IASDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH THE HONG KONG POLYTECHNIC UNIVERSITY 12TH TO 15TH NOVEMBER 2007

REDESIGN: DESIGN FOR REASSEMBLY

Mark Richardson

Monash University, Department of Design, Industrial Design, Faculty of Art and Design, Caulfield East, Victoria, 3145, Australia, www.monash.edu.au

ABSTRACT:

In a probable future of legislated Extended Product Responsibility (EPR), Carbon offsetting, and growing concern for increasing landfill levels, the necessity for a shift in design systems is becoming increasingly apparent. Manufacturers are likely to be looking for avenues to reduce carbon footprints and emissions, both in terms of manufacturing practice and embodied energy within products. Designing to minimise waste and increase product longevity will be necessary strategies to ensure successful reductions in carbon emissions. The notion of designing for the innovative reuse of existing components within highly agile manufacturing systems, or what has been called 'redesign',[1] provides the basis of a sustainable design methodology which utilises devices such as information and communication technology (ICT), rapid manufacturing and component reuse to encourage 'dematerialisation', or a net reduction in material consumption, in society. It alters the way

[1] This is a phrase coined by the Victorian Eco-innovation Lab in an initial workshop for sustainable design solutions in 2007.

products and the consumption processes are perceived and opens up unprecedented possibility for product longevity.

1. INTRODUCTION

The purpose of this paper is to propose a potential framework for a design infrastructure which is intended to offer a strategy for reducing consumptive behaviour in society. It is to be fashioned into a pilot study through the Victorian Eco-Innovation Lab (V.E.I.L.), a collaborative network of designers, architects and engineers from universities based in Victoria, Australia. The format of the paper diverges from the traditional scientific model, adopting something closer to the voice of social and cultural theory. Its aim is not to draw conclusive findings, nor outline clear methodological frameworks for the collection and analysis of data. Rather, it explores emerging design and industry trends in component reuse as a strategy for sustainable manufacture, and then offers a speculative narrative of a future design anthropology[2]. The discourse subsequently extrapolates a possible path between the present reality and the proposed future model.

This paper is intended to be considered a narrative source document which is to be subjected to further analysis and validation. It provides a viewpoint of Design as being the act of instigation and making artefacts in a holistic sense. It considers the field of creative design to be intrinsically linked with environmental factors, social need and the practices of engineering, manufacturing and production. Through this integrative approach, valuable and functional artefacts can be brought into individual's lives.

The paper explores the potential for the further development of current strategies for component reuse and ICT integration in the context of a design process. It begins by studying companies such as Freitag and Xerox who have established methods for re-using and recycling existing materials and components for both the maintenance of existing and development of new products. These systems, whilst already proving profitable, have enormous potential for expansion. Currently operating as a parasitic[3] model, they could be extrapolated to form primary, sophisticated, highly integrated constituents of the manufacturing cycle. Redesign, as a

---

[2] The Utopian theory model advocates the proposition and analysis of future visions as a method for instigating alternative political and social directions. Fredric Jameson, in the introduction to his book "Archaeologies of the Future: The Desire Called Utopia and other Science Fictions", argues that the analysis of utopian ideology cannot be denied equivalency to the analysis of historical narrative as a means of social actuation. He also recognises the interdependent nature of the two, stating that "…in the case of the Utopian texts, the most reliable political test lies not in any judgment on the individual work in question so much as in its capacity to generate new ones, Utopian visions that include those of the past, and modify or correct them." (Jameson, 2005)

[3] The notion of a parasitic model implies the *'scavenging'* of discarded components and materials for reuse in the remanufacturing process, or for incorporation into new products.

bastion for personalisation, mass customisation, component reuse and alternative product lifecycles, could potentially change the way we think of cradle-to-cradle manufacturing.

The underlying premise of the concept is the consideration of an individual product as an assemblage of functional modular components with multiple life spans, rather than a complete, stand alone object with a singular finite existence. These modular components can potentially be deconstructed, reconstructed and re-skinned in a number of different ways, turning the focus away from 'product longevity' to 'component longevity'. Ultimately, the volume of materials entering waste and recycling streams may be reduced.

Redesign could also assist the growth of new industries and manufacturing techniques. The Fab Revolution and the concept of the 'Fab-Lab' (highly adaptable rapid manufacturing hubs) (Gershenfeld, 2005), for instance, provide mechanisms for bottom-up redesign, and the integration of existing components into new, low-volume products. The potential for product personalization, distributed manufacturing systems and minimization of product miles emerge as strong potential benefits for sustainable manufacturing, increasing both efficiency and reducing costs.

2. SOME EXISTING MODELS OF COMPONENT REUSE

It is widely accepted that a net reduction in new materials and commercial consumption ('dematerialisation') and much greater efficiency will be required for sustainable production levels to be achieved. The depletion of natural resources and increased energy demands, conjoined with growing global populations and exacerbating levels of waste, have been well documented over past decades. A number of legislative actions are beginning to emerge to support the development of a sustainable future; At least two of which may have fundamental implications for industry archetypes, manufacturing systems and current models of consumption. First, carbon offsetting, for which it is hard to determine the long-term implications, could be a costly exercise for manufacturers whose industry practice is ecologically unsustainable. The automotive industry, for instance, is likely to struggle as competition rises, vehicle prices drop, and the requirement for financial or in-kind offsetting of carbon emissions becomes a reality. Second, extended product responsibility (EPR) is likely to force manufacturers to develop strategies to minimise waste materials and components entering the waste stream. Financial modelling may impose the implementation of rationalised, innovative product disposal methods, and is likely to provide incentives to shift in industrial practices, in which design could play a major role.

Redesign, a design practice which incorporates the reuse of 'still-living' components salvaged from 'deceased' or discarded products could be a way forward for sustainable production. The underlying premise of component reuse is not in itself groundbreaking — such techniques have been noticeably been part of consumer culture for at least the last few decades. However, its integration into a highly sophisticated, production system of mass customisation could be. A large number of cottage industries have emerged over the past number of decades which utilise discarded materials and components in the design of new products. These industries range in sophistication from 'parasitic' to highly integrated, symbiotic models. Freitag, a German carry-bag maker, for example, utilises discarded tarpaulins from freight trucks in its F-CUT line (Freitag Lab. 2006) (Fig. 1). With the slogan 'it's your fault', the website enables customers to interactively 'design' their own bag online by placing individual pattern pieces on any of a number of selected available tarpaulins. The pieces are cut and sewn (and trimmed with reused bicycle inner tubes and automotive seatbelts) to the desired configuration and then shipped to the customer's home address. The transaction is catalogued, providing the customer with a URL address back to a visual record of the placement of the pattern pieces on the tarpaulins used.

Figure 1: The Freitag F-CUT online design process.

Other companies such as *URoads* and *Sonic Design* have been known for their reuse of scavenged components and materials. *URoads,* a footware label, hand-stitches and finishes reclaimed tyre treads, recycled papers and other materials into unique, individualised shoes (Fig. 2). *Sonic Design* adapts discarded everyday objects into alternate life products. Hangerlight (Fig. 3) is constructed from transparent coat hangers which radially surround a light bulb, while the Deolight (Fig. 4) playfully fashions used deodorant dispensers into torches (Brower, Mallory, Ohlman, 2005). Acceptance is growing for products such as these. Retail outlets, such as Studio Hergebruik in Rotterdam, are devoted to stock originating from alternative life materials and components, providing a service for sustainable design practice.

Figure 2: URoads footware (Brower, Mallory, Ohlman, 2005).

Figure 3: Hangerlight (Brower, Mallory, Ohlman, 2005).

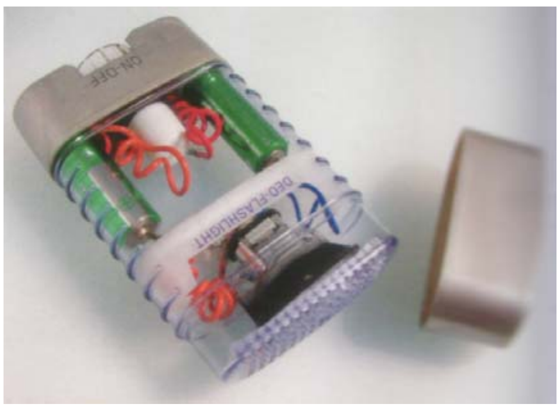

Figure 4: Deolight (Brower, Mallory, Ohlman, 2005)

Fuji Xerox Australia, since the late 1980s, has developed a far more integrative approach. Their formal method of modularisation, component recovery, and remanufacture have minimised contribution to the waste stream and saved the company millions of dollars. According to a study in 2000 (Kerr and Ryan, 2000), the integration of the system has been critical to the company's success. Fuji Xerox Australia, through a formal remanufacturing system, have been able minimise resource expenditure whilst providing customers the same level of service. Since 1999 the company has focused almost exclusively on the modularisation of their products, preferring to remanufacture these functional modules rather than entire systems in order to allow for rapid technology development. According to Kerr and Ryan, this modularisation has made disassembly easier and has allowed multiple uses across product lines. It has also allowed the implementation of *signature analysis* as a diagnostic tool to analyse the performance attributes of individual components. This provides the ability to ascertain the remaining life and performance potential of these components for reuse.

The above examples express the effectiveness of component and material reuse as a means to reduce waste and increase product value. However, they may not have yet reached their full potential. At present, the Fuji Xerox model is confined to its own product stream. There may be potential for collaboration between companies to develop ubiquitous components (or functional modules) for use across a broad range of products. The parasitic model, on the other hand, is also limited in its association with a distinctive aesthetic. In many instances the visual mark of original product is clearly evident, which, as a fashion fad is unique, however, its longevity is questionable. With the integration of rapid manufacturing systems, ICT, product service systems (PSS), and a sophisticated component-tracking and identification strategy, the reuse movement could potentially further develop into a broad-scale, highly integrated constituent of global manufacturing systems.

3. A VISION OF THE FUTURE: A CONTEXTUAL SCENARIO

The following scenario is an extension of a 'backcasting' exercise undertaken in a V.E.I.L. think-tank at the beginning of 2007 which looked into possible sustainable futures for the city of Melbourne and its surrounding regional areas (<www.ecoinnovationlab.com/2007/04/site_one_a_pree.html>). The purpose of the exercise was to project beyond current known constraints in order to develop snapshots of potential desirable futures. This vision-led approach has been utilised since the 1970s to develop solutions to complex problems in areas where there is a need for major change (Quist, Rammelt, Overschie, de Werk, G., 2005). In this case, it has highlighted a number of topics for further consideration, which are discussed throughout the rest of the paper.

… The year is 2032.

Rose, a practicing redesigner living in an inner suburb of Melbourne, Australia, is engaged in an online design review. It is taking place in Rose's immersive design studio situated in one of the most popular virtual worlds — an integrative environment now widely accepted as an essential adjunct to business life. The use of online immersive tools in her design process had opened geographic borders and expanded her clientele to a global base. Her redesign practice had recently become internationally recognised after she won a major design award for the 'Fridgy' (Sadowsky) [4]; a lightweight, collapsible, energy efficient fridge which utilised the reuse of an insulating fabric used by Boeing in their suborbital aircraft ten years previously. A number of these aircraft had recently been remanufactured and the insulating fabric updated. Rose purchased the old fabric from her regular, online component trader, incorporating it into the design.

---

[4] The underlying concept of the "Fridgy", a small, collapsible fabric refrigerator, has been sourced from the work of designer Yonatan Sadowsky. http://www.designboom.com/contest/view.php?contest_pk=3&item_pk=1026&p=1

Her client, Pieter, has joined her from his apartment in the centre of Stockholm. As man over 6', he has become accustomed to the work of the redesigner. Although he appreciates the provision for personalised ergonomic construction (most of what he owns has in some way been altered to fit), the overarching reasons for this means of purchase, whilst more expensive, are threefold. First, it provides him with a sense of wellbeing; by minimising his carbon footprint, he likes to think of himself as a caretaker for the environment, whilst not having to sacrifice all of life's small pleasures. Second, he considers the commissioned work of an artisan more valuable than the mass produced products available from regular retail outlets. In the past he has made some smart purchases from emerging designers that have since become internationally renowned; these are the objects he considers most precious. Third, he had become increasingly dissatisfied with 'blind' purchasing. This way, the purchase process intrinsically involves the advice and affirmation of an expert. His familiarity with size validation through the use of a dimensionally representative, haptic enhanced online avatar provides him with the assurance that what he experiences in the virtual translates effectively to the physical.

Pieter has commissioned Rose to design a personalised electric scooter. He had found an open-source design which he felt fulfilled most of his expectations. However, there were a number of things he wanted to change including its size and body style. They discuss the instructable [5] which outlines a previous, open-source iteration of the design. Its infrastructure is based on a configuration of ubiquitous components, which have been updated and interchanged over past years by a number of designers and engineers in order to improve efficiency and ride dynamics. All of the parts are accessible through online traders who deal with alternate-life components. However, Rose and Pieter have decided to interchange a number of them to better suit the cold conditions of the Swedish winter. The new components vary in dimension to those listed, so, to accommodate them, the scooter's frame is parametrically altered to suit.

During the modelling process the online component trader has been continuously linked to the parametric modelling software. As the component is selected and fitted, the trader instructed to put the part on hold. Each is selected based on its proximity to the rapid manufacturing facility, expected 'time to failure' (Murayama and Shu 2001), visual condition (when visible) and carbon rating. Highly sophisticated tracking and identification methods had been developed in the biotech boom in the early years of the 21st century. Updatable, organic, nanoprocessors were the most versatile solution, becoming the preferred utility. Deconstruction facilities, originally established to disassemble products for recycling, had also become an important part of the redesign and remanufacturing process. An industry had grown around the careful separation of components in order to maintain the highest quality component condition.

---

[5] The term '*instructable*' (Squid Labs, 2005) is used to describe the set of visual instructions used for making open-source gadgets. The maker documents the making process, either photographically or by video, provides a list of required components and tools, and annotates the process with a written description.

As Rose redesigns Pieter's scooter, the components that are not available locally to the manufacturer are substituted by an equivalent in the local market and the model updated. Rose stitches the last few alterations into the model and sends it to a rapid manufacturer based in Stockholm. The model, a complete assembly, includes the exact components sourced from local component holdings. It will take a few weeks for the physical product to be completed and delivered to Pieter, who lives close by.

4. REDESIGN: SOME KEY ASPECTS FOR POTENTIAL INFRASTRUCTURAL IMPLEMENTATION

It is recognised that the implementation of environmentally responsible design and manufacturing systems is unlikely to occur rapidly. The redevelopment of established manufacturing infrastructures is likely to be prohibitively expensive and beset by unforeseeable transitional issues. However, new design and manufacturing strategies like redesign can be tested on a small scale and allowed to grow organically. It is obvious, then, that the intrinsic involvement of design *as innovation* will be required.

To this date, the overarching premise of design has been to create single-life objects to be mass produced and distributed from single sources. One of the dilemmas we now face is that, in order to design for environmental sustainability, a degree of dematerialisation must occur. The system of redesign provides a framework for this through mechanisms such as personalisation, component reuse, design for disassembly, PSS, ICT, and distributed rapid-manufacturing systems. However, it will require four key shifts to bring about these changes.

4. 1. A SHIFT IN DESIGNERS' ATTITUDES.

Designers (the term 'designer' is used in a holistic, inclusive sense, i.e. architecture, industrial design, design engineering, etc.) need to reconsider the definition of a 'new' product and the value attributed to it. Commercial designers largely view products as stand-alone, single-use objects and do not consider their relativity to the broader world. This mindset can neglect to consider a product's social context, environmental impact and cultural significance. Designers need to be more aware of the down-stream effects of their practice and be encouraged to innovate above and beyond the systems in which their skills are currently being employed.[6]

A study in Sweden for a local pram manufacturer demonstrates the potential for design-led collaborative innovation (Mont, Dalhammar, Jacobsson 2006). It expounds the environmental and financial benefits of a product designed for remanufacture and component reuse, and highlights the importance of a collaborative approach to innovation. The infrastructure, in this case, was pivotal to the effective delivery of the program. The pram, a product with short periods of customer usage (and consequently, high waste at end of life and excessive energy expenditure per usage hour) is exemplary in the consideration of products as systems rather than single-life artefacts. The two-year study compared the relative benefits of using a product service system to extend usable product life, and demonstrated an overall reduction in the consumption of raw materials.

According to Mont et al., it operated on the basis of three criteria for sustainable product development: increasing product longevity through maintenance and upgrading (in this case, utilising a lease arrangement in conjunction with a product take-back system); the return of products at end-of-life to the retailer for remanufacturing, selecting the appropriate components for reuse, and recycling the remainder; and the integration of the key environmental maxim of 'reduce, reuse and recycle' into the up-front design process itself. A hierarchy of replaceable components was established, with the main structural components being utilised for up to eight customer cycles.

In this case study, the idea of what a 'product' entails and how the designer conceives and interacts with it is fundamentally shifted. The concept of the 'product' expands beyond the artefact itself, encompassing a broader system within which the object is an ephemeral assemblage of active, 'living' components. The master–slave relationship between product and component is consequently attenuated, and, it is at this point that the design process has the option for diversification — the object is no longer explicit (the end result of a linear process), it is a highly adaptable, reconfigurable, complex functional system: it has potentiality beyond specificity.

[6] A Design Director I know in the automotive field once stated that engineering's role was that of innovation, and design's role was to package technology in an aesthetically pleasing enclosure. This attitude, a still pervasive belief, undermines the power of interdisciplinary collaboration in innovation and may protract the timeframe for change.

4. 2. A REQUIREMENT FOR FURTHER DEVELOPMENT OF DESIGN TOOLS AND METHODOLOGIES

In order for dematerialisation to become a reality, energy-efficient design, manufacturing and distribution may be required. This highlights the need for the integration of ICT, parametric modelling and distributed rapid manufacturing into the design process. ICT, for instance, has the potential to revolutionise product systems. The scenario at the beginning of this paper illustrates ICT's capacity to integrate collaborative design systems, link databases to the design process, augment reality, and provide immersive environments in order to validate design decisions (Ryan 2004). ITC can potentially provide mechanisms to minimise energy consumption, waste material and product miles through borderless interactive networks.

The functional development of ICT as a representation of real world systems is desirable for the augmentation of borderless collaborative design exchange. In an exploration of the development of collaborative virtual environments (CVE) in the late 1990s, it was of fundamental importance to facilitate action and interaction consistent with the social nature of work in a specific environment (Benford, Snowdon, Colebourne, O'Brien, Rodden, 1997). The link between the movement of the 'document' in a typical workplace and co-operation between co-workers formed the basis of a proposal for CVEs. The study describes the document as a '"stratified trace" of the activities of the organisation [that] can be interrogated to this effect by those with practical knowledge of the organisation itself'. (Benford et al. 1997)

The 'document' becomes a metaphor for the infrastructural basis of a networked, information-sharing, data-storing, virtual environment. In effect, these environments become sophisticated, interactive 'libraries' containing more than text-based information. The inclusion of open-source artefacts extrapolates the facility beyond mere referencing capabilities, to that of being able to access past, present and future potentiality. In a virtual space, artefact and text are equivocal and can be stored in the same way: as bits. A designed artefact, as a virtual, open-source program, can be considered in the same way as an open-source text-based document such as a 'Wiki'[7]. It has a historical narrative, a present incarnation, and a future potentiality. Consequently, it is not necessary for the made object to be considered a singular entity, but rather, a virtual, modifiable object that overlays a physical incarnation. The master object is an immaterial program in a virtual space.

In order for the development of an effective collaborative design interface, however, there are a number of issues to be overcome. For instance, in current interface systems the divide between the representation of an

---

[7] In the manner of the online user-written Wikipedia.

object on the screen and the actual physical form can differ immensely. When ergonomic and dimensional validation is required, this becomes a critical point. That differential needs to be minimised in order to test the experiential qualities of the object and provide the assurance that 'what you see is what you get'. Immersive haptic environments could overcome many of these difficulties. At present these systems are in their infancy and are beyond the reach of many individuals, though, it appears they are not far away. Haptic tools are currently available, as is visualisation software with the ability to view objects 1:1 in an immersive virtual environment. These can already interface with some readily available digital modelling packages.[8]

When rapid manufacturing is integrated into a system with ICT and parametric modelling the possibilities for mass customisation and personalisation may become an achievable commercial reality. In *FAB: The Coming Revolution on Your Desktop – from Personal Computers to Personal Fabrication*, Neil Gershenfeld (2005) discusses the vast potential of personal fabrication. The facility of the FAB lab allows individuals to invent and make (almost) anything. The book outlines how to configure readily accessible and affordable technology to facilitate the rapid manufacturing of one-off, highly personalised artefacts.

Rapid manufacturing facilities are also currently commercially available. For instance, eMachineshop (2007) provides the capability to manufacture components for the making of one-off or limited-run products. The online service provides proprietary modelling software to make components on your own PC. These components, once completed, can be sent electronically for manufacturing, and then delivered back to the customer.

4. 3. INFRASTRUCTURES FOR AN EFFECTIVE AND RELIABLE SOURCE OF COMPONENTS

The reuse of existing components from discarded products has potential to support the development of sustainable manufacturing and consumption. McDonough and Braungart (2002) discuss the need for our product systems to imitate nature's highly effective cradle-to-cradle metabolism; a system where there is no waste. This requires components to be designed for longevity, reuse and biodegradability to feed natural systems. In the light of this, materiality is obviously of fundamental concern; however, product disassembly and component recovery, identification, evaluation, tracking and cataloguing systems are of upmost importance as supportive mechanisms. In today's consumer society, product 'lifecycle mismatch' provides a strong case for the establishment of such a system. This mismatch operates on two levels: first, the

---

[8] Mechdyne Corporation's subsidiary VRCO Inc. (2006) has developed their immersive visualisation software to interface with Autodesk's Maya and 3ds-Max (<www.vrco.com/News/Conduit_for_DCCD.html>).

performance lifecycle or usage hours are often shorter than the functional life of a product. Second, the lifecycle of components within a product differ (Li, Shrivastava, Zhang, 2004). For instance, a product comprising components with life spans ranging from 2000 to 12,000 usage hours are traditionally discarded at the point that the 2000 hour component ceases to function. An extensible product lifecycle (EPLC) strategy, according to Li et al., provides the basis for product longevity with multiple lives for components. Currently, however, the mechanisms and infrastructures required for an integrated EPLC are in their infancy, and the drivers for component reuse are not yet in place.

The emergence of take-back legislation, or EPR, may provide the impetus for industry to incorporate component reuse in their design strategies (Murayama and Shu 2001). The incentive to disassemble and disseminate components within local markets, rather than transporting entire products back to a primary manufacturing hub becomes a foreseeable reality, especially when considering international trade volumes. Under take-back legislation, due to the ephemeral nature of many parent companies, there is also likely to be orphaned products which will still require a responsible system of disposal. In addition to EPR, Carbon trading legislation may also become an issue for consideration. For instance, product and component longevity, coupled with a reduction in product miles and the minimisation of manufacturing energy expenditure, would be desirable for the reduction of carbon emissions.

In order to introduce reuse as a means to provide component longevity, the disassembly and separation of products into component parts requires a system of evaluation for reliability. Murayama and Shu (2001) explored the potential for component reuse as a system of remanufacture.[9] They found the management of such a system as having a number of difficulties: first, the unreliable timing of product returns and their variable quantity, and second, the knowledge of the embodied component types and their condition. Reuse relies on the development of a threshold matrix, where ‘time to failure’ and ‘quality deterioration’ can be determined.

The Fuji Xerox model provides a robust system of signature analysis which could be used as a foundational model. Using this as a base, the next step could be to design further intelligence into products. Products could potentially be produced with ‘neural networks’ to monitor performance and component failure, and to provide intelligent feedback to the user. For example, Spanish architect Vicente Guallart’s ‘Media House’ is a prototypical living space in which the physical and virtual are overlayed with the use of a network of

---

[9] While remanufacture provides a basis for product longevity it mainly considers it within a system of product repair and refurbishment. The distinction between remanufacture and redesign, however, is the potential for levels of design innovation. Remanufacture, as primarily involving the refurbishment of an existing product from a particular brand in a linear sequence, is relatively limited in scope. Redesign opens up the opportunity for the innovative use of components for potentially different applications.

microprocessors incorporated in the structure of the house (Bullivant, 2005). This network allows multi-level communication between the inhabitant, the components of the home, and the outside world. The 'neural' nature of the network allows a dynamic interface between the user and the structure, providing an intelligent exchange. In the same way, the integration of built-in information systems, where each module talks to the next, could provide data to a broader redesign network infrastructure. This information could be analysed on site, or tracked via the internet, by a manufacturer or service agency, and could provide valuable data about the components embodied within.

4. 4. THE ENGENDERING OF SOCIAL ACCEPTANCE FOR PRODUCTS STEMMING FROM ALTERNATE LIFE COMPONENTS

In a culture where customisation and personalisation are becoming increasingly valued, a shift in the diversification of ownership possibilities and in the way we conceive, make and purchase our products (and product services) is inevitable. The challenge for design is to develop systems which meet specific needs, yet encourage a reduction in waste-generating consumption. There are a number of differing requirements for products intended for long-term ownership (e.g. the Freitag model) and short-term use (e.g. the pram model). The intrinsic values for both scenarios require differentiation.

The adoption of an 'Arts and Crafts' approach provides a link to the designer, connecting the artefact to its creator in the mind of the customer. This connection, similar to the relationship of an artist and their work, can imbue a sense of preciousness. The current capitalist consumer model is lacking in this respect. Credit purchases, buy-now-pay-later schemes and interest-free loans can encourage a culture of instant gratification and disposability. This model provides ease of purchase (one can walk into a retail outlet, make a selection based on what is visibly available, pay via credit card and walk out again within minutes) — a superficial engagement requiring very little personal investment. The product itself is a stand-alone item with very little connection to its creator; it is isolated from its human association. It becomes tarnished while the owner is still repaying the purchase, consequently inducing a sense of dissatisfaction. Whilst a credit culture is unlikely to decline in the foreseeable future, a process that actively engages the customer — by encouraging personal contribution and investment in the very conception of the product — elevates the value of that item, amplifying the possibility of enduring personal attachment and user satisfaction.

The redesign model also potentially provides a closer link between the designer and the artefact. The opportunity for the rapid manufacturing of one-off, bespoke products provides a means by which designers can return to 20th-century Arts-and-Crafts sensibilities without the prohibitive costs and elitism associated with the demise of the original movement (Cumming and Kaplan 1991). Such systems could serve to deepen the experience of practical, emotional and hedonic pleasure in relating to the product; what Patrick Jordan refers to as a 'catch all' for pleasure-based approaches in product design (Jordan 2000). He proposes that these pleasures can be further divided into four strata: *physio, socio, psycho and ideo*. If Jordan's model is followed, it can be argued that by providing pleasure on all four of these levels, a system of component reuse within a redesign framework would foster consumer acceptance. Whilst the following considerations are brief, they are illustrative of a broader discourse.

In terms of *Physio-pleasure*, conventional single-source manufacturing and distribution and the redesign model have many similarities. On a sensory level, the immediate gratifications of an artefact in isolation (i.e. its materiality, visual form, tactile qualities, and smell) are broadly similar. However, in the former model, products need to appeal to the broadest economic base in order to justify financial investment for production. Market research prior to the commitment to tooling is often employed to establish a products potential reach in the market. Unfortunately, this can not readily adapt to micro market needs or shifts in consumer expectations and desires. Consequently, the system requires a level of commonality and is generally unable to provide for every individual's specific desires; there is a requirement that *individuals* fit the *product* rather than the reverse — a distinct disadvantage for *physio-pleasure*. Redesign differs, as with the case of Pieter's electric scooter, in its ability to 're-skin' for localised aptness. It can adapt to individual tastes, ergonomic requirements and locally available materials. The system also has the potential to dynamically update functional ineptitudes and provide the means for repair rather than abandonment.

On a *socio-pleasure* level, both redesign and traditional manufacturing and distribution models have the ability to foster social identity. Brand image is a strong imperative for producers in the current design/manufacturing model. It is difficult to determine how brand image ultimately fits into the notion of diversified mass customisation; however, it opens new possibilities for brand structures and image diversification. Current systems provide individual *choice*; however, choice is bounded by a narrowly dictated hierarchical manufacturing system. Choice must be made from the artefacts available from within a predetermined commercial system. As a consequence of the way redesign provides *diversity* in the act of commercial consumption, it opens up greater opportunities for social interaction. This interaction would be on a number of levels: with the designer at the product's conception, providing a personal connection with the artefact's creator (a luxury rarely afforded in current systems); with broader global networks of others with similar interests, such as in blog culture and virtual interaction; with immediate peers, opening up possibilities for greater discourse about the relevance of the artefact to the individual and its integration into real life. The open-source nature of the system allows individuals a sense of participation in the growth of innovation. Individual contributions aid the improvement of a system greater than themselves. In Pieter's case, the modification of an existing scooter to suit his local conditions opens up a new market for the design.

In a system which offers the possibility for broader diversity and distinction in the use of product and product services, *psycho-pleasure* can be drawn from an artefact's symbolic relevance to ideological frameworks and expressions of individuality. It can provide a greater link to one's ego. Currently, systems of design and manufacturing possess ultimate accountability for the artefact, allowing individuals a level of corporate acceptability. In a collaborative or self-determined personalised system of design, the notion of 'wearing one's heart on one's sleeve' takes on new relevance, literally, and does not come without its issues. Whatever the outcome, the interaction with the artefact can be made more emotionally intimate through personal investment. The notion of disposability, at this point, becomes a more complex process for the head and heart, parting with an object of one's own creation.

The complexity of the notion of the artefact as a system, rather than the current system of artefacts, could have broad implications for *ideo-pleasure*. Ideologically, a system which provides visible benefits to an individual's immediate needs, enriches social capital and connectivity, assists distributed local economies, and contributes to global ecological wellbeing provides a positive basis to satisfy common human values. The artefact has the potential to serve a greater function in the representation of these values.

5. CONCLUDING REMARKS

This paper serves as an illustrative medium to highlight the potential for an alternative, sustainability-focused industrial reality. It proposes a vision-led strategy for further research into collaborative design methodologies, with the intention of forging new paths to a sustainable future. The basis of the study revolves around the notion of redesign, a coalition of design, ICT, PSS, distributed economies, rapid manufacturing and component reuse. Concept validation is currently being explored collaboratively through the Victorian Eco-innovation Lab between three of Melbourne's leading universities; the results of which are intended to be published at a later date.

While the long-term implications of the redesign system remain uncertain — this paper does not provide regulatory frameworks, economic models or conclusive impact statements — it is expected that such a strategy would advance us beyond existing industrial systems, which will have difficulty conforming to increasing environmental imperatives, and provide considerable advantages for ecological, social and cultural sustainability.

A number of questions still remain unanswered. It could be argued that the move to mass customisation may only serve to encourage the proliferation of consumptive behaviour. The abuse of highly adaptive production technology which could increase rates of change for a competitive edge is a potential threat. The nature of social attitudinal change, however, remains to be seen in the light of ecological and broader environmental conditions. Currently there have been few alternatives offered to respond to the institution of environmental legislation in our post industrial processes of design and manufacturing. Designers, at present, are complicit (some would say intrinsic) to the development of 'consumer' products and mentalities for our consumptive society. It is high time for us, as designers, to be pre-emptive in our search for new ways to responsibly conceive of, and make artefacts of considerable functional, social and personal value.

ACKNOWLEDGEMENTS:

This research was carried out as a part of a joint research project funded by the Victorian Eco-innovation Laboratory, University of Melbourne. Special thanks to Professor Chris Ryan, Michael Trudgeon, Kirsty Fletcher Dianne Moy, Jon Allen and Susie Elliott whose input has been highly instrumental in the formation and development of the concept of redesign.

REFERENCES:

Benford, Snowdon, Colebourne, O'Brien, Rodden, Informing the Design of Collaborative Virtual Environments, Proceedings of the international ACM SIGGROUP conference on Supporting group work: the integration challenge GROUP '97, Phoenix, Arizona, 1997, 71 – 80

Brower, Mallory, Ohlman, Experimental Eco Design: Architecture, Fashion, Product, Rotovision SA, Mies, 2005, 112-121

Bullivant, Media House Project: the House is the Computer, the Structure is the Network, Architectural Design, Volume 75, Issue 1, January/February 2005, 51-53

Cumming, Kaplan, The Arts and Crafts Movement, Thames and Hudson, London, 1991, 206

eMachineshop, www.emachineshop.com, last accessed 28/05/2007, 2007

FREITAG lab., www.freitag.ch, last accessed 25/05/2007, Zurich, 2006

Gershenfeld, FAB: The Coming Revolution on Your Desktop--From Personal Computers to Personal Fabrication, Basic Books, New York, 2005

Jameson, Archaeologies of the Future: The Desire Called Utopia and other Science Fictions, Verso, London, 2005, XV-XVI

Jordan, Designing Pleasurable Products, Taylor and Francis, London, 2000, 11-14

Kerr, Ryan, Eco-efficiency gains from remanufacturing: A case study of photocopier remanufacturing at Fuji Xerox Australia, Journal of Cleaner Production 9, 2001, 75–81

Li, Shrivastava, Zhang, A Distributed Design Methodology For Extensible Product Life Cycle Strategy, International Symposium on Electronics and the Environment, 2004. Conference Record, IEEE, 10-13 May 2004, 214 - 219

McDonough and Braungart, Cradle to Cradle, North Point Press, New York, 2002, 103-104

Mirti, Aprile, Building as Interface: or, What Architects Can Learn from Interaction Designers, Published Online: 14 Feb 2005, DOI: 10.1002/ad.10, Architectural Design, Volume 75, Issue 1, 2005, 30–37

Mont, Dalhammar, Jacobsson, A new business model for baby prams based on leasing and product remanufacturing, Journal of Cleaner Production 14, 2006, 1509-1518

Murayama, Shu, Treatment of Reliability for Reuse and Remanufacture, Proceedings EcoDesign 2001: Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing, 2001, IEEE

Quist, Rammelt, Overschie, de Werk, Backcasting for sustainability in engineering education: the case of Delft University of Technology, Journal of Cleaner Production 14, 2006, 868-876

Ryan, Digital Eco-sense: Sustainability and ICT – A New Terrain for Innovation, Lab.3000, Melbourne, 2004, 97

Sadowsky, Fridgy, Design Boom "Kitchen is the Heart of Home" competition, 2005, http://www.designboom.com/contest/view.php?contest_pk=3&item_pk=1026&p=1

Squid Labs, www.squid-labs.com, last accessed 30/05/2007, Alameda, 2005

Studio Hergebruik, www.studiohergebruik.nl, last accessed 30/05/2007, Rotterdam

V.E.I.L., SITE ONE. A 'Pre-emptive Downshifting' neighbourhood, www.ecoinnovationlab.com/2007/04/site_one_a_pree.html, accessed 25/05/2007, 2007

VRCO Inc., Mechdyne Enables Immersive Virtual Reality Capabilities in Maya and 3ds Max 9 from Autodesk, http://www.vrco.com/News/Conduit_for_DCCD.html, last accessed 26/05/2007, Marshalltown IA, 2006