**A Continuous Approach to Physical Design**

Leonardo Bonanni

Tangible Media Group, MIT Media Lab

Thesis Proposal for the degree of Doctor of Philosophy at the Massachusetts Institute of Technology

| | |
|---|---|
| Thesis Advisor | Hiroshi Ishii<br><br>Associate Director, Media Lab<br>Muriel R. Cooper Professor of Media Arts and Sciences<br>Co-Director, Things That Think |
| Thesis Reader | Chris Csikszentmihalyi<br><br>Associate Professor of Media Arts and Sciences<br>Co-Director, Center for Future Civic Media |
| Thesis Reader | William J. Mitchell<br><br>Professor of Architecture and Media Arts and Sciences<br>Alexander W. Dreyfoos, Jr. (1954) Professor<br>Director, Design Laboratory |

**A Continuous Approach to Physical Design**

Leonardo Bonanni

Abstract

Awareness of the long-term and large-scale impacts of design can inform tools that treat the physical design process continuously and collaboratively. This thesis proposes a framework for conceiving of physical design as a distributed and unending pursuit aimed at providing social value and environmental benefit. It extends the design phase beyond the manufacturing cycle and the life of the product to account for social and material value over multiple generations. Continuous physical design can be made possible by new kinds of documentation that merge the flexibility of supply chain planning with the collective intelligence of web-based tools.

As part of this thesis, an on-line tool has been built to conceptualize the life-cycle of products in a social network. This tool – Sourcemap – provides a framework whereby physical designs can be mapped to social concerns including geography and the environment. Sourcemap aims to encourage the consideration of global environmental impacts as part of the design process. Participants engage in collective simulation that enables an understanding of the complex structures underlying modern supply chains.

Sourcemap provides the groundwork for continuous physical design through knowledge-sharing about the provenance and impacts of materials and processes. The site is being evaluated for the ways in which it influences the design process through pilot studies with product designers, small businesses and a regional development agency. These evaluations will seek to show how continuous design can influence new types of products and relationships between creators and end-users.

Table of Contents

## 1. Introduction

The present means of industrial production are unsustainable, both from an environmental and from a commercial point of view. Pollution and resource depletion are raising the cost of producing disposable products. Revenue from one-time sale undermines the long-term potential of a sustained relationship between consumers and producers. Industrial best practices and governmental regulations are moving towards models of life-cycle accountability. Advancing sustainability depends on a shift in production methods to account for material and energy use over multiple generations of products and people. Designers play a crucial role in shaping the patterns of consumption that could enable this shift. New design tools can help them to consider the varied impacts of industrial production. A collective and continued effort can facilitate widespread accounting for the costs and benefits of industrial production. These tools for collective design could support a generation of products with enhanced commercial and environmental benefit.

Current production methods are exhausting material and energy supplies while exacerbating pollution and health hazards. This is the legacy of an industrial philosophy that favors the use of exotic materials for increasingly disposable products.[1] Many of the elements we rely on to make everything from food to computers are running out at an accelerating rate. Rare materials such as indium and gallium are estimated to last another ten years at current rates of consumption, and commodities such as steel and copper have tripled in price over the recent years.[2] The price of materials has become so high that extreme efforts are being undertaken to recover elements from discarded products that were never designed for recovery.[3]

Concern over environmental degradation has prompted regulatory efforts centered on the disclosure of industrial practices. The most stringent of these regulations, Germany's Green Dot and the ISO 14000 regulation demand disclosure of material and energy inputs from manufacturing to end-of-use.[4] Disclosure allows for a more accurate image of the relationships between manufacturing processes and the environment, as well as a move toward reducing materials and energy consumption. Life-cycle design promotes the reduction in packaging, for example, as well as the use of recycled and recyclable materials.[5] This trend toward 'eco-efficiency' may only serve to delay eventual resource depletion.[6] One voluntary standard, 'cradle-to-cradle'certification, encourages material re-use through a design process where the by-products of one manufacturing process nourish another.[7]

---

[1] Bonanni, Leonardo. By a Long Land and a Long Sea Carriage: Unraveling the Reach of Product Design, in Thresholds: Journal of Visual Culture, #35, Fall 2008 (Forthcoming).

[2] Silverberg, Robert. Reflections: the Death of Gallium.

Cohen, David. Earth's natural wealth: an audit. New scientist, 23 May 2007.

[3] Grow, Brian, Tschang, Chi-Chu, Edwards, Cligg and Burnsed, Brian. Dangerous Fakes: How counterfeit, defective computer components from China are getting into U.S. warplanes and ships. BusinessWeek, October 2, 2008

[4] ISO 14401 certification, European Packaging Waste Directive.

[5] Giudice, Fabio, LaRosa, Guido, Risitano, Antonino. Product Design for the Environment: a Life Cycle Approach. CRC 2006.

[6] McDonough, William and Braungart, Michael. Cradle to Cradle: Remaking the Way we Make Things. New York: North Point Press, 2002.

[7] Cradle to Cradle Certification Guidelines

A multi-generational perspective on life-cycle design depends on a shift in the patterns of consumption where one-time sale and disposal are transformed into a sort of temporary material stewardship and renewable energy use. This radical shift is unlikely to be supported by industry, who will need new infrastructure, or by consumers, who are generally limited to selecting between very similar product options. The design community has potential to help transform patterns of consumption, both by designing efficient products and by promoting consumer attitudes that favor a paradigm shift in sustainability.[8]

The instruments of design shape to a great extent the types of artifacts that are produced: witness the impact of computer-aided mechanical design tools on the burgeoning of a new complexity in architectural form.[9] New tools that address large-scale and long-term issues in design could influence the way products are being designed, manufactured and consumed.

A number of design tools exist to assist in the professional engineering pursuit of life-cycle assessment, the foundation of design for the environment.[10] However these tools are static, designed for single users and only accessible to environmental engineers. As commodities and techniques evolve, so must design tools account for the shifting costs of production. Engaging designers together with producers and consumers will rely on a system with multiple points of entry, including a learning component. The reliance on linked data, such as established databases, can help engender trust in the system. Accuracy and neutrality are facilitated by an open source system that engages users in validating and contributing to the system.

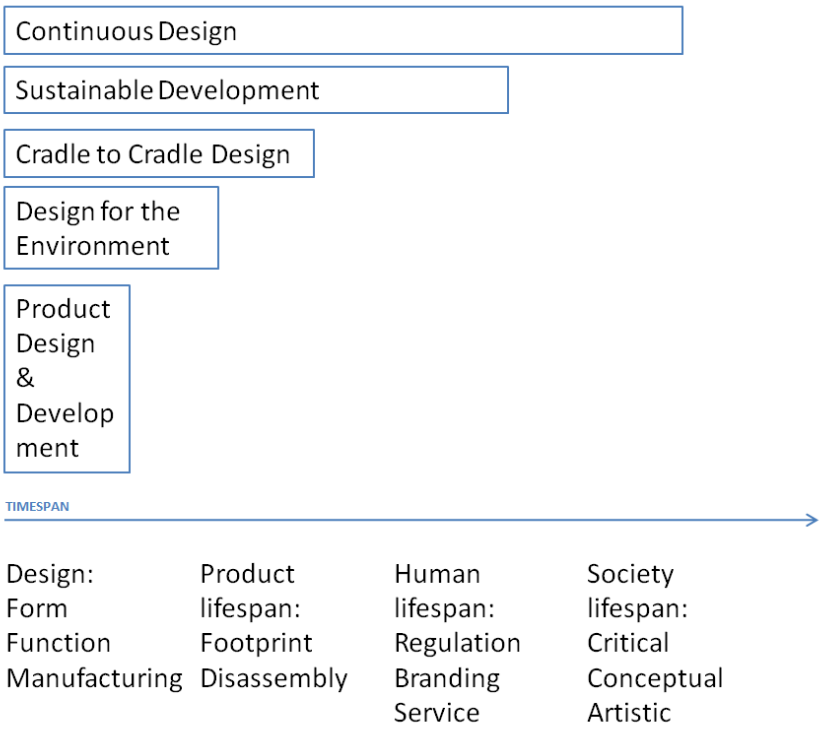
With tools capable of tracking the shifting supplies of materials and energy, and accounting for the life-long impacts of design decisions, it will be possible to achieve a paradigm shift in eco-efficiency. Making these decisions transparent could shift market structures by pressuring producers to evaluate and disclose their supply chains. Most importantly, the new sensibilities provided by new tools can change the way we think about products enough to help usher in sustainability.

[8] Dunne, Anthony. Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design. MIT Press, Cambridge, 2006.

[9] Aranda, Benjamin, Lasch, Chris, Balmond, Cecil, and Kwinter, Sanford. Pamphlet Architecture 27: Tooling. Princeton Architectural Press, 2005.

[10] Simapro (the expensive option), openLCA (the cheap option.

## 2. Conceptual Framework




Design practice is evolving to take on longer-term challenges. The traditional product design and development process is primarily concerned with formal and functional considerations leading to manufacturing ramp-up. Design for the Environment (based on Life Cycle Assessment) and Cradle to Cradle Design (based on sustainable product retirement strategies) extend the considerations of designers to the end of the product life. Sustainable Development, on the other hand, considers the long-term impact of products at the scale of human life-spans. Sustainable Development is a largely regulatory effort, aiming to manage resources while fostering industry. Designers have taken a long-term perspective to design in terms of providing services and conceiving of branding strategy that consider the relationship between consumers and producers over one or more generations. Continuous design is proposed as a means of considering the impact of design decisions over societal time spans, where the traceability of materials and ideas is paramount to relevance over multiple generations of technical development and resource availability. Traditionally defined:

> *Continuous design* is a software development practice of creating and modifying the design of a system as it is developed, rather than specifying the system completely before development starts, (as in the waterfall model) or in bursts at the beginning of each iteration[11]

This thesis proposes that the continuous approach needs to be applied to physical design in order to satisfy the long-term needs of society. As with software, continuous physical design relies on a plan

[11] http://en.wikipedia.org/wiki/Continuous_design

(source code) that is shared and always evolving (version control). The context in which a physical (or digital) product is manufactured is constantly shifting, both in terms of available resources and ultimate applications. Continuous resource management is transforming construction processes, for example, through Construction Management Systems that allow on-demand delivery and assembly of parts[12]. Continuous systems enable shared use of cars and bicycles and have been proposed to bring about an urban transportation revolution[13]. Product design and development needs to account for the constantly shifting landscape of supply and demand as well as environmental and social impacts. Sourcemap is a step toward open and collective planning for physical design, a building block of continuous design on a large scale. Future developments will seek to connect the loose ends at the extremes of supply chains. Continous design ultimately aims to account for the total impact of design decisions to achieve sustainable development at the time scale of a society's lifespan. This thesis aims to answer how continuous design practice can be integrated with design and business methods and what its impact could be.

[12] U.S. Department of Transportation Federal Highway Administration. Construction Management Systems: Automated Contract Tracking. October 2001, FHWA-IF-01-022.
[13] Mitchell, William J. et. Al. (June 2008). Mobility on Demand: Future of Tranportation in Cities."

### 3. Sourcemap.org

People around the world are intimately connected through the products we make, buy and throw away. Understanding these relationships is crucial to shifting away from unsustainable practices in manufacturing, design and consumption. Regulatory efforts do not help to reveal the techniques that could be used to produce a paradigm shift in design and consumption. The practice of transparency could help to spread the lessons of progressive designers and consumers beyond the expert audience. Sourcemap is a web-based tool made to help producers and consumers understand the costs and benefits of products and services.[14] The site has three interdependent aims: to impart environmental literacy, to foster collective simulation, and to advance the practice of transparency. Environmental literacy is a building block of sustainable design, which can inform and benefit from a shared platform for estimating wide-ranging impacts of design practices, which can in turn shift practices toward the traceability and transparency required to foster literacy and to reduce environmental impacts. The site is intended to inspire a paradigm shift in product design, to serve as a strategic aid to plan for ensuring the long-term sustainability of business and ecology, and to benefit local and regional markets world-wide.

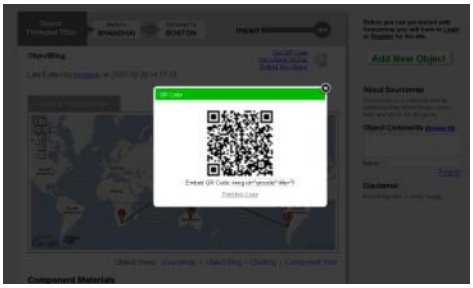

Sourcemap.org: a basic object entry, showing the map visualization and life-cycle assessment calculator

**How it works**

A distributed effort may be the only way to account for the myriad elements that comprise supply chains and environmental assessment. Providing tools for a wide range of users to estimate the consequences of specific production patterns makes it possible to achieve a collective simulation that is more accurate and widespread than current means. User-generated content can more rapidly and dynamically populate a vast database of elements than the opaque and centralized systems in place today. A public tool that

[14] Sourcemap: http://sourcemap.org

openly reveals its data and methods can help to inspire trust and engage a wider audience.



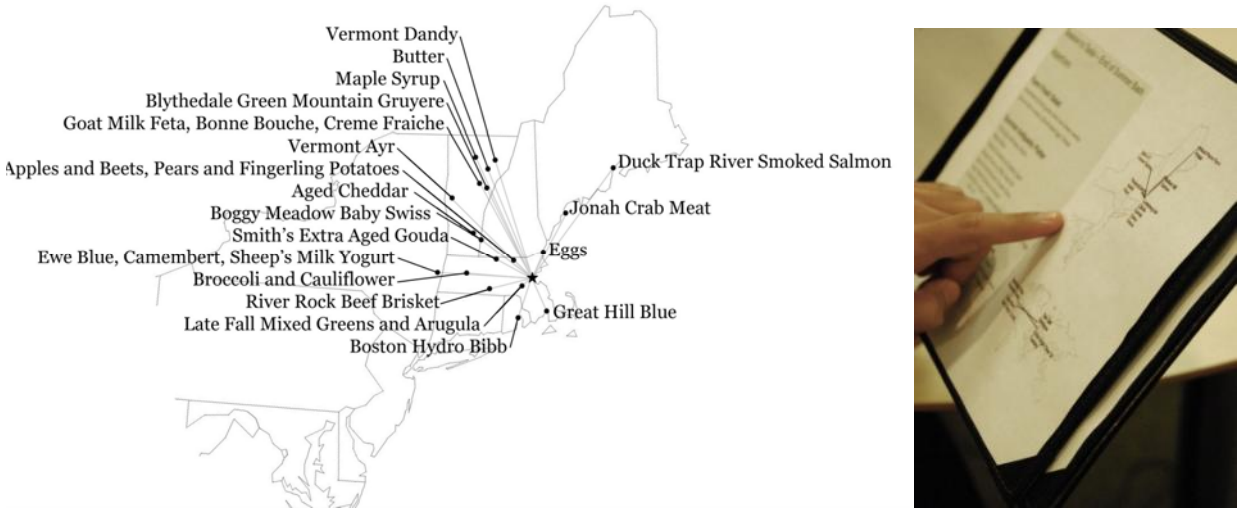

One of the export options for Sourcemap is a QR code to be printed out and attached to products so that shoppers with a camera phone can retrieve the entry for each item.

Sourcemap is a web-based social network built around individual products and services. It was designed to promote transparency by engaging users to publish supply chain information in exchange for environmental assessment information and marketing benefit. Trust is paramount to building a tool for traceability: Sourcemap relies on the accuracy of linked data from authoritative databases together with a free and open architecture to educate, encourage and verify designs in an ecological context. Authors construct a bill of materials and processes by browsing the site's linked databases of commodities and their provenance. A life-cycle assessment is continuously updated with each entry, providing immediate feedback on the impacts of materials and shipping. The interaction is focused on a map visualization that provides an intuitive legend for the bill of materials and doubles as an evocative display of an object's global reach. In turn, Sourcemap provides a number of ways to be instantiated on other websites and in the physical world to connect the practices of consumers and producers to a shared platform for transparency.

Sourcemap uses a simplified life-cycle assessment (LCA) method to approximate the life-cycle impact of products and services. The database accounts for three phases of life: manufacturing, operation and disposal. Manufacturing impact is calculated using the IDSA's Okala life-cycle database[15] and a custom provenance calculator based on the British Geological Survey[16], independent research and a custom-built mapping calculator. The additional impact from particular manufacturing processes and means of shipping can also be considered. Energy use during the life of a product is computed based on the location of operation, and multiple end-of-life options including re-use and re-cycling are assigned a weighted impact. The resulting interface is simple enough for many industrial designers to use, but sophisticated enough to approximate engineering analyses enough to be useful.

The process of using Sourcemap generates media content that can be useful as part of the marketing process, both on-line and in the physical world. Each object has an automatically generated badge which can be embedded in an external web site to provide a brief glimpse into the 'localness' and 'greenness' of a product. Visitors clicking on the badge are returned to Sourcemap, where they can independently verify the calculations. The map itself can be printed onto products, packaging and informational materials including menus. The site can generate an optical code that can be printed onto the product and direct shoppers to its Sourcemap entry. In the future, all of the data associated with individual

[15] IDSA Okala Guide: http://www.idsa.org/whatsnew/sections/ecosection/index.html
[16] British Geological Survey: http://www.bgs.ac.uk/




Sourcemap is collaborating with local food producers, distributors and restaurateurs to provide maps that can be used as part of informing consumers and sustaining local markets.

products and the site as a whole will be made available for anyone to generate new types of visualizations and interpretations.

**Aims**

The tools of design shape the design process and its considerations. Sourcemap aims to prioritize transparency and social consciousness through a different kind of design simulator. Sourcemap has three principal aims: to teach environmental literacy, to promote the practice of Design for the Environment, and to create a framework for transparency and traceability. Using Sourcemap is a learning process; it allows users to being understanding the complex calculations of life cycle assessment. Using the site to research and refine a design indirectly promotes many of the goals of environmentally-conscious design, such as material and energy conservation. Populating the site with user-generated footprint estimates provides a database of best practices and introduces local suppliers to a larger public.

**Learning**

The process of design is universal; a universal design tool needs multiple points of entry for people whether they are designing a dinner menu or an airplane part. Sourcemap was designed with a constructive learning approach so that designers without life-cycle assessment experience can learn about the range of system variables simply by using the site. The process of entering data into this interface is in itself a learning experience as designers are confronted with the task of naming materials, investigating their provenance and visualizing these on a map. Materials which are commonly chosen based on price, appearance or availability may be substituted for less common alternatives when considered on the basis of weight and distance traveled. The process of discovering where a material comes from and where it goes faces designers with the cultural context of their producers and consumers. Sourcemap evolves into a shared resource for supply chain calculations, visitors can compare various strategies, discover new materials and suppliers. Since the site is structured as an open

network, anyone can leave comments or suggestions or create alternate versions of an object to explore alternative options. By exporting the data to the point-of-sale (both on-line and off-) producers can pursue a dialogue with consumers to understand which criteria are most important. Sourcemap will be evaluated in part on how producers and consumers engage in learning about design for the environment.

**Design for the Environment**

Computer interfaces prioritize certain values through the input criteria and the measures for success. Using Sourcemap can favor certain types of decisions commonly referred to as Design for the Environment (DFE), such as reducing material use and packaging, the use of recycled materials, and the extension of product life[17]. This is made possible by the simultaneous comparison of materials, shipping methods and life-cycle strategies. Sourcemap will be evaluated through case studies in terms of the quantitative differences in the impact of products designed using the system.

**Transparency**

Design regulation depends on private systems that can limit the extent to which novel techniques are adopted. While environmental footprint and life-cycle assessment are growing in acceptance, they require expert tools that are expensive and do not of themselves help teach Design for the Environment[18]. The opacity of supply chains makes it difficult for individuals and small companies to address the issue[19]. Sourcemap is an open-source system that uses a social network to maximize the potential for cross-fertilization in the domain of design for the environment. The system provides a simplified life-cycle assessment tool; but its principal aim is the disclosure of design decisions so that a general audience can understand the opportunities for new practices as they present themselves. This practice of transparency is the fundamental element of a continuous design practice as it allows for a larger base of users and contributors. As with the Free Software movement, expert users can ultimately advance the design of the site beyond the understanding of its development team through applications in a variety of niche domains. Sourcemap will be evaluated in terms of where and how the practice of supply chain transparency is useful, how it is used and what its benefits and disadvantages may be.

[17] Giudice, Fabio, LaRosa, Guido, Risitano, Antonino. Product Design for the Environment: a Life Cycle Approach. CRC 2006.

[18] Newing, Rod. The long and the short of measuring carbon footprint. The Financial Times, October 9, 2008, on page 2 of the Sustainable Business section.

[19] Dean, J. and Tam, P-W. “The Laptop Trail” in The Wall Street Journal, 9 June 2005.

## 4. Resources

The Sourcemap system is already functional, and its continued development relies on the software development by open source contributors and user studies conducted by the Medialab team. The work has been conducted with funds from the Tangible Media Group and TTT Research Consortium at the MIT Media Lab.

**Equipment**

Web Software development

ML/TMG funding (TTT Consortium)

**Personnel**

The Sourcemap project is a distributed open-source development project.

Project Management and Evaluations

Leonardo Bonanni (MIT)

Software Management

Matthew Hockenberry(MIT)

Environmental Engineering

Alexander J Pak (MIT)

Map Development

David Zwarg (Avencia)

Software Development

Cathy Wu(MIT), Mengjie Ding(MIT), Ryan Ko(MIT), Sooyeon Jeong(MIT)

Advisors

Dave Newbold (IBM), Mako Hill (MIT), Archie Prentice (HIE)

## 5. Timetable

| | |
|---|---|
| Evaluation Period | November 1st, 2008 – June 1st, 2009 |
| Sourcemap Private Beta Release | February 3rd, 2009 |
| Sourcemap Public Beta Release | April 15th, 2009 |
| Thesis Proposal Critique Session | To Be Determined |
| Thesis Dissertation Defense | September, 2009 |
| Thesis Document Submission | December, 2009 |

**Evaluation**

The design and user base for Sourcemap is being fostered through continued user studies carried out with individuals interested in applying the tool to their design and business needs. These evaluations are to include subjective and objective measurements aimed at improving the user interface and confirming that the project's underlying aims are met. The site will be evaluated in terms of:

i. Its capacity to foster literacy about life-cycle assessment and Design for the Environment
ii. The types of business strategy, design and production that are associated with its use
iii. The benefits and challenges associated with a transparent approach to supply chain design

Two types of trials are anticipated: short-term workshops where users will use Sourcemap for individual projects and long-term interventions where organizations use of the site as part of a continued practice. Between November 2008 and June 2009, a number of designers, business owners and regional groups will be evaluated, including:

**Designers**

- Michael Lin, Research Assistant, MIT Media Lab, Cambridge, MA (short-term)

  Michael is the designer of the Roboscooter, a vehicle that represents a paradigm shift in public transportation. As part of his design process, he will use Sourcemap to determine the benefits and disadvantages of his design and optimize it. He will also use the footprint information as part of an information campaign for the scooter's first deployment at the 2010 World Cup in South Africa.

- Elena Corchero, Researcher, DistanceLAB, Forrest, Scotland (long-term)

  Elena is an inventor and designer of several products who is starting an ethical production company in Inverness, Scotland to produce some of her designs. She will use Sourcemap to

learn about design for the environment and to make changes in her product designs, especially material selection, as well as to disclose her process on-line and on the product packaging.

**Business Owners**

- Caroline Gregory, Owner, Lovat Arms Hotel, Fort Augustus, Scotland (short-term)

  Caroline is the owner of an eco-hotel on the south coast of Loch Ness. She will be using Sourcemap to calculate the carbon footprint of visitors traveling to her hotel and operations to determine how many carbon offsets she should bu0079

- Cairngorm Brewery, Aviemore, Scotland (short-term)

  Cairngorm is the only organic brewery in the Highlands of Scotland. They will use Sourcemap to calculate their carbon footprint and to market their product through an embed on their web site.

- Robert Harris, Owner, Season to Taste Catering, Cambridge, MA (long-term)

  Robert owns a catering company known for being able to provide sustainable meals based on his extensive knowledge of regional food suppliers in New England. He is using Sourcemap to product informational maps that accompany his events and as a tool for marketing his company's efforts.

**Regional Organizations**

- Highlands and Islands Enterprise, Scotland (long-term study)
  Potential clients:
  - Visitscotland.com (tourism bureau)
  - Visitscotland.org (tourism industry resource)
  - Scottish Events Planning Bureau
  - Taste of Arren (Regional food organization)
  - Isle of Skye (regional commerce association)

  These projects are in the process of being designed. They will consist of a sustained study of how using the site can foster new kinds of sustainable business thinking and an approach toward user-generated transparency in marketing.

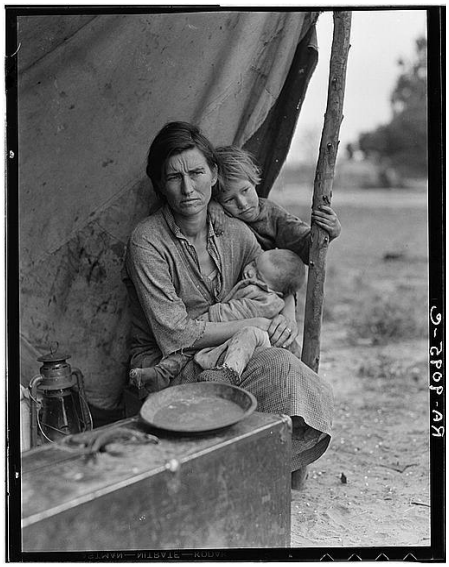
## 6. Related Work

### Design for Truth: Why Transparency is Fundamental to Sustainability

Product design is an offshoot of modern public relations and one of the cultural forces that has helped to shape consumer behavior over the past five decades. Together with PR, product design has benefited centralized manufacturing institutions that have sought to promote material and energy consumption and the life-styles that accompany them. The American environmental movement, itself born from an aesthetic desire, has become aligned with product design through efforts directed at 'greening' products. Strict new regulations could have a measured impact on pollution and resource depletion. But so long as the channels of communication remain those forged by modern public relations, the dialogue is biased toward preserving existing modes of production. These are so entrenched and complex that understanding and addressing them will depend on a collective effort, itself impossible without a glimpse into the practices that belie them. At this early stage of efforts to design for environmental benefit, it could be very productive to approach the design process through the collective and open traditions of open source and continuous software design. Many of the recent advances in alternate products, services and models of life-cycle point toward the need for a continuous approach to physical design that prioritizes transparency to foster collaborative invention.

### A Brief History of PR

Modern public relations evolved from the capacity to centralize the channels of communication to present unified messages across media. The widespread availability of newspapers in the 19th Century represents the first time that local communities could afford to publish their own media. These unabashedly regional representatives were often critical of external forces, including the growing heavy industries. Branded as 'muckrakers' by the leaders of industry, these independent news outlets were ultimately bought up and conglomerated into few nation-wide newspaper chains. These large players were able to consolidate advertising on a national scale, creating a direct and largely homogenous channel of communication to large swaths of the country. Ironically, the first successful use of this national press was made by the FDR administration in an effort to illustrate the need for greater government assistance to combat the poverty brought about in part by industrial interests – those same companies that had consolidated the press. FDR's contribution to the realm of public relations was the use of various media to shape an issue with a coherent message. Professional photographers were sent to the poorest rural areas of the country to depict



FDR's Works Progress Administration pioneered modern public relations, in part by commissioning a variety of media that was distributed to the press to underscore the administration's message, such as this photograph by Dorothea Lange subtitled "Migrant agricultural worker's family. Seven children without food. Mother aged 32, father is a native Californian. March 1936."

the plight of working people, for example, and these images were supplied to the press as illustrations. This government channel was ultimately used to shape public opinion during World War II, after which the same methods were widely adopted by industry[20].


Capitalizing on the US environmental movement's concern for nature, the packaging industry founded *Keep America Beautiful* as part of an effort to prevent regulations banning disposable containers.

**Environmentalism in the US**

The environmental consciousness of the US public was born out of a desire to preserve the natural beauty of the landscape, not its underlying health. The first environmental preservation was carried out under Theodore Roosevelt to protect large swaths of untouched land by designating them as National Parks, in part to preserve wildlife hunting grounds[21]. The modern environmental movement did not come about until Rachel Carson's 1962 book *Silent Spring*, which called for an end to the use of toxic chemicals in part because of their potential impact on wildlife[22]. The environmental movement it sparked resulted in the Clean Air Act of 1971, the first effective governmental limits on industrial practices on the basis of pollution. At the same time, American industry was perfecting a number of PR techniques including *catalytic issue management*: creating a coherent media message to anticipate an issue that has not yet risen to public consciousness[23]. Capitalizing on the aestheticized nature of American environmentalism, the packaging industry devised a campaign to engender a sense of public responsibility for littering in anticipation of regulations banning the distribution of disposable containers. Their well-regarded front organization 'Keep America Beautiful' (KAB) was effective in reducing the appearance of waste while permitting unchecked production of aluminum, glass and later plastic containers for single use[24]. Similar techniques were later used to convince consumers to 'recycle' materials rather than re-use them; this handsomely benefited new KAB member Waste Management, Inc. while producing a surplus of low-grade, un-recyclable material.

**Industrial Best Practices**

After the pioneering efforts of the US Clean Air Act, environmental movements outside the US have spurred the most stringent regulations governing resource depletion and pollution, and later ethical standards. These regulations rely almost entirely on private bodies that centralize the process of evaluating and certifying products, often at high cost. International standards including ISO 14001 (calling for Life-Cycle Assessment) and the Reduction of


The EU's 'Green Dot' is the most stringent regulation to date on consumer products – can't you tell?

[20] This synopsis is largely drawn from Ewen, Stuart. Pr! A Social History of Spin. Basic Books 1998.
[21] Guha, Ramachandra. Environmentalism: A Global History. Longman, 1999.
[22] Carson, Rachel. Silent Spring. Mariner, 2002.
[23] Elwood, Wiliam N. (editor). Public Relations Inquiry as Rhetorical Criticism: Case Studies of Corporate Discourse and Social Influence (Praeger Series in Political Communications)
[24] Rogers, Heather. Gone Tomorrow: the Hidden Life of Garbage. New York: the New Press, 2005.

Hazardous Substances (RoHS) directive, as well as the MBDC 'Cradle to Cradle' certification are voluntary standards that call for private disclosure of material inputs and outputs during manufacturing. The most stringent obligatory regulation – the European Packaging Waste Directive (so-called 'Green Dot') is based on the 'polluter pays' to leverage a tax on products based on the cost of disposing of their packaging. Obtaining these regulations can be costly and time-consuming, leaving out many smaller producers. While all of these standards require some amount of internal accounting and disclosure, none of them involve the public beyond a simple 'eco-label' printed on the packaging. Furthermore, a number of companies do not reveal (or investigate) the practices of their contractors, resulting in an incomplete picture of the total production impact[25]. A distributed, ground-up approach is the only way to account for many of the externalities of manufacturing and disposal of consumer products.

Further efforts toward transparency seek to elevate environmental literacy and consumer involvement on a company-by-company basis. Eco-fashion brands[26] have disclosed what they know of their environmental impact and supply chains as part of a marketing effort, and some start-ups[27] share their process to gain a cult following before going to market. The web promises a channel for transparency that is less costly and more democratic than regulatory bodies. At the same time, new models of production and ownership are made possible by web-based marketing, sale, and distribution. A new model for distributed certification could become possible with a shift toward new models of design and public relations, from a centralized and discrete process to a collective, continuous approach.

[25] Students and Scholars Against Corporate Misbehavior (SACOM), High Tech - No Rights? A One Year Follow Up Report on Working Conditions in China's Electronic Hardware Sector

[26] Timberland labels its products with a nutritional label indicating the energy, material and social cost of an item: http://timberland.com/ Patagonia reveals its supply chains and the benefits and disadvantages of its material selection: http://patagonia.com/

[27] The manufacturers of the widget Chumby have a blog where they discuss in detail parts of the manufacturing process: http://chumby.com/ Tcho chocolate invites the press into its factories and supply chains to document their environmentally sensitive, ecologically correct practices: http://tcho.com/

**Hyperlinked Atoms: Open Source and Continuous Design in the Physical Domain**

The open and collective traditions of the software community have created new opportunities for product designers to engage in the social issues around industrial production. Centralized, discrete processes have permitted the consolidation of one-way life cycles where massive quantities of materials and energy are devoted to making products from which little stands to be recovered at end-of-life. There is a great demand for collective invention to shift the practices of manufacturers, designers and consumers toward environmental benefit. A continuous approach to physical design is aimed at permitting the sort of distributed, evolving framework for the way we make and use products that would foster sustainable environments and economies on a large scale.

Life-cycle assessment is the first step in accounting for the multi-faceted impacts of design in order to target them more effectively. Designers are indirectly responsible for all of the materials consumed and emitted by the processes involved in making products, and new informational systems are making it possible to account for them far past the traditional 'life-cycle.' For example, automobiles are marketed to end-users and designed for a life span of ten years, despite the fact that the energy embodied in manufacturing them is as great as the energy they consume during use. Car-sharing programs are now possible where vehicles could last much longer – and have far more productive lives – in part because the web allows for seamless scheduling, and radio-activated keys permit a sort of shifting ownership[28]. In 2004, science fiction author Bruce Sterling described a new kind of product he termed 'spimes,' [29] objects that – through radio-frequency identification tags and the web – could be traced during their lifetimes so that the process of developing them, owning them and throwing them away can become part of an extensive material chain in which no knowledge or material is wasted. In his words:

> *Until you express your desire for this object, it does not exist. You buy a spime with a credit card, which is to say, you legally guarantee that you want it. It therefore comes to be… After the purchase, manufacture, and delivery of your spime, a link is established through customer relations management software, involving you in the further development of this object. This link, at a minimum, includes the full list of spime ingredients (basically, the object's material and energy flows), its unique ID code, its history of ownership, geographical tracking hardware and software to establish its position in space and time, various handy recipes for post-purchase customization, a public site for interaction and live views of the production change, and bluebook value… At the end of its lifespan the spime is deactivated, removed from your presence by specialists, entirely disassembled, and folded back into the manufacturing stream… The data it generated remains available for historical analysis by a wide variety of interested parties…The spime is a set of relationships first and always, and an object now and then*[30].

In Sterling's view, a physical product is akin to software designed by a continuous process: one where the design is continually improved even after the software is released, and updates are deployed on a regular basis to add functionality. Commonplace in web and open source software development,

[28] The popular Zipcar car-sharing service now exists in over 20 cities worldwide: http://zipcar.com/
[29] Sterling, B. "When Blobjects Rule the Earth," Keynote at SIGGRAPH '04.
[30] Sterling, Bruce. Shaping Things. Cambridge, Massachusetts: the MIT Press, 2005, pp. 76-7.

continuous design has the potential to cost less than up-front planning, while providing a product earlier and including unforeseen improvements over its life.[31] It also fosters a community approach where diverse contributors can shape the product over the course of its existence.

The free software movement (also called 'open source') relies on a form of continuous design that is made possible by the open dissemination of the design documentation behind software products – its source code. A number of widely successful software products have been made in this manner, in part because it can benefit from a large number of contributors, many of whom are users – not developers – and more likely to know how the software should work. Although rare, the same approach is having success in specific domains of physical design. One site fosters the development of customized prosthetic devices by allowing users to contribute their designs, many of which would never be possible given the costs of medical device research.[32] In fact, the development of many key technologies – including the personal computer, the steam engine and the process for making steel – has been possible by the open dissemination of technical specifications, and the fostering of a community to address the problem collectively.[33] The search for environmentally and socially beneficial solutions to product design stands to benefit from a society of innovators to shift practices toward a radical new sustainability.

The foundations are in place for a continuous approach to physical design which engages designers together with manufacturers and consumers in a dialogue around new models of production. A number of techniques are being developed to inform consumers at the points of purchase using a cellular phone or other portable device[34]. This can be coupled to on-line databases that help determine the ethical and environmental ratings of companies and materials to guide purchasing[35]. While consumer purchasing may shift consumption habits toward a certain brand vs. another, they are easily manipulated by public relations and unlikely to promote paradigm shifts in consumption patterns of the kind that designers have the ability to introduce. There is a need for a new kind of design process, with its own tools, where products are outlived by their plans – or their designers, where many contributors can collaborate on the invention, use, and re-use of precious materials to provide sustainable business models with substantial social and environmental benefit.

[31] Fowler, Martin. Is Design Dead? Available at http://martinfowler.com/articles/designDead.html

[32] The open prosthetics projects: http://openprosthetics.org/

[33] Meyer, Peter B. Episodes of Collective Invention. US Department of Labor, Bureau of Labor Statistics, August 2003.

[34] Steffen, Alex, ed. Worldchanging. New York: Abrams, 2006. The Corporate Fallout Detector is mentioned on Page 116
Buy it like you mean it: http://bilumi.org/

[35] Ethiscore: http://ethiscore.org

## 7. References


Aranda, Benjamin, Lasch, Chris, Balmond, Cecil, and Kwinter, Sanford. Pamphlet Architecture 27: Tooling. Princeton Architectural Press, 2005.

Blevis, E. 2007. Sustainable interaction design: invention & disposal, renewal & reuse. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (San Jose, California, USA, April 28 - May 03, 2007). CHI '07. ACM, New York, NY, 503-512.

Buy it like you mean it: http://bilumi.org/

Bonanni, Leonardo. By a Long Land and a Long Sea Carriage: Unraveling the Reach of Product Design, in Thresholds: Journal of Visual Culture, #35, Fall 2008 (Forthcoming).

Bonanni, Leonardo. Future Craft: How Digital Media is Transforming Product Design. In the Extended Abstracts of Computer Human Interaction (CHI) Florence, 5-10 April 2008.

British Geological Survey: http://www.bgs.ac.uk/

Carson, Rachel. Silent Spring. Mariner, 2002.

Casper, Monica: Synthetic Planet: Chemical Politics and The Hazards of Modern Life. Routledge, New York, New York: 2003

Chumby industries (http://chumby.com) founder Andrew 'Bunnie' Huang published videos from the device's Chinese manufacturing line, among other things, at http://www.bunniestudios.com/blog/

Cutlip. Public Relations History: From the 17th to the 20th Century: The Antecedents (Lea's Communications) (Paperback)

Cohen, David. Earth's natural wealth: an audit. New scientist, 23 May 2007. http://www.science.org.au/nova/newscientist/027ns_005.htm

Coombs, W. Timothy, Holladay, Sherry, and Reynolds, Frances. It's Not Just PR: Public Relations and Society.

Cradle to Cradle Certification Guidelines: http://www.c2ccertified.com/

Csikszentmihaly, M. and Rochberg-Halton, E. The Meaning of Things : Domestic Symbols and the Self. Cambridge University Press, 1981.

Dean, J. and Tam, P-W. "The Laptop Trail" in The Wall Street Journal, 9 June 2005, available at http://online.wsj.com/public/article/SB111825761813954442-d4x_lQnm5A2GOO1NR6Wi_DBAyys_20050709.html?mod=blogs

Dunne, Anthony. Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design. MIT Press, Cambridge, 2006

Elwood, Wiliam N. (editor). Public Relations Inquiry as Rhetorical Criticism: Case Studies of Corporate Discourse and Social Influence (Praeger Series in Political Communicatio)

Energy Star: http://www.energystar.gov/

EPEAT: http://www.epeat.net/Criteria.aspx

Ethiscore: http://ethiscore.org

European Packaging Waste Directive: http://www.greendotcompliance.eu/en/common-questions.php

Ewen, Stuart. Pr! A Social History of Spin. Basic Books 1998.

Feenberg, Andrew. Questioning Technology. New York and London, Routledge, 1999.

Fenichell, Stephan. Plastics: The Making of a Synthetic Century HarperCollins,
New York, New York: 1996.

Fortun, Kim. Advocacy after Bhopal: Environmentalism, Disaster, New Global Orders. Universtiy of Chicago, 2001.

Fowler, Martin. Is Design Dead? Available at http://martinfowler.com/articles/designDead.html

Giudice, Fabio, LaRosa, Guido, Risitano, Antonino. Product Design for the Environment: a Life Cycle Approach. CRC 2006.

Grow, Brian, Tschang, Chi-Chu, Edwards, Cligg and Burnsed, Brian. Dangerous Fakes: How counterfeit, defective computer components from China are getting into U.S. warplanes and ships. BusinessWeek, October 2, 2008. Available at:
http://www.businessweek.com/magazine/content/08_41/b4103034193886.htm

Guha, Ramachandra. Environmentalism: A Global History. Longman, 1999.

Gutowski, Timothy G. Design and Manufacturing for the Environment, The Handbook of Mechanical Engineering, Springer-Verlag Dec 6, 2004.

IDSA Okala Guide: http://www.idsa.org/whatsnew/sections/ecosection/index.html

ISO 14401 certification: http://www.iso.org

McDonough, William and Michael Braungart. Cradle to Cradle: Remaking the Way we Make Things. New York: North Point Press, 2002.

Meyer, Peter B. Episodes of Collective Invention. US Department of Labor, Bureau of Labor Statistics, August 2003. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=466880

Mitchell, William J. et. Al. (June 2008). Mobility on Demand: Future of Tranportation in Cities.” Available at http://cities.media.mit.edu/pdf/Mobility_on_Demand_Introduction.pdf

Newing, Rod. The long and the short of measuring carbon footprint. The Financial Times, October 9, 2008, on page 2 of the Sustainable Business section.

Patagonia: http://patagonia.com

Pollan, Michael. Farmer in Chief in The New York Times Magazine, October 9, 2008. Available at http://www.nytimes.com/2008/10/12/magazine/12policy-t.html?_r=1&pagewanted=all

Raymond, E. The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary. Cambridge, MA: O'Reilly, 2001.

Rogers, Heather. Gone Tomorrow: the Hidden Life of Garbage. New York: the New Press, 2005.

Rohs: http://www.rohs.gov.uk/Default.aspx

Rosner, David and Gerald Markowitz. Deceit and Denial.

Shore, Jim. Continuous Design. In IEEE Software January/February 2004pp. 20-2. Available at http://martinfowler.com/ieeeSoftware/continuousDesign.pdf

Silverberg, Robert. Reflections: the Death of Gallium. http://www.asimovs.com/_issue_0806/ref.shtml

Simapro: http://www.pre.nl/simapro/default.htm

Sourcemap: http://sourcemap.org

Steffen, Alex, ed. Worldchanging. New York: Abrams, 2006. The Corporate Fallout Detector is mentioned on Page 116

Sterling, Bruce. Shaping Things. Cambridge, Massachusetts: the MIT Press, 2005.

Sterling, B. "When Blobjects Rule the Earth," Keynote at SIGGRAPH '04. Available at http://www.viridiandesign.org/notes/401-450/00422_the_spime.html

Students and Scholars Against Corporate Misbehavior (SACOM), High Tech - No Rights? A One Year Follow Up Report on Working Conditions in China's Electronic Hardware Sector, Available at http://sacom.hk/wp-content/uploads/2008/07/executive-summary-report-may-2008.pdf

Timberland: http://timberland.com/

Tweeney, D. "What's Inside Your Laptop?" in PC Magazine, 14 March 2007, available at http://www.pcmag.com/article2/0,1759,2102888,00.asp

Ulrich, Karl and Eppinger, Steven. Product Design and Development. McGraw Hill Higher Education, 2003.

U.S. Department of Transportation Federal Highway Administration. Construction Management Systems: Automated Contract Tracking. October 2001, FHWA-IF-01-022. Available at http://www.fhwa.dot.gov/construction/fs01022.pdf

Vezzoli, Carlo and Manzini, Ezio. Design and Innovation for Sustainability. London: Springer-Verlag, 2008.

Zelezny, Lynnette C. (editor), Schultz, P. Wesley. Promoting Environmentalism (Journal of Social Issues).