. We are still fuzzy on the meaning of environmental costs to ensure consistency across the board.

• It is a bigger challenge that I thought.

• We've concluded that the normal generic analysis process is applicable to estimating costs associated with environmental issues and developed a general environmental cost element structure. We have not concluded specifically what should be broken out. Although we may be able to model environmental processes, data limits current estimates.

• Environmental costing is difficult. The workshop gave us a good first view of what is required.

• The conclusion was made that environmental costs are those that can be tied to a specific regulation or directive. A lot of environmental costs are captured in overhead. The problem is what to break out separately or if the break out is required.

• Building databases is probable in all areas but availability of reliable data will force limitations.

• Top area for putting effort is compliance, P^2, management and Cost Risk. Need for consistency in writing cards, WBS's, specifications and looking at cost throughout DoD.

• Environmental costs are not collected by weapon system but are by facility and/or function. There is no clear definition of what environmental cost means. There is absolutely no consideration of externalities to DoD. System requirements must list explicit environmental requirements. Need for cost accounting system and database that captures and stores cost data by location, type, cost, function and weapon's system.

• The generic estimating process can be applied to the CCA process to try to identify environmental costs.

• I have a greater understanding of the problem of estimating environmental costs and why or when we might try to systematically tackle the problem. Some things that come to mind are:
  - -Should there be an MSV for D&D?
  - -Environment issues should be addressed when compliance involves activities other than the current way of doing business.
  - - As future cost data is gathered for production and O&S (i.e., H/W, support, maintenance), environmental costs should be captured and eventually be part of our historical databases.

The question is at what rate, if any, will our current cost factors/methodologies increase in the future in relation to increasing environmental requirements/regulations.

- I think the disposal phase needs to be addressed separately. This area of Life Cycle Environmental Cost is where there should be cost model development.

• As a government participant, I feel that the workshop successfully concluded that there is a way/ways to cost environmental cost by weapon system. Although the data may be hard to come by, I feel there is some hope as far as costing environmental issues.

• We developed a process for identifying if environmental costs are included in a weapon system's estimate. Relating to the process, we developed a matrix for showing where those are included within a weapon system. We may not be able to directly break out those costs, but the matrix can help show where they are.

• Environmental costs are difficult to quantify in a format that is easily reported. Many "environmental costs" cannot be separated from "operational costs". We must have a standard WBS in order to create a "model" and to be able to compare costs in order to assure environmental costs have been captured. This requires a clear definition of what really are "environmental costs".

• We defined a WBS for environmental costing - the "Box" (ECES). This is a guiding framework for all discussion, analysis, etc.

• We determined an approximate ranking of the relative importance of cost driving elements of a cost estimating system. The ranking of these elements varies greatly depending on the point of LCC at which the assessment is made. The model(s) produced as a result of this workshop can be valuable to both program managers and independent cost estimators.

INDUSTRY PERSPECTIVES

• There is no clear cut method of distinguishing the environmentally related costs of a product to a high degree of accuracy.

• Precise definitions of the type of environmental issues/factors (i.e., air compliance, air pollution prevention, etc.) are required and need to be standardized. Also, the "right" questions need to be asked of the parties providing the data, i.e. those who contribute to the environmental cost database.

• Preliminary cost element structure developed. Existing database/cost models are inadequate. New database/cost models must be developed and must be shared with industry.

• Environmental costs will be integrated as an element of the overall weapon systems cost. Funding of weapon systems must take into consideration these environmental costs. Need consistent approach to estimating cost.

• Environmental costs will be reported by contractors for each weapons systems. Procedures will need to be planned for and at a future date implemented to separate environmental costs associated with each program/contract. Need a definition of environmental cost across industry.

• It is important that the customer define explicitly what information they want tracked, how they want it tracked, and provide the funds to track it.

• The question I still have is "where is the value-added in tracking environmental costs?" Why are they different than any other cost? The weapons system needs to be costed at a number that

reflects all the costs no matter if they are environmental or not. The check is have they been included in the total costs?

- The most important number that is not being costed is at the D&D phase. We should look at establishing a milestone to reflect these costs more realistically in the time frame where they will be occurring.

- The identification and quantification of the cost impact of environmental considerations will become a part of the acquisition, operation, and ultimate disposal of all weapon systems in the future. Contractors will have to be responsive to and report on those factors.

- The issue of what defines an environmental cost (in general or for a weapon system) remains unresolved. An accounting approach was adopted for present purposes, but this begs the question of the total economic cost to which future programs may be held to account by society.