A. Standard Form 424

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D. Abstract

***Sorting Code**:* 2004-P3-S6 – Resources

Title: AWARE: Facilitating Informed Consumer Purchasing Decisions through Point-of-Sale Access to Product Sustainability Information ***Project Period:*** Sept 30, 2004 – May 30, 2005
EPA Project Amount: $9,945 ***Total Project Amount:*** $28,945
Faculty Advisor: Steven J. Skerlos ***Institution:*** University of Michigan, Ann Arbor, Michigan
Student Represented Departments and Institutions: Departments of Mechanical, Electrical and Computer, Civil, and Environmental Engineering and the Schools of Business Administration, Art and Design, and Natural Resources.

Project Summary:

Perhaps best exemplified by the "tragedy of the commons," barriers to sustainability may be as much socio-cultural as technological. In a market economy, industrial production of consumer goods and services is driven by patterns of decision-making in the marketplace, a largely socio-cultural activity. However, individuals make these decisions with little or no ability to "rationally" gauge the environmental influence of their ultimate choices. We feel there is a fundamental challenge to sustainability in designing an appropriate, practical, flexible access information system through which consumers can obtain and consider relevant environmental ramifications of the goods they purchase daily.

The Aware concept is proposed to address the challenge of informing consumers of the broader environmental repercussions of individual purchasing decisions at the Point-of-Sale. An appropriate scope has been mapped out for the project period of Phase I that will take advantage of the skill set of the investigators and yield a significant and concrete result. Specifically, the investigators propose to develop a prototype system, to be demonstrated with real products, composed of a portable device (PDA) used to scan product UPC barcodes and automatically retrieve product and producer information. This scope focuses not only on the technical elements of database design and wireless data transfer, but also on the collection, aggregation, and organization of data for a chosen class of products and the development of a method, or "aesthetic," of presenting this information to consumers at various levels of detail in a way that is understandable, practical, and customizable.

Our intent is to empower consumers to participate in the determination of tradeoffs regarding the type and form of the planet's prosperity. The availability of relevant information will support an adaptive education process between the consumer and the broader effects of relatively "ordinary" marketplace decisions, driving advancement towards sustainability culturally *and* technological sustainability.

Two primary objectives lie at the heart of this investigation. First is the development of a reasonable and pragmatic database and device to provide relevant life-cycle product characteristics to the consumer at the point-of-sale. Second is an evaluation of the potential influence the availability of such information has on consumer decision making. Given successful development of a prototype system (database and device), the investigators hope to examine the following question: can "private" preferences be contrasted with "public" consequences in the mind of the consumer? The investigators propose to assess, both before and after use of the prototype system, a population of consumers regarding their knowledge of such public consequences and their decisions in the marketplace via a voluntary program of surveying and direct observations.

The Aware project will provide three major avenues for implementation as an educational tool at the University of Michigan. First, both graduate and undergraduate students will be provided with the opportunity to collaborate in design teams towards the realization of Aware in four interdisciplinary capstone design courses. Second, members of the student organization Engineers Without Borders / Engineers for a Sustainable World will have the opportunity to participate through consultation and guidance of the design course teams as well as individual design projects. Finally, material developed throughout the Aware project will be incorporated into the growing DfE@UofM web resource, which provides engineering students and faculty with a on-line Design for Environment resource center.

E. Research Plan

1. P[3] Project Description

The proposed concept, termed "Aware", is intended to address the challenge of informing consumers at the point-of-sale of the broader environmental impacts relevant to individual purchasing decisions. An appropriate scope has been mapped out for the project period of Phase I that will take advantage of the skill set of the investigators and student design teams while yielding significant and concrete results. Specifically, the investigators propose to develop a prototype system, to be demonstrated with real products, composed of a portable device (PDA) used to scan product UPC barcodes and automatically retrieve product and producer information. The selection of an appropriate group of products is discussed below. This scope focuses not only on the technical elements of database design and wireless data transfer, but also on the collection, aggregation, and organization of data for the chosen class of products and the development of a method, or "aesthetic," of presenting this information to consumers at various levels of detail in a way that is understandable, practical, and customizable.

Figure 1. Consumers in developed markets are typically bombarded with a large number of products that have few fundamentally differentiating factors, and hence make decisions based mostly on price, brand, and packaging alone.

Figure 2. Handheld computers (PDAs) oufitted with UPC barcode scanners could function as an effective means to providiing additional information, such as environmental characteristics, to consumers at the point of sale.

1.1 Problem Definition

Perhaps exemplified by the "tragedy of the commons" [1] (Hardin, 1968), barriers to sustainability may be as much socio-cultural as technological. In a market economy, industrial production of consumer goods and services is driven by patterns of decision-making in the marketplace, a largely socio-cultural activity. However, individuals make these decisions with little or no ability to "rationally" gauge the ultimate social and environmental influence of their choices. For example, the automobile market is directed towards the satisfaction of "private" preferences - size, acceleration, style – as opposed to "public" or social preferences – reduced global warming impacts, air pollution, and resource consumption. We feel there is a fundamental challenge to sustainability in designing an appropriate information system through

[1] The "tragedy of the commons" states that situations where private benefits are obtained with public costs tend to lead to greedy decision-making, which results in negative global consequences; for example Global Warming / Climate Change as a result of distributed air pollution.

which consumers can obtain and consider tradeoffs among environmental impacts of the goods they purchase every day.

1.2 Innovation and Technical Merit

The Aware concept transcends the incremental optimization of individual technologies by instead facilitating systemic change by developing a framework for informed individual decision-making. In addition to regulation, the market can provide pressure on companies to make advancements towards sustainability by empowering consumers with knowledge that will enable them to include environmental and social tradeoffs in their decision-making process and direct their dollars toward companies who perform responsibly. While some companies have begun to use personal scanner devices as part of the shopping experience (AirClic, 2002), these efforts focus primarily on consumer convenience and health concerns rather than awareness of social and environmental impact. Organizations that do collect and publicize information on social and environmental performance of companies, such as the EPA Toxic Release Inventory (EPA, 2004) or Co-op America's "Responsible Shopper" website (Co-op America, 2004), provide information that is relatively easy to access; however, this information still requires consumer research and is not, in general, customizable, convenient, and available at the point-of-sale. Difficulties with available environmental data are addressed below. Overall, the Aware concept is to provide customizable information to consumers at the point-of-sale in a way that is practical and easy to understand while enhancing the shopping experience.

Design and development of this concept involves significant challenges. Existing personal digital assistant (PDA) handheld computers, portable UPC barcode scanners, wireless networking technology, and database management software can be utilized to realize Aware. However, significant technical challenges remain in developing a method to display useful, usable, and desirable information appropriately within the capabilities of a handheld computer, developing software to interface with the user and communicate with an online database via wireless connection, developing an appropriate structure for that database, developing a wearable or mounted method for using the device, researching environmental inventories for a set of products, and assessing usability and potential for influencing purchasing decisions. We detail plans for meeting these challenges through collaborations between the principal investigators and student design teams in several cross-disciplinary courses and student organizations in the coming sections.

Figure 4a. A Preliminary Aware concept.

Figure 4b. Each user defines characteristics which are most important for consideration in purchasing decisions.

Figure 4c. Scanning a product provides information and alerts for product characteristics that are important to the user. Consumers can also ask Aware to suggest alternative products that score well given the user's criteria.

1.3 Sustainability

A great proportion of the drive for sustainability is, appropriately, technological. Examples can be found in the engineering of renewable energy sources, non-polluting or net-shape manufacturing processes, pollution prevention efforts, and development of material recycling techniques. While these developments are crucial, we cannot ignore social influence in the drive for sustainability. In developed market economies, the industrial production of material goods and the provision of services are primary contributors to the accumulating degradation of the environment. With purchasing decisions, consumers support the conditions of production and provision, while they seldom have any knowledge or understanding of these conditions and therefore cannot make informed tradeoffs.

Currently, unsustainable activities, if addressed at all, are typically driven by restrictions made via direct governmental regulation or market interference in addition to voluntary technological improvements on the part of producers themselves. This process is certainly not disconnected from the market mechanism, illustrated by taxes levied on "luxury" goods or "gas guzzlers" and the effective use of tradable permits, however this process tends to be disconnected from the "everyday" purchasing decisions of consumers. For example, CO_2 taxes may influence purchasing decisions, although in practice the consumer may perceive only a higher monetary cost and simply search for a lower-cost substitute, potentially shifting impact instead of alleviating it. In short, we might say that artificially elevating prices to reflect shared social costs, like environmental impact, does not necessarily reflect the connection between the consumer, the product and its impact.

Recent history has seen significant reductions in environmental impact resulting from the deconstruction of barriers to the flow of information between the manufacturers and the general public. For example, The Dow Chemical Company has found economically reasonable ways to drastically reduce environmental emissions when faced with the requirement of making these figures available to the public, without any additional direct regulation of these emissions[2]. Such immediate consequences relate directly to the knowledge that the public has the power to mediate purchasing decisions with factors not present in the (strictly monetary) purchase price. Such benefits to the environment might be expected with the availability of the Aware system. In fact, the diffusion of sustainable technology into practice generally has little economic incentive without direct regulation or consumer demand for decreased environmental risk associated with production and use technology. This demand cannot occur without deconstruction of the barriers to a practical and usable flow of information between consumers and industry.

1.4 Measurable Results

The primary objective of the Aware concept is to increase the diffusion and quality of environmentally conscious decision-making in the marketplace. To this end we aim to find a suitable group of products to develop a prototype database. An effective categorization for such product groups exists in stores in which these products are commonly sold; for example, supermarkets (Kroger, Albertson's, Safeway) or consumer electronics stores (Best Buy, Circuit City, CompUSA). A primary result will then be the description of this product group, the resultant database with environmental characteristics, and the device capable of accessing and displaying this information on-demand.

[2] Between 1989 and 2002, they had achieved a 78 % reduction by weight for T.R.I. reported releases (Dow 2004).

Naturally, the selection of a product group will be driven by data availability and quality. Life-Cycle Assessment (LCA) studies have not been undertaken for most consumer products, and where LCA studies have been accomplished, they cannot, in general, differentiate between products on the market in the sense appropriate here: products on the market are in many ways very similar to one another, often differing in price, brand and packaging alone. LCA studies can provide consumers with a rationale to select between technological substitutes, such as use disposable paper filters or a single copper mesh filter for brewing coffee, although these studies are not yet undertaken in sufficient mass, breadth, or detail to allow for consumers to differentiate between more subtle market substitutes. For example, choosing one brand of coffee grounds over another could not be a decision predicated on currently available LCA studies. However, there does exist an international standard, ISO 14040, specifying appropriate procedures for data collection, presentation, and product labeling. Perhaps even more appropriate are the type of characterizations available through the Swedish Environmental Product Declarations (EPDs; EPD 2004).

In addition, the Aware system must be able to effectively communicate underlying technical data to consumers without negatively affecting the shopping experience. This aspect requires that we consider as an objective the ease and fluidity with which a consumer can use the device and database to learn about life-cycle environmental inventories of products in the selected group. Most important is the ability to immediately receive clear, qualitative characterizations of a product's impact, with respect to potential substitution goods, in a manner to which the consumer can relate. In addition, Aware should give the consumer the capability to make comparisons between chosen products in terms of the per-unit (e.g. ounce, liter for food goods) inventory data. Furthermore, to support an adaptive education process, the consumer must be able, but not

	Production	Consumer use	End of life (Sv)	Total
Non-renewable resources				
Material resources (kg)	188	15	0.005	203
Energy resources (kWh)	930	4080	0.11	5010
Renewable resources				
Material resources (kg)	1	192	0.07	193
Energy resources (kWh)	13	3240	-	3250
Energy consumption (kWh)	943	7320	0.11	8260
Emissions				
Greenhouse gases (kg CO_2-eq)	185	205	62	452
Ozone-depleting gases (kg CFC-eq)	0	0	0	0
Acidifying gases (mol H^+-eq)	52.3	9.3	2.6	64.2
Ground level ozone gases (kg POCP-eq)	0.08	0.05	0.14	0.27
Eutrophication compounds (kg$_2$O -eq)	4.4	2	0.7	7.1
Recyclable resources				
Materials (kg)	3.3*	-	47.3	50.6
Energy (kWh)	-	-	184	184
Waste (kg)				
Hazardous waste	0.09	0.16	0.16	0.41
General waste	284	262	7	553

* Data for the recycling at the supplier is not included.

Figure 3a. Environmental Product Declaration (EPD) data for an Electrolux Refrigerator.

PRODUCT DESCRIPTION

Electrolux ER 8801 C

Data for: Production/Use/EOL

	unit	value	
▽ **Non-Renewable Resources**			
Material Resources	(kg)	183	
Energy Resources	(kWh)	3170	
▽ **Renewable Resources**			
Material Resources	(kg)	111	
Energy Resources	(kWh)	1890	
Energy Consumption	**(kWh)**	**5060**	
▽ **Emissions**			
Greenhouse Gases	(kg CO_2-eq)	343	△
Ozone-Depleting Gases	(kg CFC-eq)	0	
Acidifying Gases	(mol H^+-eq)	50	▽
▽ **Waste**			
Hazardous Waste	(kg)	0.32	
General Waste	(kg)	402	

Figure 3b. Furthermore, the manner in which data is presented has a distinct impact on the capability of the audience to absorb the message and meaning of that data.

required, to traverse increasing levels of detail back to the original, quantitative characterization underlying the aggregated qualitative results along with appropriate background information, definitions, descriptions, and explanations. The method of presentation, or "aesthetic," will be a significant step towards bringing the environmental relevance of purchasing decisions to the consumer population.

1.5 Evaluation Method

Evaluation of the more concrete aspects of the Aware system, the product group and database, is relatively straightforward. The investigators plan to use the development experience to review the reduced scope of the Aware system proposed here to a full-scale Aware system.

Evaluation of a presentation "aesthetic" and the influence of environmental characteristics on point-of-sale decision-making is more challenging. As has been described, the average consumer in developed markets has neither the process nor access to the data required for informed and educated decision-making with respect to the environment. Evaluation of the effectiveness of the Aware system will take place through "before-and-after" survey and observation studies of volunteer subjects. Such studies are within the experience of the primary investigators. Again, this will lead to a great deal of insight for future developments. Perhaps most important will be evaluation of the chosen presentation "aesthetic" with respect to its capability to quickly present relevant and meaningful environmental characteristics in way that lends itself to comprehension.

1.6 Implementation Strategy

A detailed strategy for implementation of Phase I of the Aware concept is provided in Section 3. The strategy will be led by the team of primary investigators who will guide the project throughout the period and facilitate student design team involvement in developing various aspects of the project through several interdisciplinary design courses. A detailed discussion of the design courses is provided in Section 2. In short, implementation will involve research, design, and implementation of hardware, software, and conceptual components in addition to a testing phase to assess the potential impact of providing information to consumers at the point-of-sale through this system.

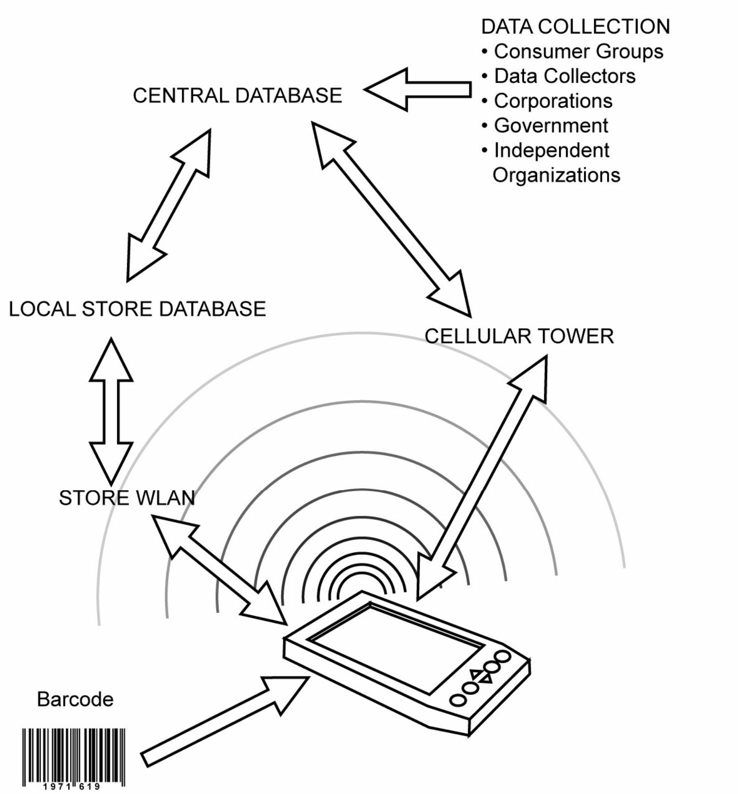

Figure 5. Flow of information in the Aware system. A large central database communicates with consumers either 1) through direct communication with the central database via the cellular system or 2) through a WLAN wireless connection to low-overhead local store databases keeping up-to-date information at reasonable costs. Queries for database entries are accessed on-demand by scanning the available product barcode.

2. Implementation of P^3 Concepts as an Educational Tool

The Aware project will function as an educational tool in several important ways. First, design, development, and implementation of Aware will be accomplished through the participation of several interdisciplinary student design teams from these courses (and possibly others):

- Mechanical Engineering (ME) 589, *Eco-Design and Manufacturing*, is an interdisciplinary course focused on applying environmental principals in manufacturing and design to reduce environmental impact associated with engineered products. This graduate-level course is typically attended by students from mechanical, chemical, civil/environmental engineering and the school of natural resources and the environment. A major component of the course is an open-ended eco-design and manufacturing term project, during which students focus on the application of the principles learned during the term in an area of interest or previous experience.
- Engineering (ENGR) 450 is a project-based interdisciplinary design course bringing together senior-level engineers of various disciplines to work together to design and develop a product.
- Mechanical Engineering (ME) 450, *Design and Manufacturing III*, is the capstone design course for the mechanical engineering curriculum and involves taking a design from need identification and problem definition through full design specification and prototyping. Projects are usually proposed and sponsored by industry, by researchers at the University, or by non-profit organizations.
- The team of principal investigators has previously connected the ME 450 course with design courses taught in the School of Art and Design's Industrial Design program through interdisciplinary projects with strong user and/or aesthetic requirements coupled with strong technical components. Aware is an ideal project for continuance of these collaborations over the next academic year, and fits well with the coming offering of the course *Less Is More: Dematerialization* in this department.

Secondly, student members of the University of Michigan Engineers Without Borders / Engineers for a Sustainable World (EWB/ESW) organization will be able to participate directly in the development of Aware by working with the team of principal investigators and consulting with student teams. A component of Aware will be allocated to a designated EWB/ESW team. EWB/ESW members represent various engineering disciplines, including aerospace, civil/environmental, electrical engineering and computer science, chemical and mechanical engineering.

Finally, the results of the aware project will be integrated into the DfE@UofM website, a central resource for information on environmental science and design for environment educational materials that was developed originally for the Department of Mechanical Engineering and is currently being broadened in scope by EWB/ESW members to be applicable to a variety of engineering disciplines. The information gained in developing Aware will be integrated into the resources in addition to a demo of the Aware software, which can be used in the future to teach engineering students about quantifiable aspects of environmental impact study and communication of technical results to the general public.

3. Project Schedule

A natural place to begin demonstrations of the Aware system lies in "occasional" rather than "everyday" purchases. These products, such as televisions, refrigerators, or DVD players, are more likely to have an understood environmental impact with available data, and potentially have impacts about which consumers may be surprised to learn; for example the extremely high "second-order" material consumption in microchip manufacturing (Williams, 2002). Upon generating interest in the capabilities of Aware and the increasing availability of environmental inventory data, the system could be expanded in a number of ways: 1) corporations may see a competitive advantage in joining the system; and 2) as experience is gained with inventory collection, a greater number of "everyday" products, such as food items, could be included in the Aware system. Implementation of this first step in the development of the Aware concept will involve partnerships between the team of primary investigators (PI Team) and student design teams in several cross-disciplinary courses. A preliminary schedule is provided in Table 1, taking into account the timing of these courses.

Student design teams from the ME 589 graduate course on Eco-Design and Manufacturing will participate in product identification, collect life-cycle inventory data, research environmental impacts for those products, and develop initial concepts for methods of displaying information to users in ways that are concise, relevant, and applicable. At the start of the following semester, students in the interdisciplinary ENGR 450 capstone design course will design and code the database and wireless connection with the handheld device using the information provided by the previous team, and a mechanical engineering design team from the ME 450 capstone design course will work with students from the School of Art and Design to prototype a design of how the handheld device may be made affordable to consumers with a wearable or cart-clip option to facilitate shopping use. Finally, the prototype will be used to test effectiveness on a representative sample user population through observed product purchasing decisions with and without use of Aware, and through a survey questionnaire.

Table 1. Preliminary schedule for Phase I.

Task	Leadership	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Jan-05	Feb-05	Mar-05	Apr-05	May-05
Product Scope Identification	PI Team	■	■	■	■							
Design User Interface	PI Team				■	■	■	■				
Code User Interface	PI Team					■	■	■				
Research on scanning technology	PI Team							■	■			
Code scanning interface	PI Team								■	■		
Survey Design	PI Team								■	■		
Survey Implementation & Analysis	PI Team										■	■
Product Scope Identification	ME 589			■	■							
Data Collection	ME 589			■	■	■						
Product Impact Assessment Research	ME 589			■	■	■	■					
Information Display Design	ME 589				■	■	■					
Database Design	ENGR 450							■	■			
Research on wireless communication	ENGR 450							■	■			
Code Database	ENGR 450								■	■		
Code wireless communication protocol	ENGR 450								■	■		
Integrate full prototype	ENGR 450									■	■	
Design of Aware user unit	DES / ME 450							■	■	■		
Design of wearable / cart mounts	DES / ME 450							■	■	■		
Prototyping	DES / ME 450									■	■	

4. References

AirClic, “Progressive Grocer Busch's Supermarkets Partners with Beeline Shopper” March 8, 2002 <http://www.airclic.com/news/news_nc_038.html>

Co-op America, Responsible Shopper Website, accessed 19-March-2004, <http://www.responsibleshopper.org>

Dow Chemical, accessed 22-March-2004, < http://www.dow.com/dow_news/manufacturing/2003/20030710a.htm >

Environmental Product Declarations, accessed 22-March-2004, < http://www.environdec.com/>

EPA Toxic Release Inventory, accessed 19-March-2004, < http://www.epa.gov/tri/>

Hardin, G. (1968) “The tragedy of the commons” Science v.162 pg.1243-48.

Williams, E. (2002) “The 1.7 Kilogram Microchip: Energy and Material Use in the Production of Semiconductor Devices” Environmental Science & Technology v.36 (n.24)

F. Resumes

Professor Steven J. Skerlos **(www.umich.edu/~skerlos)**
Department of Mechanical Engineering
University of Michigan, Ann Arbor MI 48109-2125

A. PROFESSIONAL PREPARATION

Bachelor of Science in Electrical Engineering with Highest Honors (May 1994)
Department of Electrical and Computer Engineering
The University of Illinois at Urbana-Champaign

Doctor of Philosophy in Industrial Engineering (January 2000)
Department of Mechanical and Industrial Engineering
The University of Illinois at Urbana-Champaign
Doctoral Thesis: Microfiltration of Synthetic Metalworking Fluids Using Al_2O_3 Membranes
Academic Advisors: Professors Richard E. DeVor and Shiv G. Kapoor

APPOINTMENTS

Assistant Professor (January 2000 to present)
Department of Mechanical Engineering
The University of Michigan at Ann Arbor

PUBLICATIONS (*http://www.engin.umich.edu/labs/EAST/publications.htm*)

Most Relevant Publications to Proposal:

Hula A.., Jalali, K., Hazma, K., Skerlos, S.J., Saitou, K. 2003, "Multi-Criteria Decision Making for Optimization of Product Disassembly Under Multiple Situations", To appear in *Environmental Science and Technology*.

Zimmerman, J.,Keoleian, G.A., Hayes, K., Skerlos, S.J., 2003, "Comparative Life Cycle Assessment of Vegetable versus Petroleum Based Metalworking Fluids", To appear in *Environmental Science and Technology*.

Skerlos, S.J., Morrow, W.R., Chan, K-Y, Hula, A., Seliger, G., Basdere, B., Prasitnarit, A., 2003. "Evaluating the Profit and Environmental Characteristics Of Global Cellular Telephone Remanufacturing." Proceedings of the *Electronics Goes Green 2003* International Congress and Exhibition: Life-Cycle Environmental Stewardship for Electronic Products, Boston, MA, May 19-22, 2003. Also in Proceedings of the Colloquium on e-ecological Manufacturing, Technical University Berlin, March 27, 2003, pp. 143-147.

Skerlos, S.J., Hayes, K.F., Morrow, W.R., Zimmerman, J.B., 2003, "Diffusion of Sustainable Systems through Interdisciplinary Graduate and Undergraduate Education", To appear in the *Proceedings of the ASME: Manufacturing Science and Engineering Division*. Washington, D.C., Nov., 2003.

Michalek, J., Papalambros, P.Y., Skerlos, S.J., 2003, "A Methodology for Studying the Effects of Emissions Policies on Optimal Vehicle Design Decisions", To appear in the *ASME 2003 Design Engineering Technical Conference (DETEC2003)*, Chicago, Illinois, September 2-6, 2003.

Sutherland, J.W., Skerlos, S.J., Olson, W.W., Gunter, K.L., Haapala, Khadke, K., Sadasivuni, and Zimmerman, J., 2003. "Environmentally Benign Manufacturing: Status and Vision for the Future", *Transactions of NAMRI/SME*, Volume XXXI, Hamilton, Canada, May 20-23, 2003. A report of results from the National

Science Foundation Workshop on Environmentally Benign Manufacturing held in September 2001 (Ypsilanti, MI).

<u>*Other Publications:*</u>

Tung, Y-C., Lin, C-T, Zhang, M., Kurabayashi, K., Skerlos, S.J., 2003, "PDMS-Based Opto-fluidic Microsystem for Flow Cytometry", To appear in *Sensors and Actuators B: Chemical.*

Zimmerman, J., Clarens, A., Hayes, K., Skerlos, S.J., 2003, "Influence of Ion Type and Concentration on the Emulsion Stability and Machining Performance of Two Semi-Synthetic Metalworking Fluids", Submitted to *Environmental Science and Technology* on January 17, 2002.

Zhao, F., Urbance, M., Skerlos, S.J., 2002, "Mechanistic Model of Coaxial Microfiltration for Semi-Synthetic Metalworking Fluid Microemulsions", *Accepted to the Japan/USA Symposium on Flexible Manufacturing*, Hiroshima, Japan, July 15-18, 2002.

Skerlos, S.J. and <u>Zhao, F.</u>, 2003, "Economic Considerations in the Implementation of Microfiltration for Metalworking Fluid Biological Control", Submitted to the *Journal of Manufacturing Systems* on January 20, 2003.

HONORS AND AWARDS

13. Gilbert Whitaker Grant Award for the Improvement of Teaching, 2003 - 2004
12. UM College of Engineering 1938E Award, 2003
11. ASME Nominee to New Faces in Engineering, National Engineers Week, 2003
10. Caddell Memorial Materials and Manufacturing Award (with Fu Zhao, Ph.D. candidate), 2002
9. Alice and Joe Spira Teaching Excellence Award, 2002
8. National Science Foundation Faculty Early Career Development Award, 2001 - 2005
7. General Motors Foundation Fellowship Award, 1997 - 1999
6. Department of Mechanical and Industrial Engineering Fellowship Award, 1994-1996
5. Department of Electrical and Computer Engineering Henry O. Koehler Scholarship, 1993-1994
4. Dow Chemical Scholarship, 1992-1993
3. College of Engineering Elmendorf Travel Award, 1992
2. Lincolnshire Corporate Center Scholarship, 1990
1. Illinois State Scholarship Award, 1990

HONORS AND AWARDS

American Environmental Engineering and Science Professors (AEESP)
American Society of Mechanical Engineers (ASME)
Institute of Industrial Ecology (ISIE)
Society of Manufacturing Engineers (SME)
Society of Tribologists and Lubrication Engineering (STLE)

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EDUCATION

University of Michigan

Ann Arbor, MI (*1999 – present*)
Mechanical Engineering, Optimal Design Laboratory
MS 2001, Thesis: Interactive Building Layout Optimization
PhD Topic: Product Design for Heterogeneous User Populations

Carnegie Mellon University

Pittsburgh, PA (*1995 – 1999*)
BS Mechanical Engineering 1999, Minor: Engineering Design
Honors Research: Computational Design, Industrial Design
Graduated first in the ME class of 1999 GPA: 4.0

WORK EXPERIENCE

Graduate Student Instruction Mentor

University of Michigan Center for Research on Learning and Teaching • Ann Arbor, MI (2003 – present)
Trained and assisted graduate student instructors, facilitated student feedback on teaching and provided teaching evaluations. Rackham certified Michigan Teaching Fellow.

Graduate Student Instructor

University of Michigan • Ann Arbor, MI (2000 – present)
Taught and advised the capstone mechanical engineering design course. Developed new course material. Initiated interdisciplinary student interaction with other departments, universities, and industry. Developed an interactive course web portal. Also assisted with a graduate course on Design Optimization and assisted in creating and executing a new course on Analytical Product Design.

Research Engineer

Xerox – The Document Company • Rochester, NY (1999)
Designed and implemented improvements to a distributed embedded digital control system for paper path handling.

Design Engineer

General Motors • Warren, MI (1998)
Worked with an multidisciplinary team to design and prototype a future concept vehicle with engineering documentation to show concept feasibility.

Reliability Engineer

General Motors • Warren, MI (1997)
Developed and implemented a procedure to quantify the reliability of commercial components of machinery and equipment in the assembly plant environment.

C++ Programming Tutor

Carnegie Mellon University • Pittsburgh, PA (1997)
Tutored students in the C++ programming language

Designer

Linear Systems Corporation • Rochester, MI (1994 - 1996)
Designed automotive tooling. Trained employees in AutoCAD. Developed new CAD tools.

RESEARCH EXPERIENCE

Engineering Design Research

University of Michigan • Ann Arbor, MI (2001 – present)
Developed theory and applications of product design decision models that consider the interactions between engineering design and heterogeneous user preferences in social and economic contexts.

Collaborative Design Research

University of Michigan • Ann Arbor, MI (2000 – present)
Helped to initiate several collaborative, interdisciplinary research and education initiatives among six departments and two universities.

Engineering Design Research

University of Michigan • Ann Arbor, MI (1999 – 2001)
Designed and implemented an object-oriented, graphical interactive optimization tool for architectural building layout. The tool assists exploration in the conceptual stage of design.

Engineering Design Research

Carnegie Mellon University • Pittsburgh, PA (1998 – 1999)
Implemented a Java tool to generalize the design space of some consumer products using shape grammars. The grammars can generate objective-based designs and provide insight toward understanding aesthetic qualities of designs.

ADDITIONAL EXPERIENCE

Product Design: Designed and developed several innovative products including Aware: The Shopping Information Manager (international design team), Draperz: The Clothing Coordinator for Teens, the Havoc All-Terrain Concept Vehicle., and a safety shower chair for people with disabilities.

Software: Matlab, Simulink, Alias Wavefront, AutoCAD, Unigraphics, CAD-AM, Pro Engineer, Ansys FEA, Working Model, Visual Studio, Excel, PowerPoint, Access, Illustrator, Pagemaker, Photoshop, Mathtype, Labview, various embedded circuit software

Computer Languages: C/C++, Java, LISP, HTML, OpenGL/GLUT (Windows, Unix, DOS, MacOS, PalmOS)

Foreign Languages: Beginning Spanish and Chinese Cantonese and Mandarin

Active Organization Membership: Engineers Without Borders (Education Chair), American Society of Mechanical Engineers, American Association for Artificial Intelligence, Amnesty International, American Civil Liberties Union, WCBN-FM (Public Service Announcement Director), and Rackham Interdisciplinary Institute.

Volunteer Work: Instructor for Detroit Area Pre-College Engineering Program, Michigan Mentor Program, University of Michigan Graduate Student Symposium Chair, New Graduate Student Recruiter, New Foreign Graduate Student Mentor, WEAVE Sound Painting Ensemble, and public radio sound engineer, disc jockey and reviewer.

G. Budget

Personal Salaries	not eligible		0
Fringe Benefits @ 30%	not eligible		0
Total Salaries & Fringe Benefits			**0**

Materials and Supplies (Justify in Proposal)

Prototoyping	*Unit Cost*	*Units*	
Primary Device with Scanning Capability (Symbol, Palm7)	2500	1	2500
Wireless Networking Capability (Router)	400	1	400
Software Development Tools/Licensing	400	1	400
Machine Shop / Prototyping Materials	300	1	300
Office supplies	100	1	100
Database/Interface Development Consultation	50	12	600
Demonstration/Evaluation			
Direct Survey Costs	100	1	100
Survey Participation Incentives	20	20	400
Demonstration Products	200	1	200
Travel (Justify in Proposal)			
Attendance at Final Conference, Washington D.C., U.S.A.	500	3	1500
Total Direct Costs			**6,500**
Indirect Costs @ 53%			3,445
TOTAL SPONSOR COSTS			**9,945**

H. Budget Justification

Personal salaries and fringe benefits are not eligible for the EPA P^3 award. It is expected that the Aware prototype will be developed using available hardware that is typically sold for industrial inventory applications, such as the Symbol SPT 1800 Series that include wireless, scanning, and programmable capabilities. Prices are not publicly available for these products; however, previous quotes from Symbol Technologies provide an estimate of $2500. In addition, a wireless router ($400) will be needed to link the wireless handheld with a PC database, and development software ($400) is needed to program the handheld device user interface, the PC database (using an existing PC), and communication between the two through the router. Several short professional consultations (estimated 12 hours total) will be utilized to review and develop a strategy for efficient database design and wireless communication to provide proper direction. A prototyping budget of $300 will allow use of layered manufacturing techniques or traditional manufacturing techniques to show how a consumer version of such a device would look and how it might be held in an in-store cradle, wearable clip, or external scanner activation button, especially in cooperation with student design teams for design prototyping of add-in products not available or too expensive on the market. Miscellaneous office supplies cover a nominal $100 estimate.

In order to measure and evaluate results, a survey will be developed to assess the affect of Aware on consumer awareness and purchasing decisions. Survey development and incidental costs are estimated at $100, and participation incentives are estimated at $20 each for 20 respondents, although this may be restructured depending on the depth required per survey. Demonstration products will be purchased for an estimated $200 in order to test consumer responses to those products with and without Aware. In addition, the group will need to facilitate demonstration of the prototype, with real products ("Demonstration Products"), at the final design competition at the close of the project period to illustrate the system's efficacy.

Under the guidelines of the E.P.A. P^3 award, a reasonable allocation of the awarded funding is to provide for transportation and lodgings for this event to present the final design. An additional 53% is required for indirect costs using University guidelines.

This project requests $9,945 from the EPA. The in-kind support for this project by the host institution consists of 5 senior design projects (at minimum, valued at $2900 each), and one half summer month of Professor Skerlos' time (valued at approximately $4500 dollars). This results in a minimum in-kind contribution of $19,000.