Design, Sustainability and Business - *Research-through-practice informed by practise as research (Portfolio)*

This research explores the influence of the early design stage on the environmental impact of products and the roles and interactions of key players in minimising this impact during the new product development cycle.

This body of work is unique in that it brings together the findings of two Government funded research initiatives (the Deep RED (Resource Efficient Design) and Retail Lab research initiatives) and a commercial design research commission for a short life retail display system for the Robert Horn Group (all proposed and undertaken by the investigator). It applies design research methodologies, in which the investigator is a leading authority, to utilise practice based design research to inform theory. The Deep RED project incorporates specific environmental design research projects for EON, Travis Perkins, Primarius UK, Scott Bader and Antone; the Antone project being further developed as part of Retail Lab research, eventually becoming a specific commission for the Robert Horn Group and a patent application (GB1216474.5)

This research confirms that a products environmental impact is largely established in the concept stages of the new product development (NPD) cycle, it identifies issues concerning the use of environmentally sustainable materials relating to cost and availability and also identifies that there are significant opportunities not only to reduce the environmental impact of products but to reduce costs in so doing. In addition findings from this research highlight issues in supply chain communication and collaboration relating to supply chain management and in particular how this could relate to UK Design Consultancy and the use of Life Cycle Analysis tools. Findings have been disseminated by patent and culminated in two international conference papers and two international journal publications.

CONTENTS

Output Description

This research provides further evidence that a products environmental impact is largely established in the concept design stages of the new product development (NPD) cycle and that if this can be managed effectively it can lead not only to products with a reduced environmental impact but to more cost effective products that generate increased revenue for their developers.

The research achieves this through undertaken a number of design development research projects that track the role of the key players who can influence sustainability in NPD, that identify issues relating to accessing new materials, processes and associated supply chains and identify issues with using ECO tools within the UK Creative Design Community.

This portfolio is composed of 5 sections:

Section one provides summaries of the four key case studied that emerged from the Resource Efficient Design in the Supply Chain (Deep RED) research project.

Section two demonstrates how one of these case studies (a short life, sustainable, retail display system) has led to an environmentally sustainable, commercially viable product for the retail sector and a patent application for an innovative assembly system that has made this product possible, demonstrating that effective use of design in the early stages of NPD can indeed lead to a product that has both a reduced environmental impact and reduced manufacturing cost, making for an economically viable product.

Section three is a short summary of the Resource Efficient Design (RED) in the Supply Chain (Deep RED) research project.

Section four lists how this research has been disseminated.

Section five provides evidence of how Fords RED research was used as part of the House of Lords Science and Technology Committee on Waste Reduction Report published in August 2008

This research builds on the work undertaken by Ford as part of his Resource Efficient Design (RED) Initiative work which was submitted as an output for RAE 2008. This work was focussed on investigating methods whereby companies can minimise the environmental impact of their products...

This portfolio centres on a second project entitled Resource Efficient Design in the Supply Chain (or Deep RED) a £320,000 design research project funded by the East Midland Development Agency in 2009. Whereas the first RED Initiative project sought to engage a large number of collaborating companies, Deep RED differed in that it undertook only four projects deeply in order to understand the implications of supply chain integration and communication on resource efficiency in NPD.

This portfolio also makes reference to the Retail Lab design research project (also proposed and undertaken by Ford), which provided a platform to test and evaluate the short life, sustainable retail display system.

This portfolio includes reference to two international conference papers and associated journal publications. The first presents the finding of the Deep RED project and the second highlights the uptake (or lack of it) of life cycle analysis tools (which was revealed while undertaking the Deep RED research) in the UK product Design Community.

SECTION 1

Resource Efficient Design in the Supply Chain (Deep RED) Case Studies

1 Travis Perkins – Packaging for Screws and Nails.

2 Scott Bader – Natural Fibre Reinforced Composites

3 Primarius UK – Light Weight Train Seat

4 Antone Sustainable Retail Checkout Desk for Comet
(Short Life, Sustainable Retail Display System)

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Resource Efficient Design in the Supply Chain (Deep RED)

The development of packaging of construction materials to reduce waste using Resource Efficient Design (RED) techniques

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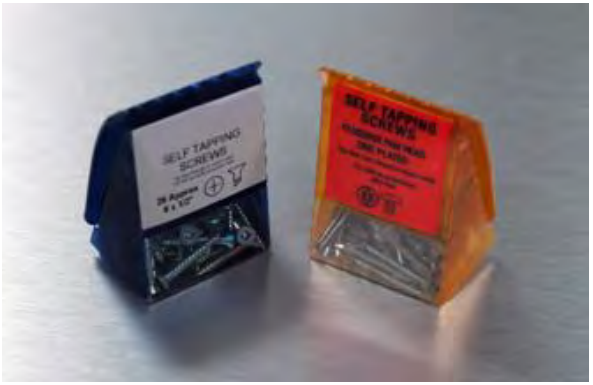
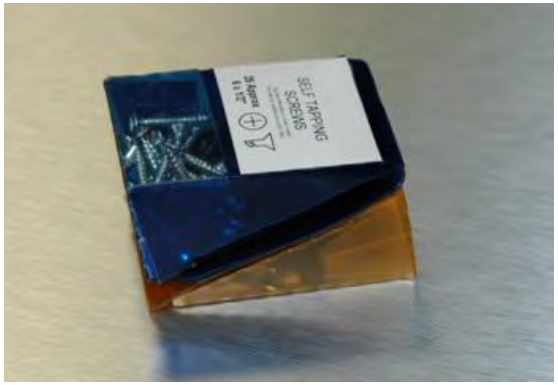
Travis Perkins Packaging for Screws and Nails – The Problem





Travis Perkins Packaging for Screws and Nails – The Solution

PROJECT SUMMARY

Building on the success and impact of The Resource Efficient Design (RED) Initiative programmes funded by EMDA and delivered by De Montfort University, the programme was developed to extend RED knowledge into East Midlands' supply chains. Overall, the programme aimed to define best practice and skills development opportunities, deliver tangible business performance improvements and contribute to regional policy objectives.

Resource efficient design has proven to be an effective method of delivering tangible and measurable business improvements (e.g. new products, employment and GVA), whilst addressing strategic regional objectives. The highly successful RED programmes demonstrated the importance of resource efficient and environmental design to mainstream manufacturing and retail companies. However, in order to maximise regional business and strategic development impacts, it was identified that resource efficient design activities need to extend throughout the supply chain of products and services. In particular it is an essential prerequisite of a fully functioning supply chain that a sustainable supply of appropriate raw materials are available to stakeholders at all stages, especially where interdependency of supply chain links has the potential to converge the interests of stakeholders at all positions in the chain.

A key focus of the Resource Efficient Design in the Supply Chain programme was the emphasis on skills development for resource efficient design and low-carbon product development, and the transfer of the requisite knowledge to East Midlands SMEs through sector-focused training.

To maximise environmental impact and business opportunities it is necessary to:

- Develop resource efficient design within the low carbon supply chain context;
- Transfer knowledge and develop skills within supply chains;
- Extend resource efficient design techniques into the production, marketing and end-of-life of products and services;
- Extend resource efficient design from product design into other areas of the economy;
- Develop and utilise low carbon and sustainable material supply chains to displace high carbon and petrochemical materials.

Case study: Travis Perkins

Travis Perkins is one of Europe's largest retailers of building materials and supplies. They own a number of retail and trade brands including Travis Perkins, Wickes, Keyline, City Plumbing, CCF, Tile Giant, and Benchmarx. This project is concerned with the waste arising from the storage, transport, warehousing and retailing of products. Much construction materials end up as waste without having been used. It will have a natural focus on the design of packaging used within the group.

Understanding the problems around these issues is complex but it appears to be the way that the entire retailing/warehousing system is designed that causes the problem. This is exacerbated by the fragile nature of some of the materials used in construction. For example there is a significant amount of plasterboard waste due to the brittle product and the need to keep it dry. This has an obvious financial implication, however, the resource efficiency implications are massive given the level of embedded carbon within the product and the volume of materials used every year.

Benefits to company:

This piece of work will see a detailed review of retail and packaging systems for five key product lines. These lines will be determined by reviewing waste volume and cost (CO_2 and financial) data from the business and then running a short workshop with the company to focus attention.

Once the product lines have been selected we will undertake a cut-down life cycle assessment of them identifying the larger environmental impact and then developing design strategies to reduce the impact of:

- The product
- Its storage and transport
- Its packaging
- Its use, and
- Its disposal

This will aim to produce redesigned procurement, retailing and distribution systems; re-designed packaging; and possibly redesigned products. The project will produce:

- A showcase low carbon packaging, distribution and retailing.
- Environmental and CO_2 savings over the life-cycle of the products (reduced carbon footprint)

Knowledge transfer opportunities:

- Showcase example of innovative packaging design, product design, distribution and retailing.
- Skills development in packaging design, product design, retail and distribution systems.

Scope

This proposal addresses the loss of product through the retail chain as a result of weaknesses in packaging design, product design, distribution and merchandising. It will also consider how the products are used.

The intention is to improve the following (not ranked):

- Packaging (optimise)
- End of Life – can we close the loop?
- Material efficiency in product design

In addition, the intention is to maintain *or* improve the following (not ranked):

- Sales
- Brand
- Profit margin

The Project

3 potential projects were identified:

- Packaging for slabs
- Adhesive dispenser to replace ‘mastic gun’ type applications
- Packaging of small volume screws and nails etc.

Packaging for slabs is still ongoing and early research revealed an existing solution for the adhesive dispenser, this case study therefore focuses on packaging for small volumes of screws and nails.

The Problem

The packaging for screws and nails are distributed and sold in Wickes and Travis Perkins stores in either cardboard boxes for larger amounts of product or in vacuum formed PVC packs for the smaller volumes of typically screws and nails (of the type that are sold on a Euro Hanger system).

In both circumstances product is packaged by hand in China and shipped to the UK.

Wickes and Travis Perkins have been criticised by Trading Standards in recent months for the grossly inefficient packaging of the small amounts of screws and nails in the vacuum formed packs. As this area potentially could potentially yield more immediate gain it was felt that this area was worthy of the greatest amount of attention.

The existing vacuum formed packs are available in only 4 sizes, so product has to fit the most appropriate available. This can result in some packs being only %15 to %20 full of product and seldom better than %50, hence the criticism from Trading Standards.

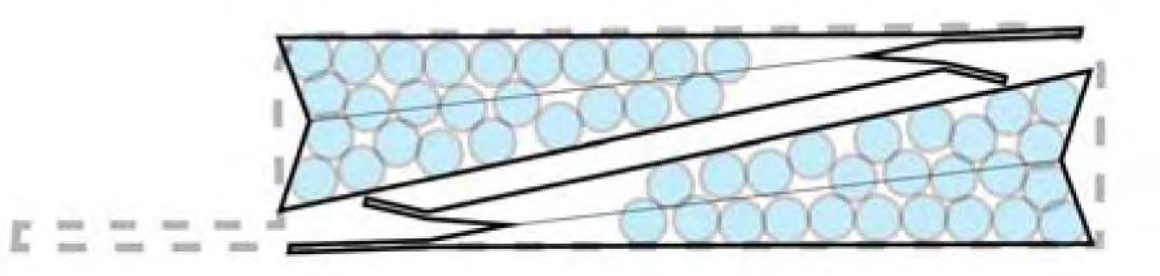
This has led to a highly innovative wedge shaped concept in card.

The wedge shape enables a much more efficient use of space halving the amount of waste volume being shipped from China.

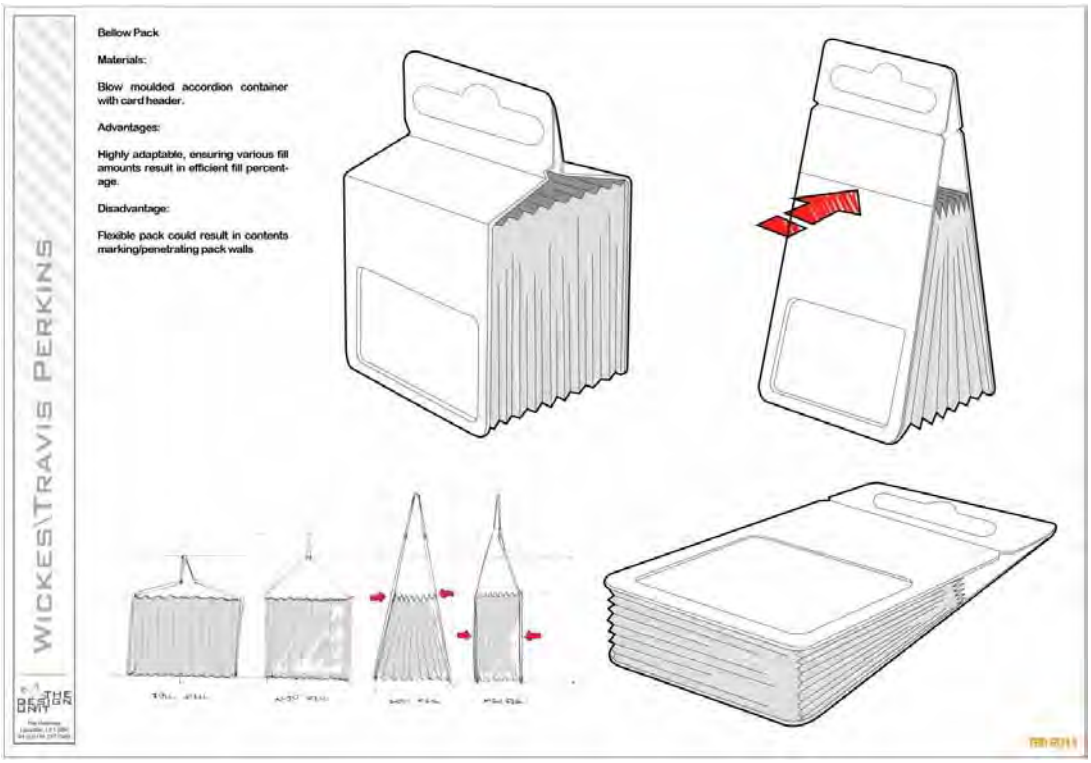
The design still provides an effective display of product and opportunity for graphic application and user instructions.

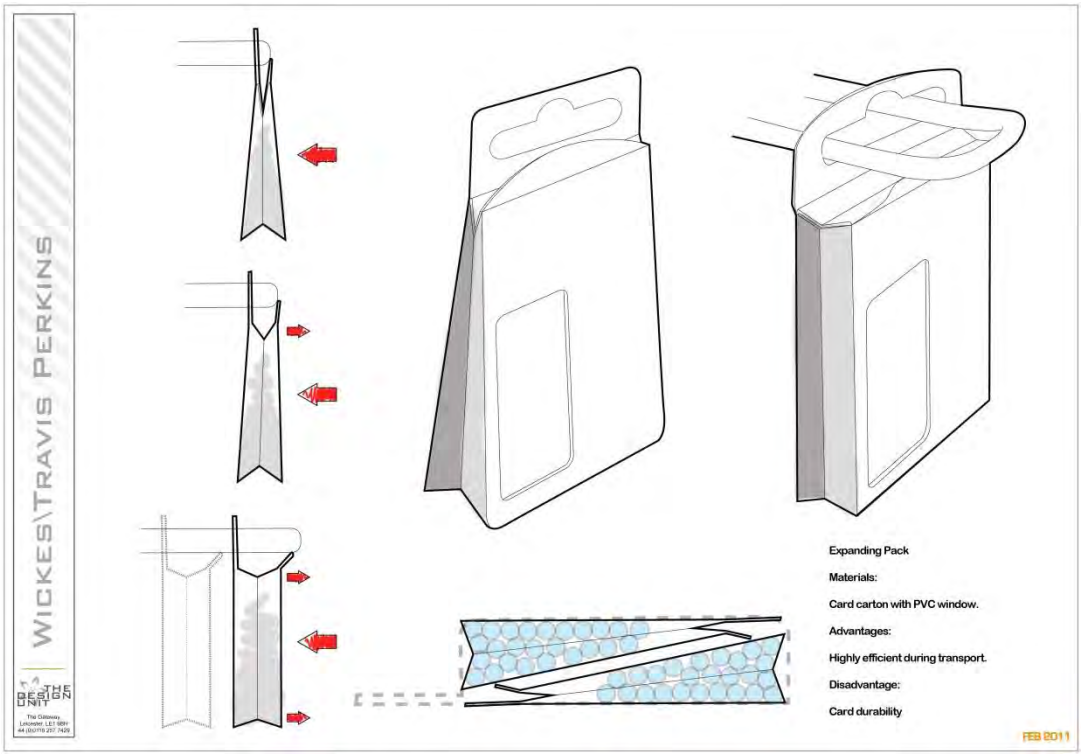
End of life is vastly improved using the card which is readily recyclable.

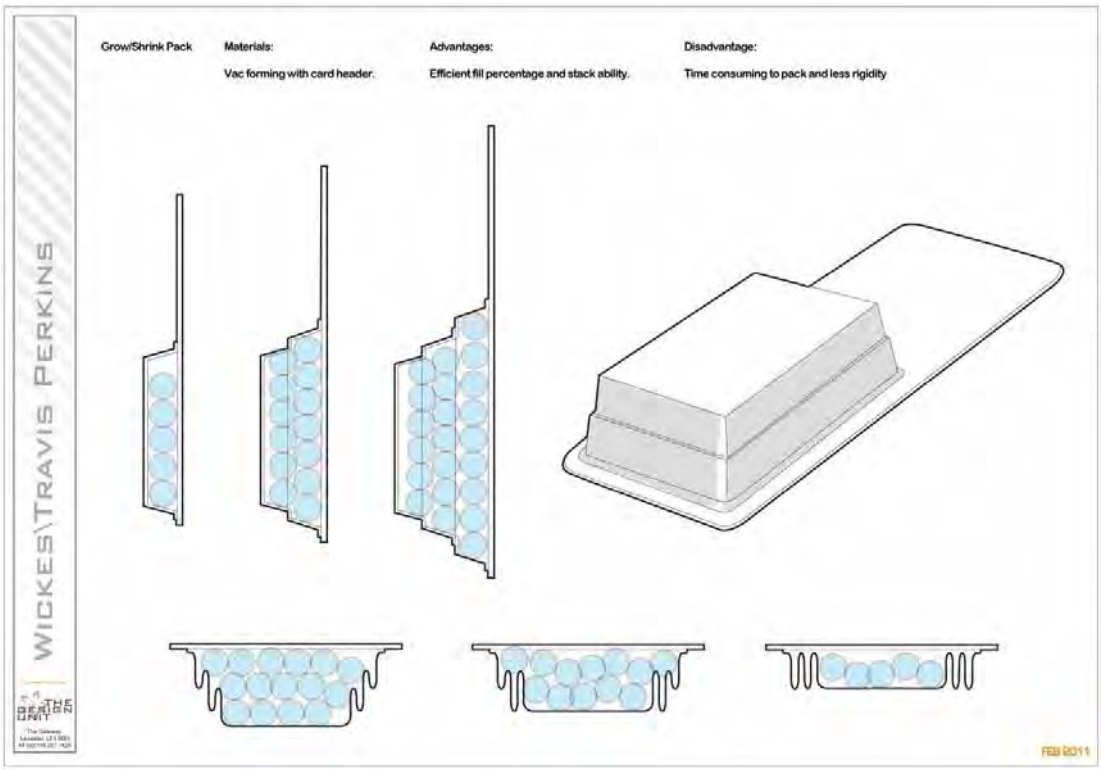
The Concept

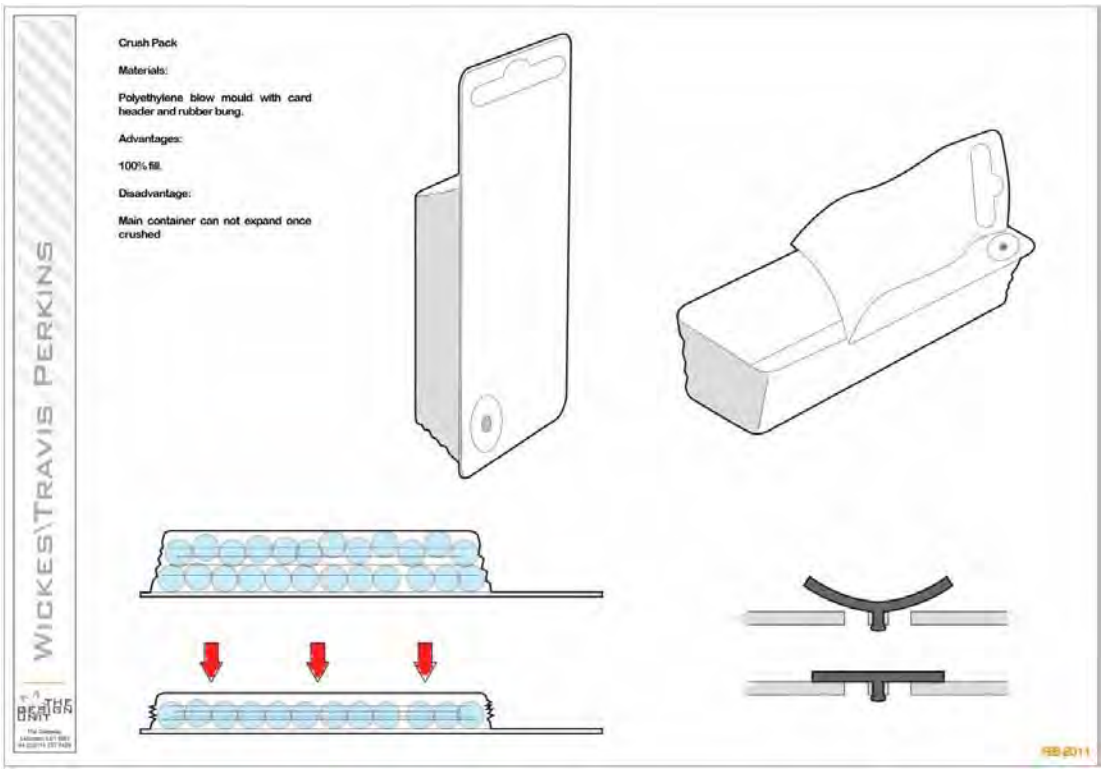


Concept Designs






Grow/Shrink Pack
Materials:
Vac forming with card header.
Advantages:
Efficient fill percentage and stack ability.
Disadvantage:
Time consuming to pack and less rigidity
WICKES\TRAVIS PERKINS
FEB 2011


Crush Pack
Materials:
Polyethylene blow mould with card header and rubber bung.
Advantages:
100% fill.
Disadvantage:
Main container can not expand once crushed
WICKES\TRAVIS PERKINS
FEB 2011


COSTA
COSTA


WOOD
SCREWS

Prototypes


Travis Perkins
WOOD SCREWS
Pozidriv Countersunk
Zinc Plated
10 x 4" 25 Approx
QUALITY CHECK
Travis Perkins
SELF TAPPING SCREWS
Wickes
SELF TAPPING SCREWS
Tap their own thread in sheet metal
25 Approx
6 x 1/2"
Wickes
SELF TAPPING SCREWS
Tap their own thread in sheet metal
Pre-drill an undersized pilot hole
25 Approx
6 x 1/2"

Second Stage Concept Development

Plastic Versions

Card Version

Initial, Basic CO2 Evaluation

Reducing the packaging volume by %50 has instantly reduced the CO2 in shipping product from China by %50.

In addition the prospect of packaging in the UK may now ne more viable.

The weight of the pack itself has been reduced by 1g representing %10, fuel and CO2 savings are being evaluated.

Transport Carbon Emissions

Table 1: Travis Perkins Packing reduction impact upon shipping fuel use *1				
	Fuel Use based upon 28 day trip	Total Embodied CO_2 (CO_2/kg) *2	Units Shipped *4	Total Embodied CO_2 (CO_2/kg) per unit *2
Orginal Packaging *3	217000.00	570710.00	150000	3.80
New Packaging	217000.00	570710.00	300000	1.90

*1	Based upon a 7750 TEU capcity ship - World Shipping Council - RECORD FUEL PRICES PLACE STRESS ON OCEAN SHIPPING May 2, 2008
*2	Based upon a CO_2 emission factor of 2.630 kg CO_2 per litre - Diesel BRE MAN 3 Checklist
*3	Calculations based upon ship used to full capacity with product
*4	The number of units is an assumed figure to demonstrate a 50% reduction in packaging

Further Investigation

Initial concept evaluation is encouraging.

Three key areas remain to be investigated these are:

- Cost of new pack against the old
- Strength and durability of the new pack against the old
- Ease of use to the consumer of the new pack

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Resource Efficient Design in the Supply Chain (Deep RED)

The development of sustainable natural fibre composite materials using Resource Efficient Design (RED) techniques

A case study project with Scott Bader Co. LTD

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Scott Bader Co. LTD Case Study

Scott Bader is a multinational materials development and chemical company employing 600 people worldwide with manufacturing sites in Europe, Middle East, South Africa and has a turnover of 220 million Euros. Market leading products are sold globally under well established brands such as Crystic®, Fireguard®, Crestomer®, Texipol®, Texigel®, Texicryl® a and Polidene®. Primary product groups are: Unsaturated polyester resins and gelcoats, Structural adhesives and bonding pastes, Conventional and inverse water based polymers and Solvent based resins. Products are used in the composites sector for a wide variety of applications – automotive, aerospace, marine, wind energy etc.

Natural fibres have already been demonstrated as having lower density than synthetic equivalents of Kevlar and glass and also possessing useful FR properties as seen in the Camira STING^{plus} product developed in conjunction with TEAM.

TEAM are established as the leading university research group in the UK in the local production and processing of natural fibres eg flax and nettle. Scott Bader is one of the leading suppliers of resins to the composites industry in the UK.

The project would be to engineer new materials using sustainable natural fibres, for a variety of applications. The aim is to produce a number of textile geometries using fibres produced by TEAM, and also hemp and ramie sourced from overseas in line with the faculty's strategy on sustainability. Evidence of a suitable supply chain of fibre with requisite quality and properties will be demonstrated. Scott Bader will provide the infusion and performance testing. Results will provide evidence of best fibre/yarn/structure for composite materials guiding direction to potential end uses.

Project outcomes:

- This feasibility study will demonstrate the structure/property relationships of a range of textile reinforcement structures with a number of natural fibres. Resultant composite materials will also demonstrate the effectiveness of resin/fibre bonding.
- Supply chain issues of sourcing high quality fibre will be investigated.

Potential Benefits to company:

- A showcase new low carbon material + associated intellectual property + improved green credentials
- Environmental savings and waste reduction over product life-cycles (reduced carbon footprint)

Potential Knowledge transfer opportunities:

- Showcase example of innovative new low carbon material development
- Skills development in applying eco-design strategies, and new material sourcing and exploitation
- New supply links potentially created in the East Midlands in the materials and associated sectors if possible

The Project

The intention is to evaluate the following (not ranked):

- Structure/property relationships of a range of textile reinforcement structures with a number of natural fibres
- Weight reduction; increased bulk; improve strength : weight ratio)
- Bonding techniques, resin requirements
- Supply chain issues regarding quality and quantity
- End of life - disassembly and recycling potential
- Materials specified suitable for recycling at end of life
- Perceived and actual durability

Additional Background

A Global Company manufacturing a wide range of UPR, DCPD and VE Resins, Compounded Resins, Gelcoats, Bonding Pastes and Structural Adhesives for the composite industry. They are also a major European distributor of reinforcements and ancillary products, offering moulders everything needed to make quality composite parts.

Scott Bader Composites supplies high quality, technically superior polyester resins and gelcoats under the CrysticR brand name from manufacturing locations around the world. As pioneers in glassfibre composites since the 1940s, the Crystic brand has gained a world-wide reputation for quality and reliability. This reputation has been maintained through on-going investment in research, innovation and new product development.

Current Supply Chain

Scott Bader supplies products to a diverse customer base of manufacturers making finished products for both industrial and consumer goods. Depending on the needs and location of a customer, products are supplied either directly to an end user or via our network of authorised agents, distributors and stockists.

The main markets that the Composites, Adhesives & Speciality Polymers business units actively serve are as follows:-

Marine - Leisure, lifeboats, fishing boats, minesweepers and patrol boats.

Automotive & Transport - Sports cars, caravans, mobile homes, specialty vehicles, bus, truck, train, tram, metro.

Building & Construction - Doors, cladding, baths, sinks, showers, modular bathrooms, tanks, pipes, covers, canopies, kiosks, worktops, counters in conventional GRP or solid surface decorative effects.

Pipes & Pipe Re-lining - GRP & polymer concrete pipes, pipe re-lining and repair.

Chemical Containment - tanks & storage vessels, pipes, ducts, coolers and scrubbers.

General Industrial - a wide range of general fibreglass component applications, including shop mannequins, swimming pool slides, theme park and playground equipment and garden ponds.

Wind Energy - blades, nacelles, nose cones.

Graphic Arts - flexible packaging coatings, heat sealable and blister adhesives, overprint varnishes, ink binders for paper, board and film / foil substrates.

Building & Decoration - water resistant ceramic tile adhesives, grouts, sealants, primers and cement modification

Coatings - Industrial wood finishing, maintenance and marine, automotive refinish, anticorrosive primers, architectural coatings.

Textiles & Furnishings - Non wovens, pigment and dye printing, fire retardant coatings, Chromojet Carpet Printing and Textile Finishing.

Context

It has been recently reported that around 38% of natural fibre usage in textiles is cotton while polyester accounts for around 47%. As the population expands and the demand for fibres for more technical uses increases, other natural fibres are coming forward with claims of improved performance, including regenerated cellulose fibres from bamboo and woodpulp. Allied to this, glass, aramid and carbon fibres are being widely promoted for use in textile reinforced composites but with the increasing interest in sustainability there is the potential for natural fibre reinforcements to find a market in low density, biodegradable materials.

The ever increasing drive for sustainability has brought about a renewed interest in the use of natural fibres. Within the European mainland French and German applications of natural fibres within fields such as the automotive industry are well established, however within the UK, any expansion in their use is hampered by the lack of an established supply chain. In order to provide an alternative and sustainable product in the UK market place work is being undertaken by De Montfort University to provide an embryonic supply chain encompassing growers, processing capacity and end users. Components in various sectors are being investigated where the benefits of lower density composites can be used to advantage.

Many non-structural parts are made from plastic to reduce weight as much as possible. Such plastic components can be replaced by textile reinforced composites, usually based around glass fibres. However there is a growing interest in using lower density natural fibres in composites for non-structural applications. Composite materials reinforced with natural fibres are being developed; their applications are still limited but they are required to play a role in future industry.

Natural fibre composites

A composite material is defined as an arrangement of fibres of a resistant material (reinforcements) contained in a matrix whose strength is lower. The matrix (binding) holds the reinforcement in the correct orientation and transfers loads into and between fibres, the commonest being glass, aramids and carbon. Natural fibres are divided in to two main groups; organic fibres - vegetable (cellulosic) and animal (protein), and mineral fibres such as asbestos. While many varieties of natural fibres exist, those of most interest have a structural role in nature and commonly used because of availability.

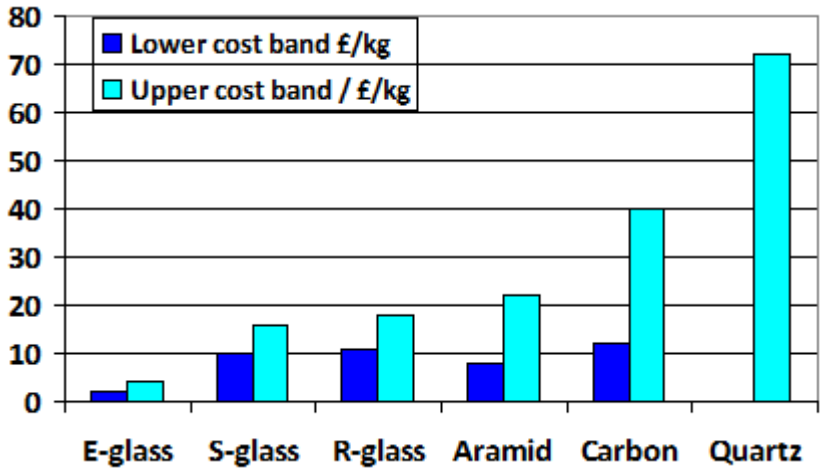
Natural fibres, such as flax, are renewable raw materials, fully combustible, cheaper than carbon and aramid, have a lower density than glass and they also have good specific mechanical properties. A material is said to be biodegradable when it is degraded by micro-organisms (bacteria, for example). The result of this deterioration is the formation of water, carbon dioxide and/or methane and possibly by-products non-toxic to the environment. Natural fibres are considered as neutral vis-à-vis CO_2 emissions in the atmosphere since their combustion or biodegradation produces only a quantity of carbon dioxide equal to that which the plant has absorbed during its growth. Incorporation of a natural based resin that are currently being developed commercially will make composites eminently biodegradable.

The use of unidirectional reinforcement enables composites to have anisotropic properties providing enhanced performance where required. Chopped fibre, random orientation results in more isotropic materials. Natural fibres cannot be used where continuous filaments are required but converted into yarns and then woven into fabrics is an option. These woven systems from standard looms, can be used as an alternative to a uniaxial preform but more crimp (cross over points) creates weak spots. Deformation to complex shapes will also be affected by the design of the woven fabric. The initial work described is a preliminary study of the effects of weave structure. Carded cross lapped nonwovens that are needle punched to aid handling have also been produced for comparison

Manufacture of fibre reinforced composites are common whether the fibre is a traditional one, glass, carbon or aramid, or natural fibres such as flax and hemp. Thermal degradation of natural fibres can restrict not only the potential operational temperature but also the nature of the matrix. Higher temperatures can result in degradation of the cellulose fibres and gas emissions. For a thermoplastic matrix, the transformation temperature has to stay under 230°C so polyethylene or polypropylene are commonly used.

Glass fibre reinforcements have a purchase cost of approximately £2 per kilogram, the quantities purchased are high and manufacture is consistent. In comparison to this carbon fibres cost approximately £30 per kilogram, thus resulting in a higher costing end product.

Costs for each of the various reinforcement fibres is shown graphically. There are a number of variants within each generic family, some of which may exceed in price the upper band. In general, the mechanical properties and environmental resistance, particularly temperature resistance, increase with increasing cost. The range of prices for different fibre types is dependent on variations in quality, which dictate the strength and durability of the fibre.



Cost Comparison (Gurit 2010)

Natural fibres, dependent on quantity and quality will be at the lower end of this scale.

Fibre	Current Volume (raw fibre) mT	Fibre Cost $/kg
Flax	0.45	2.0-3.0
Hemp	0.08	0.5-1.5
Nettle	negligible	high
Jute	3.3	<0.5
Ramie	0.29	3.0-3.5

Cost comparison (Horne 2010)

Simply and overall there is potential for a significant cost and weight saving (in comparison with glass fibres).

The significant unknown area and area for primary investigation is performance, predominantly strength.

Initial Performance Investigations

The significant unknown area and area for primary investigation is performance, predominantly strength.

Woven samples of a cotton and flax mix were produced for initial evaluation.




Make up of Initial Test Samples

Ne 16_2 60/40 (Cotton/Flax)
Bending Tests

WARP DIRECTION		Sample 1			Sample 2			Sample 3			Sample 4		
		I	II	III	I	II	III	I	II	III	I	II	III
Bending length / cm	a	2.05	2.40	2.20	1.80	1.90	2.20	1.80	1.85	1.75	2.00	1.95	1.65
	b	1.70	2.00	2.05	2.05	2.05	1.95	1.50	1.70	1.85	1.50	1.80	1.70
	c	2.20	2.00	2.00	2.00	1.95	2.20	1.80	1.60	1.65	1.80	1.85	2.00
	d	2.00	2.05	2.05	1.95	1.90	1.90	1.60	1.80	1.75	1.90	1.90	1.70
Mass / g		1.0631	1.0607	1.0518	1.3004	1.3085	1.2832	1.6295	1.7156	1.6352	1.6543	1.6566	1.6375
Thickness / cm													

WEFT DIRECTION		Sample 1			Sample 2			Sample 3			Sample 4		
		I	II	III	I	II	III	I	II	III	I	II	III
Bending length / cm	a	2.20	2.30	2.10	1.75	2.10	1.60	2.50	2.35	2.45	2.65	2.60	2.60
	b	2.15	2.45	2.30	2.00	2.20	2.10	2.20	2.30	2.45	2.25	2.25	2.35
	c	2.10	2.05	2.20	2.35	2.40	2.30	2.25	2.10	2.20	2.65	2.45	2.45
	d	2.30	2.30	2.10	2.15	2.10	2.10	2.40	2.40	2.30	2.45	2.60	2.50
Mass / g		1.1962	1.2046	1.2008	1.3144	1.3352	1.3052	1.6749	1.6869	1.6794	1.6495	1.6489	1.6914
Thickness / cm													

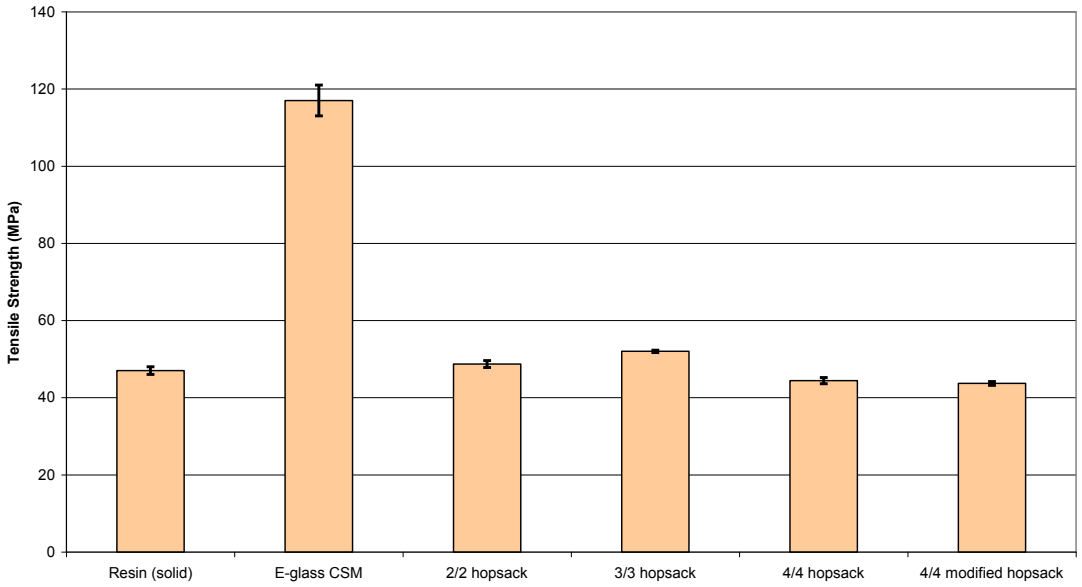
Values (Mean Bending Length)

WARP DIRECTION	Sample 1			Sample 2			Sample 3			Sample 4		
	I	II	III	I	II	III	I	II	III	I	II	III
Bending length / cm	1.99	2.11	2.08	1.95	1.95	2.06	1.68	1.74	1.75	1.80	1.88	1.76
Mass / g	1.0631	1.0607	1.0518	1.3004	1.3085	1.2832	1.6295	1.7156	1.6352	1.6543	1.6566	1.6375
Thickness / cm	0.72	0.73	0.73	0.86	0.90	0.92	1.15	1.15	1.19	1.14	1.17	1.16

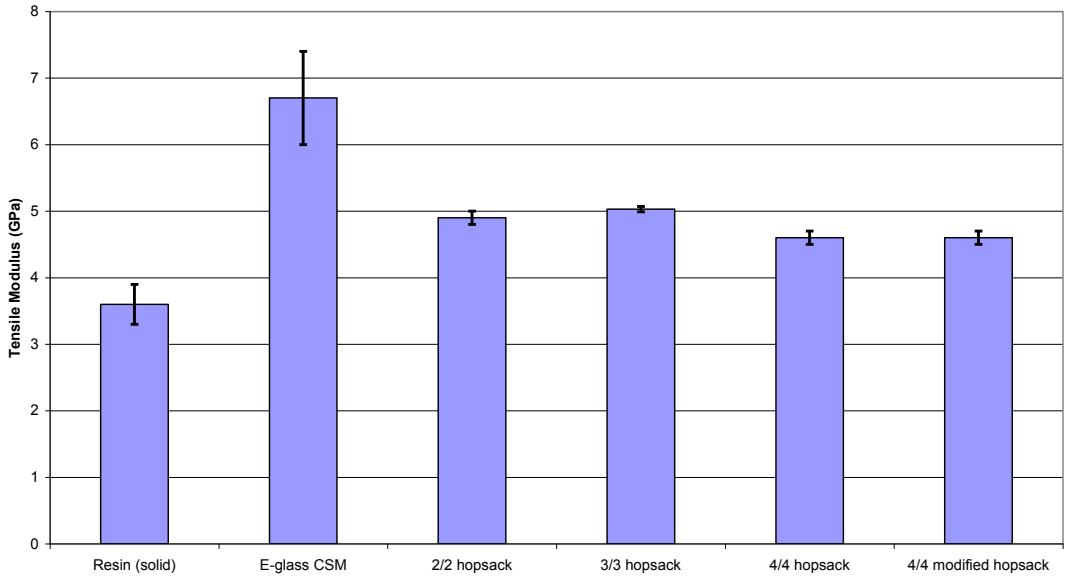
WEFT DIRECTION	Sample 1			Sample 2			Sample 3			Sample 4		
	I	II	III	I	II	III	I	II	III	I	II	III
Bending length / cm	2.19	2.28	2.18	2.06	2.20	2.03	2.34	2.29	2.35	2.50	2.48	2.48
Mass / g	1.1962	1.2046	1.2008	1.3144	1.3352	1.3052	1.6749	1.6869	1.6794	1.6495	1.6489	1.6914
Thickness / cm	0.71	0.71	0.72	0.88	0.90	0.85	1.14	1.16	1.14	1.17	1.13	1.16

Test Results

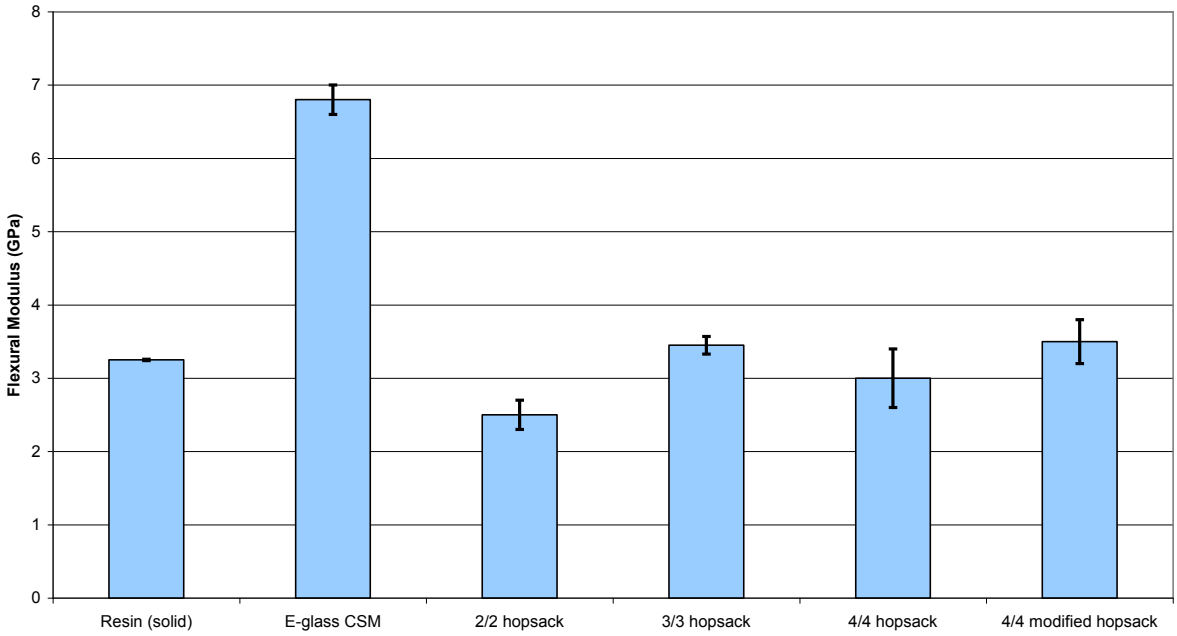
Tensile strength of woven NF/UP composites (unreinforced resin and E-glass CSM for comparison)



Tensile modulus of woven NF/UP composites (unreinforced resin and E-glass CSM for comparison)



Flexural modulus of woven NF/UP composites (unreinforced resin and E-glass CSM for comparison)



Analysis of Initial Results

As can be seen the initial results, although interesting and informative, are disappointing.

With only marginal gains with the natural fibre reinforcing in tensile strength and modulus and flexural modulus and a loss in flexural strength against solid resin and with significantly inferior results compared to E-glass reinforcing, the use of natural fibres is likely to be limited.

Further Investigation

All samples evaluated to date have been woven in structure. Further tests are being undertaken with a ‘loose’ fibre configuration.

In addition there may be some scope in using natural fibres as a bulk filler (reducing the amount of expensive resin required in a particular application) where structural requirements are minimal. This will limit and influence the nature of the supply chain to be approached with this material.

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Resource Efficient Design in the Supply Chain (Deep RED)

The development of a new fuel-efficient train seat using Resource Efficient Design (RED) techniques

primarius UK limited

Seating and Interior Solutions for the MassTransit Industry

A case study project with Primarius UK LTD

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Primarius UK Light Weight Train Seat – The Problem

primarius UK limited
Seating and Interior Solutions for the MassTransit Industry

Primarius UK Light Weight Train Seat – The Solution

primarius UK limited
Seating and Interior Solutions for the MassTransit Industry

Primarius UK Light Weight Train Seat – The Solution

primarius UK limited
Seating and Interior Solutions for the MassTransit Industry

PROJECT SUMMARY

Building on the success and impact of The Resource Efficient Design (RED) Initiative programmes funded by EMDA and delivered by De Montfort University, the programme was developed to extend RED knowledge into East Midlands' supply chains. Overall, the programme aimed to define best practice and skills development opportunities, deliver tangible business performance improvements and contribute to regional policy objectives.

Resource efficient design has proven to be an effective method of delivering tangible and measurable business improvements (e.g. new products, employment and GVA), whilst addressing strategic regional objectives. The highly successful RED programmes demonstrated the importance of resource efficient and environmental design to mainstream manufacturing and retail companies. However, in order to maximise regional business and strategic development impacts, it was identified that resource efficient design activities need to extend throughout the supply chain of products and services. In particular it is an essential prerequisite of a fully functioning supply chain that a sustainable supply of appropriate raw materials are available to stakeholders at all stages, especially where interdependency of supply chain links has the potential to converge the interests of stakeholders at all positions in the chain.

A key focus of the Resource Efficient Design in the Supply Chain programme was the emphasis on skills development for resource efficient design and low-carbon product development, and the transfer of the requisite knowledge to East Midlands SMEs through sector-focused training.

To maximise environmental impact and business opportunities it is necessary to:

- Develop resource efficient design within the low carbon supply chain context;
- Transfer knowledge and develop skills within supply chains;
- Extend resource efficient design techniques into the production, marketing and end-of-life of products and services;
- Extend resource efficient design from product design into other areas of the economy;
- Develop and utilise low carbon and sustainable material supply chains to displace high carbon and petrochemical materials.

Case Study: Primarius UK

Primarius UK Ltd is a subsidiary of the Prestfold Group. The company is a major supplier of seating and interior components to the mass transit industry, providing a range of products and support services to manufacturers and operators of road and rail transportation systems.

The project would be to design and engineer a new seat for trains which features cutting edge light weight materials but with high flame resistance, and that can be recycled at end-of life (after approximately 10 years). The train seat should ultimately raise public perception of mass transport and improve the experience of the user on trains. Primarius UK would manufacture the new train seat, for installation on trains manufactured by Bombardier, Hitatchi and/or Siemens. The project would address closed loop production, take-back systems and be designed for disassembly and recycling by Primarius UK. A focus of the project is sourcing new materials which could reduce the overall weight of the train seats and ultimately, the amount of fuel used and CO_2 produced by trains.

Benefits to company:

- A showcase low carbon train seat design + associated intellectual property + improved green credentials
- Environmental and CO^2 savings over the train/seat life-cycle (reduced carbon footprint)
- Reduced wear to rail tracks due to lighter trains
- Training and skills development for staff

Knowledge transfer opportunities:

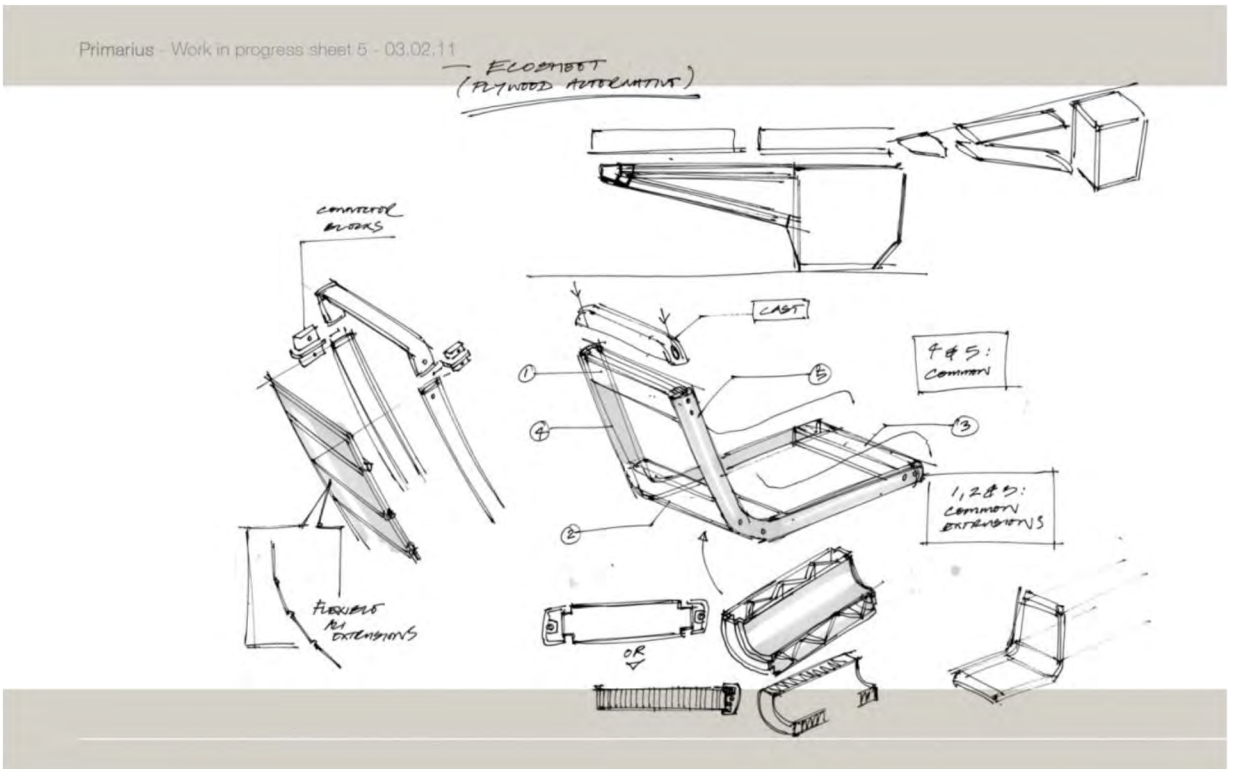
- Showcase example of innovative product design that features low embodied energy + showcase materials
- Example of how forecasting, envisioning and sustainable innovation can lead to attractive, user-centred public transport
- Skills development in new material sourcing and exploitation
- New supply links potentially created in the East Midlands in the materials and transport sectors

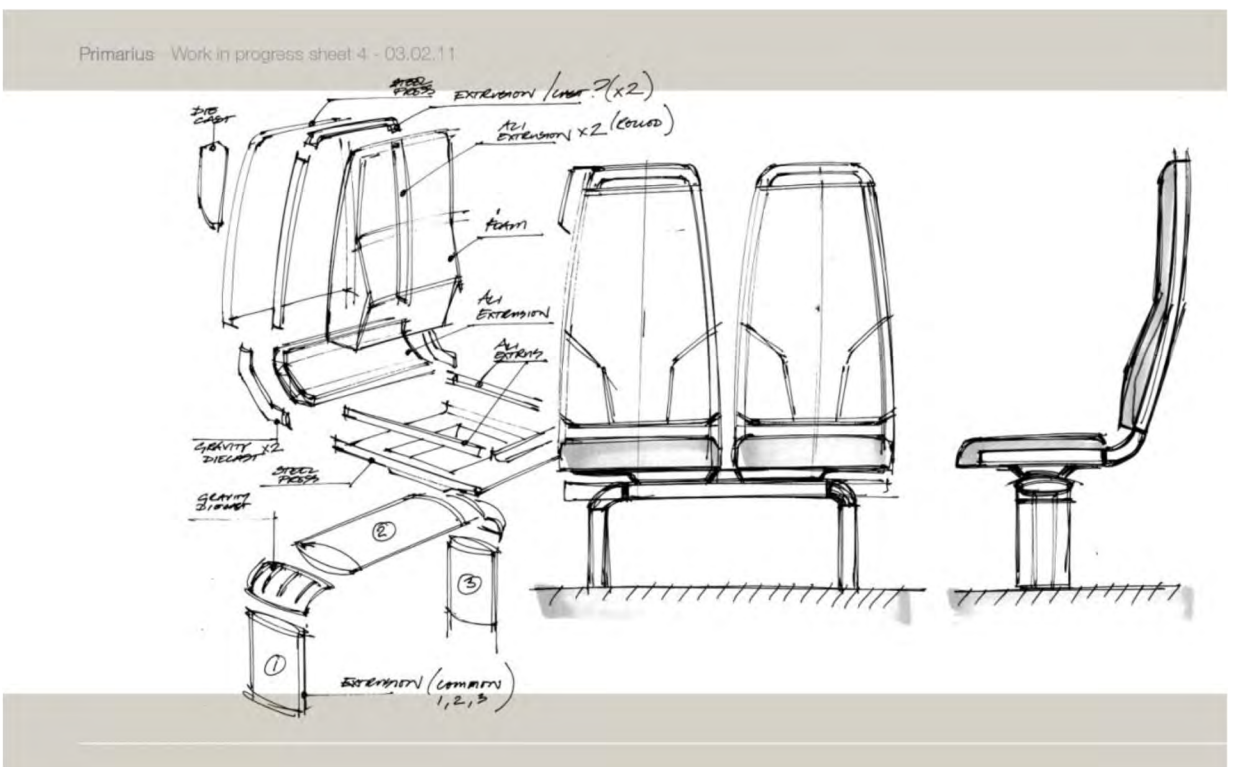
The Project

he intention is to improve the following (not ranked):

- Weight (to be reduced; improve strength : weight ratio)
- Packaging (minimise)
- End of Life - Disassembly and recycling potential
- Materials specified suitable for recycling at end of life
- Perceived and actual durability

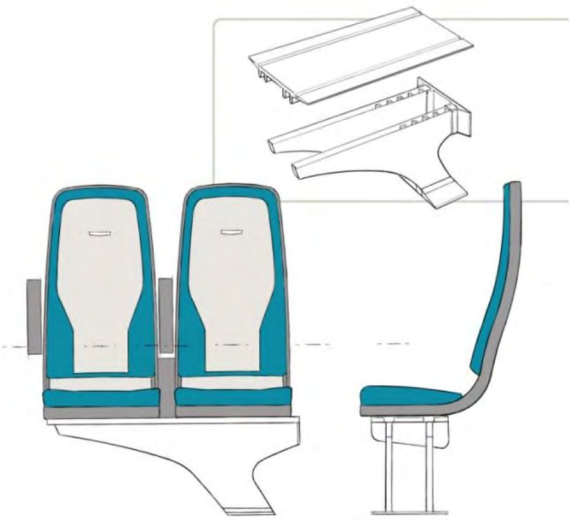
Early Concepts Design



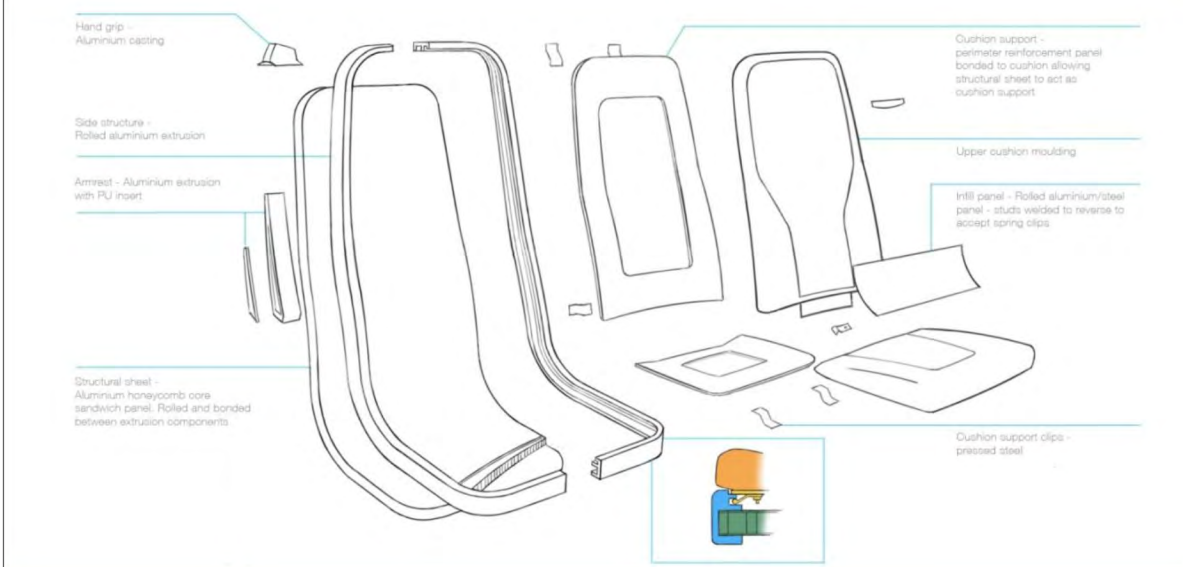


Concept Proposals

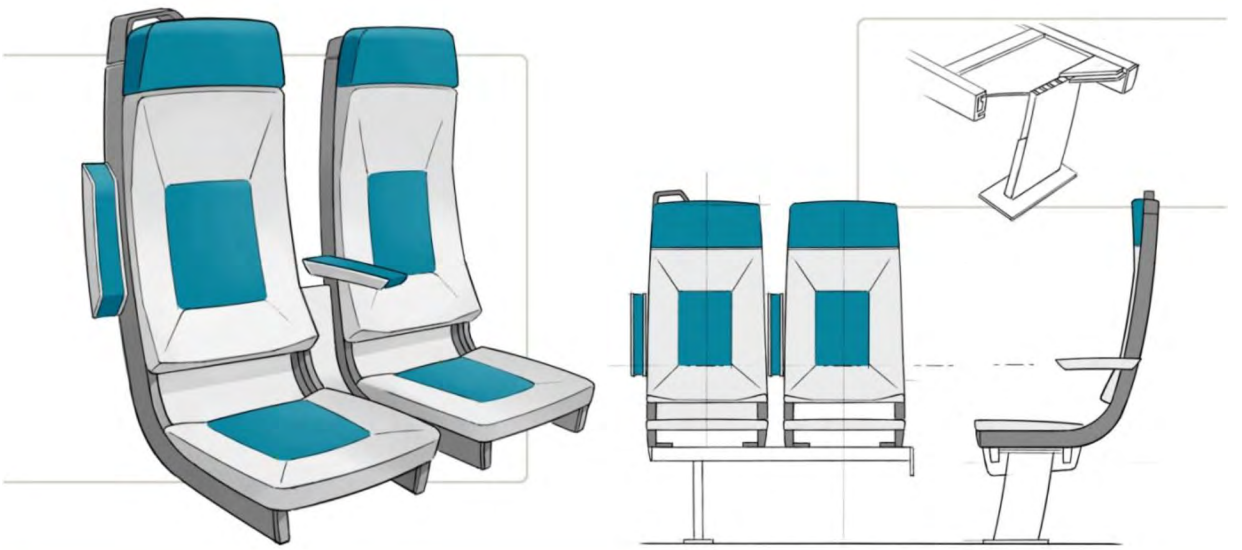
Primarius - Concept 2 sheet 1 of 2 - 02.02.11



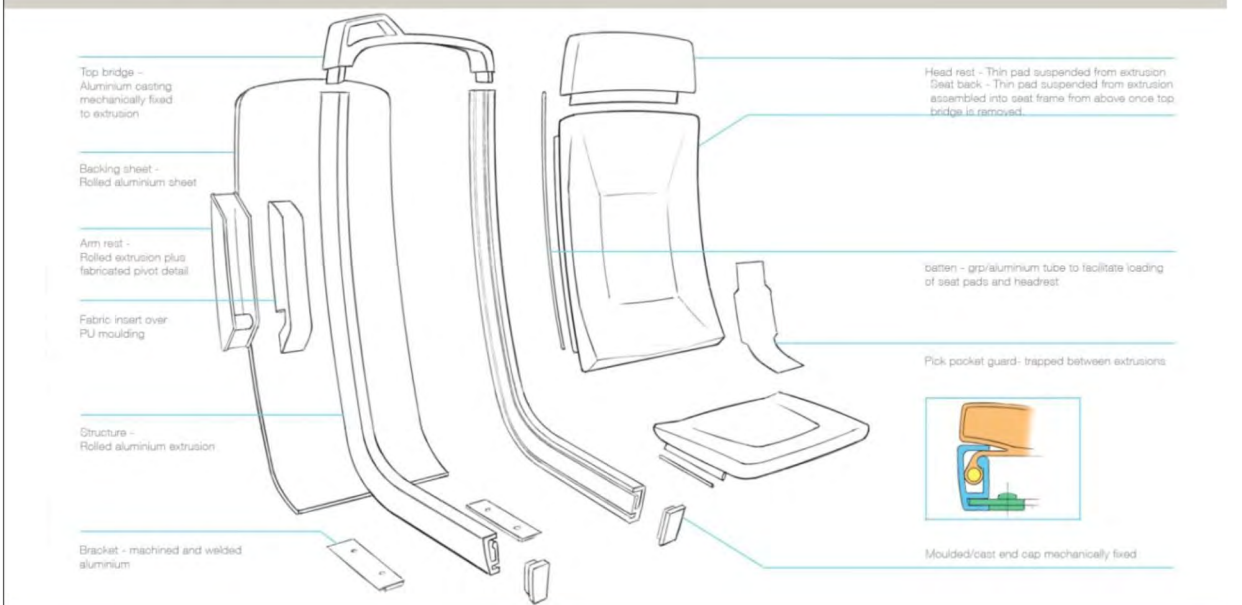
Primarius - Concept 2 sheet 2 of 2 - 02.02.11



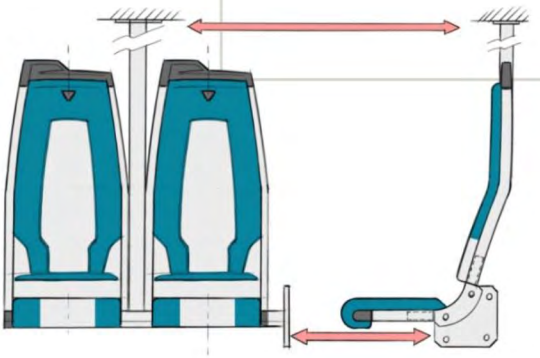
Primarius - Concept 4 sheet 1 of 2 - 02.02.11



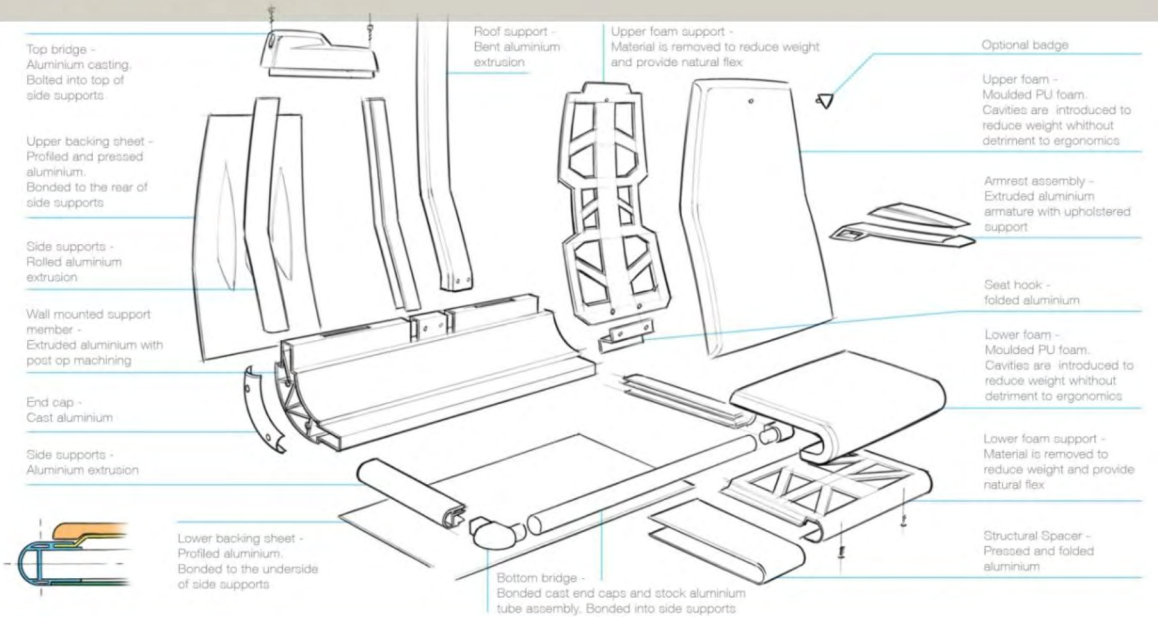
Primarius - Concept 4 sheet 2 of 2 - 02.02.11



Primarius - Concept 5 sheet 1 of 2 - 02.02.11



Primarius - Concept 5 sheet 2 of 2 - 02.02.11



Finite Element Analysis of Support Structure

Summary of Design

The proposal is to use aluminium extrusions creatively (that is use the benefit of extrusions to enhance the assembly of the product) on a cantilevered base support system.

In addition the polyurethane will be reduced by %50 by using and innovative flat board spring system or by eliminating it altogether by using a new carbon fibre wool being sourced in Japan (dependant on cost).

The current projection is that a train seat pair will be reduced from 35kg to 28kg, reducing the overall weight of a 4 carriage train by over 1250kg

Initial, Basic CO2 Evaluation

Carbon calculations are a little tricky as the use of aluminium utilises far more energy in its production than steel.

However the 1250kg saving will reduce diesel consumption by about %1; it is estimated this will reduce the annual fuel bill of one typical train company by £100,000 to £250,000.

Embodied Carbon Calculations

Table 3: Embodied CO_2 emissions associated with train seat materials

	Seat Weight (kg)	Mild Steel *1	Alluminium *1	Polyurethane Foam *1	Polyester Fabric	Total Embodied CO_2 for Seat (CO_2/kg)
Old Seat Design	35	50%	0%	40%	10%	72.70
New Seat Design	28	25%	25%	40%	10%	106.25
Embodied CO_2 (CO_2/kg) per Kg		1.37	8.24	3.48	NA	

*1 Sustainable Energy Research Team (SERT) of the University of Bath. The survey, 'Inventory of Carbon & Energy (ICE)' V2.0,

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Resource Efficient Design in the Supply Chain (Deep RED)

The development of new retail point-of-sale units using Resource Efficient Design (RED) techniques

ANTONE

A case study project with Antone LTD

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Comet (Antone) Sustainable Retail Display – The Problem


COMET


comet
comet

Comet (Antone) Sustainable Retail Display – The Solution

PROJECT SUMMARY

Building on the success and impact of The Resource Efficient Design (RED) Initiative programmes funded by EMDA and delivered by De Montfort University, the programme was developed to extend RED knowledge into East Midlands' supply chains. Overall, the programme aimed to define best practice and skills development opportunities, deliver tangible business performance improvements and contribute to regional policy objectives.

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- Extend resource efficient design from product design into other areas of the economy;
- Develop and utilise low carbon and sustainable material supply chains to displace high carbon and petrochemical materials.

Case Study: Antone

Antone is an SME shop fitting / POS manufacturer established in 1960 based in Leicestershire. Design work is outsourced to local freelancers whilst there are CAD technicians employed onsite (to do part drawings etc). Most of Antone's clients are large national/international brands (Chanel, Comet, Wilson etc). Units are currently manufactured mostly out of timber/MDF products, with high gloss finish for cosmetics Point of Sale Units. Some metalwork is also used in units - Antone use metal specialist subcontractors where necessary. All shop fitting products/POS units manufactured on site.

Benefits to company:

- A showcase resource efficient point of sale product
- Intellectual property
- Improved green credentials
- Environmental and CO_2 savings over the retail unit's life-cycle (reduced carbon footprint)
- Training and skills development for staff

Knowledge transfer opportunities:

- Showcase example of innovative recyclable POS design featuring low embodied energy
- How to design with life-cycle in mind - Example of how innovation can lead to resource efficient design
- Skills development in a sector not currently widely practising RED

The Project

The design, manufacture and installation of display units and systems is a significant and underpinning aspect of most aspects of retail and retailing; companies both large and small rely heavily on effective display within their stores and shops.

The need to keep stores 'up-to-date' is ever present which is often undertaken after only a few months let alone years; however this pivotal aspect of retail appears to have had very little attention with regard to sustainability and resource efficiency.

Current systems are made specifically for each retailer usually based on simple basic joinery methods, typically MDF and chipboard panelled boxes clad or sprayed in appropriate finishes.

Due to the need to have a minimum impact on retail time, installation and refurbishments' have to be undertaken in as

1 Retail point of sale units manufactured by Antone for Comet

short a time as possible. This has led to complete units being manufactured complete and off-site, installation is a highly co-ordinated event taking place in a matter of hours, often overnight.

Inevitably little is re used from these display installations at the end of life, the majority of the material finding its way into a skip. At best some of it may find its way into an incinerator (which would have to be at a high temperature to avoid issue with formaldehyde and paint finishes).

Current environmental (basic) issues:

- Systems are built complete off-site and are therefore bulky
- Bulkiness requires excessive space during transportation to the retail outlet being constructed or refurbished
- Construction materials are inherently heavy
- Need for durability in the retail environment adds to weight characteristics

Now is therefore an appropriate time to re evaluate the design, construction and implementation of typical display systems of this type leading toward a **more sustainable** and possibly **re useable** approach.

However the following main design/performance criteria cannot be sacrificed:

- Any new system should not significantly impact on the time required to install and therefore should not negatively impact on retail performance.
- Durability and performance should not be inferior to existing systems

The Concept

The proposed concept is based on the use of industrial grade corrugated cardboard. The best configuration has been the use of 2 layers of 2 ply board with the ply running at 90 degrees to each other to give maximum strength.

An innovative corner strength and assembly feature has been developed to enable the easy clamping together of the assembly on-site. The on-site feature of this design is a major feature of the approach.

The design has been developed as a flat pack system that can be adapted to any display configuration. Designs can simply be designed in the form of 2D nets and folded to the required shape.

Cable management, lighting and many other features can be built in. Designs can simply be knife or laser cut.

It is proposed that the carcass be clad in fabric or very thin sheet material.

The unique clamping system allows for quick disassembly for ease of refurbishment and recycling.

Sustainable Retail Display System for Comet (Antone)

This was outcome from the Deep RED project with the most immediate opportunity for positive environmental impact, hence its further development.

Savings in carbon, fuel, emended energy, materials are potentially considerable in addition to improved end of life credentials.

The system is:

- Light
- Uses a significant amount of recycled material
- Makes recycling of material at end of life more achievable
- Quick to assemble (not high skill based)
- Quick to disassemble
- Quick to refurbish (valuable in the retail context)

Key features:

- Rigid card middle sections
- External cladding (rigid or flexible) not bonded to middle section
- Supplied flat pack
- Held together with cordage based tensioning system (patent applied for)
- Easy to disassemble by cutting cordage

Overall Comparison

An overall comparison of the current and proposed design is as follows:

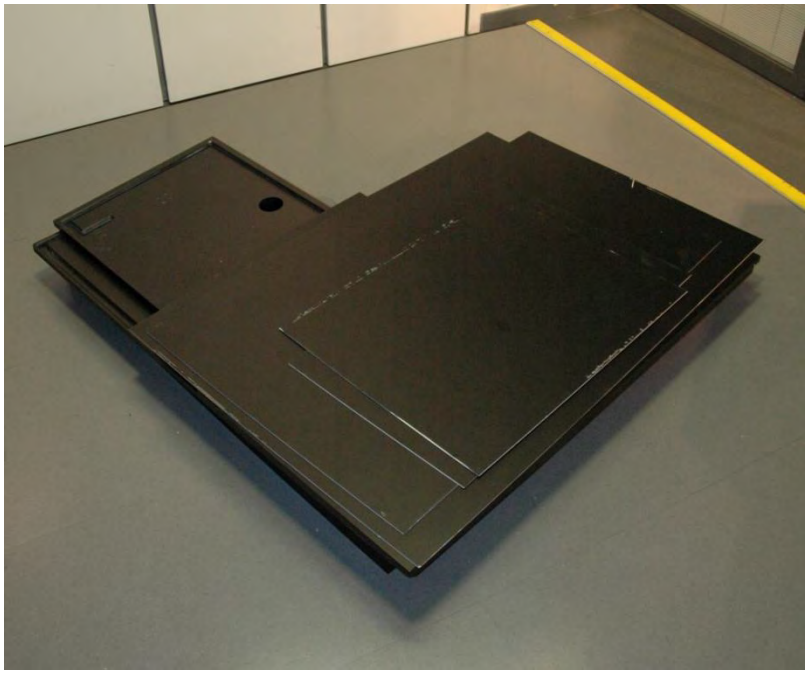
- A 49% reduction in weight
- An increase in recyclability
- A total of a 45% reduction in shipping volume
- A reduction of 50% in shipping carbon impact (weight based)
- A reduction of almost 12% in embodied carbon impact.

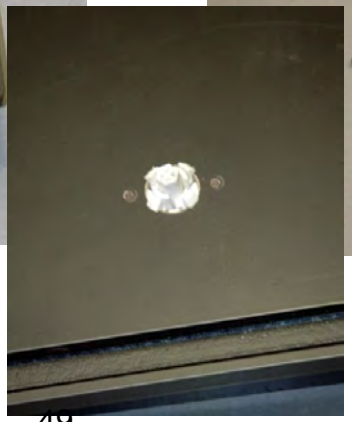
The sales units per year for a particular customer could be 500. If the concept was rolled out across the whole of the UK this could increase to 12,500 units.

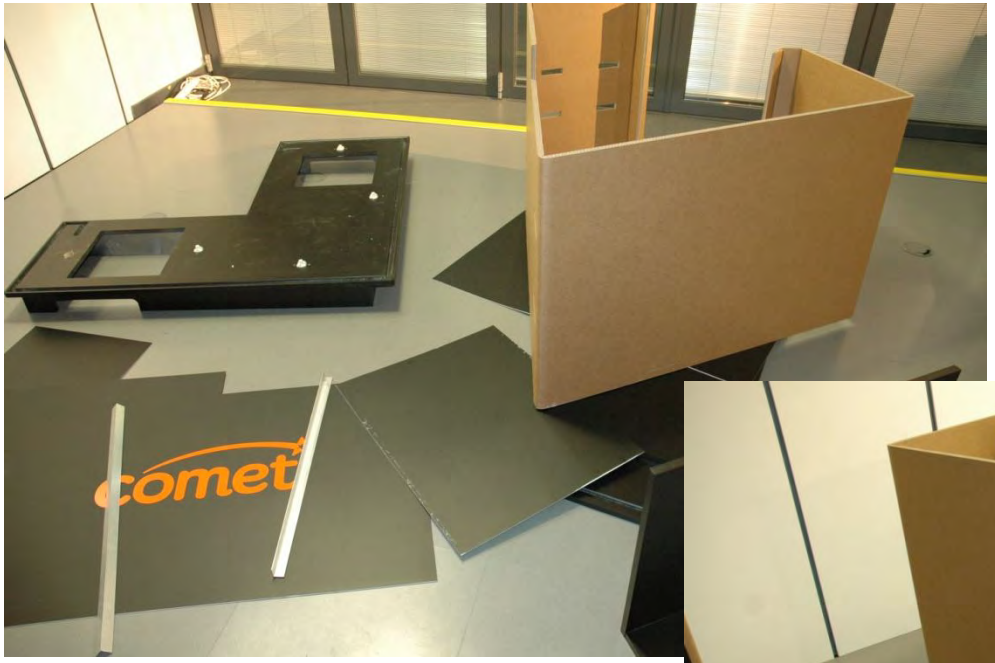
If these sales figures were achieved the following savings could result:

	500 units per year	**12,500 units per year**
Savings in raw materials (t)	27.6	690
Diversion from landfill (t)	7.5	187.5
Transport carbon savings (t)	4.8	120
Embodied carbon savings (t)	9.75	243.8

Total carbon footprint savings of up to 363.8 tonnes.



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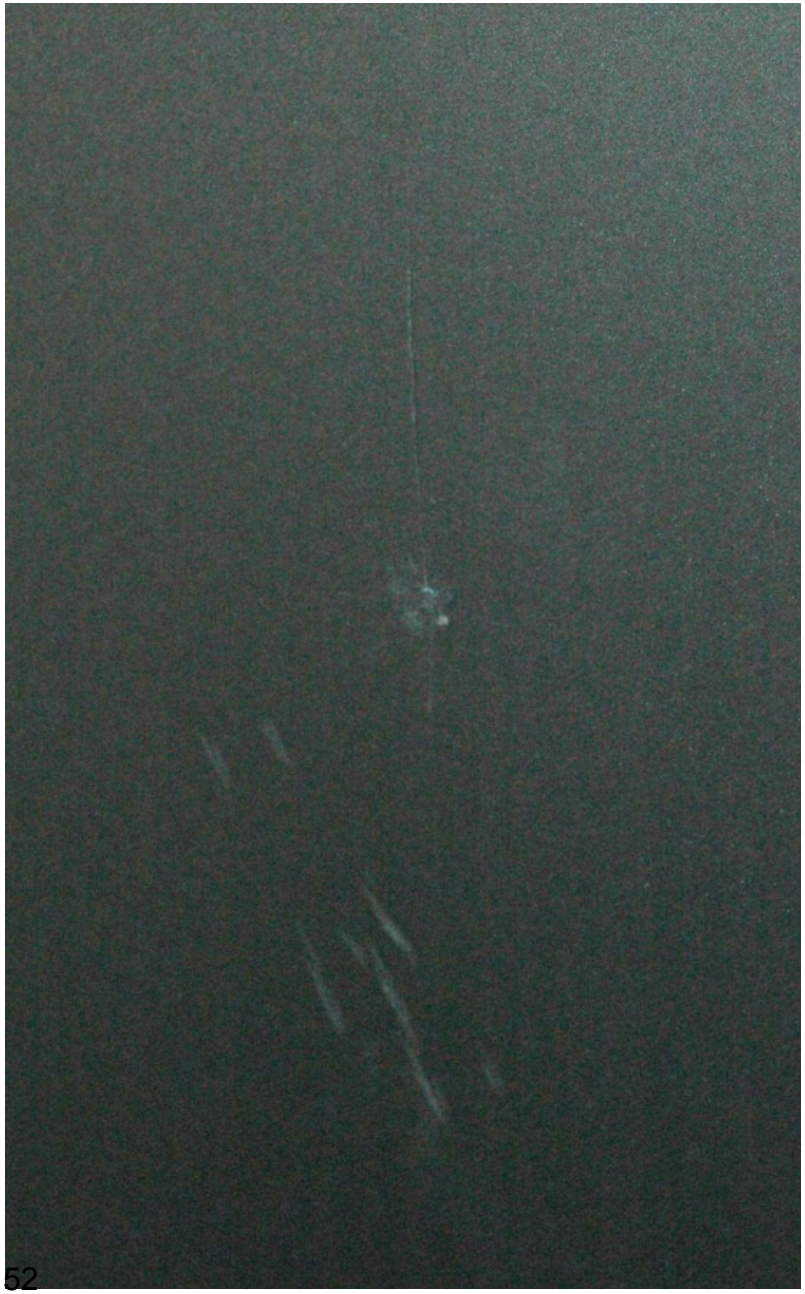
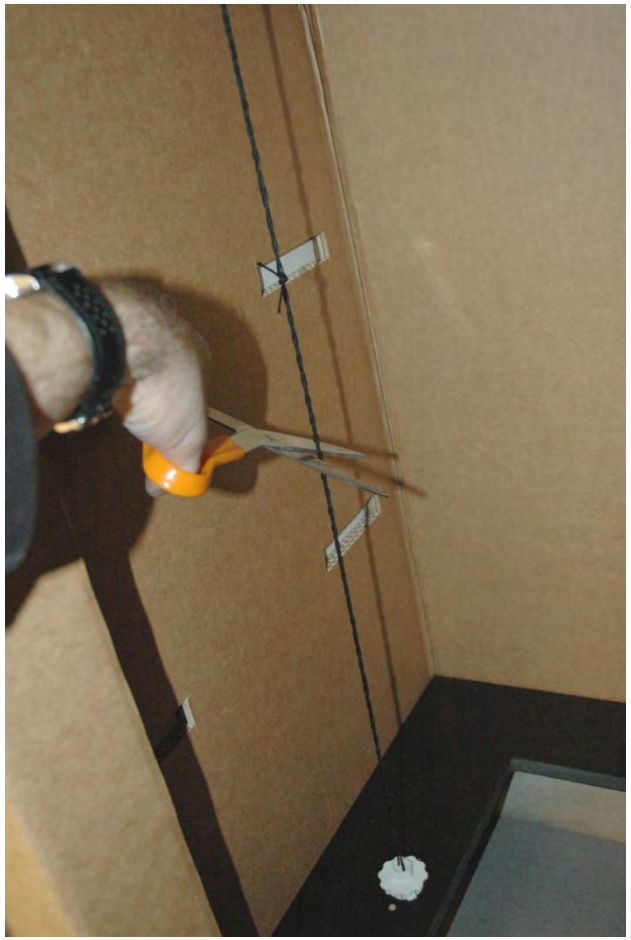
THE DESIGN UNIT
design research and consultancy






comet
comet

SECTION 2

1 The Retail Lab Context

2 Short Life, Sustainable Retail Display System for the Robert Horn Group – The Retail Ready System

3 Tensioning System Patent Application (for Short Life, Sustainable Retail System)

The Retail Lab and its Context

The Retail Lab was a £1000,000 design research project proposed and implemented by Ford and funded by the East Midland Development Agency.

The research was focussed developing methods enabling the Retail Sector to minimise their environmental impact. Again this research built on the RED Initiative work of 2006 – 2007.

The lab itself is equipped to ‘mock up’ retail environments and test and evaluate their environmental impact in addition to consumer reactions to those environments.

This proved an ideal facility to test and evaluate the short life, sustainable, retail display systems initially for Comet (Antone) and subsequently the Retail Ready system for the Robert Horn Group.

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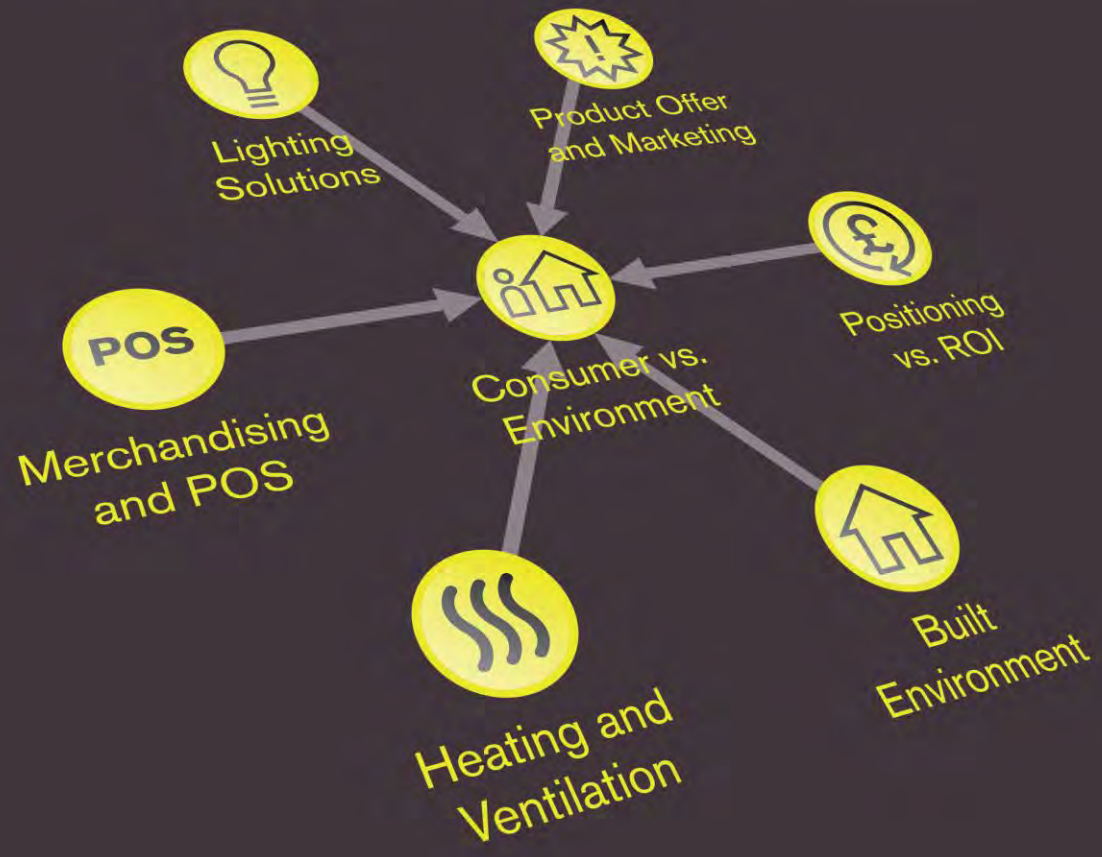
Measuring the **interrelationships** between the various factors of the **retail environment**



Measuring the interrelationships between the various factors of the retail environment

Human factor measurement technology

Consumer vs. Environment

Extensive consumer response assessment:

- Free roam eye motion monitoring
- EEG analysis
- Ground pressure mapping
- Vicon motion analysis
- Audio visual tracking

Lighting Solutions

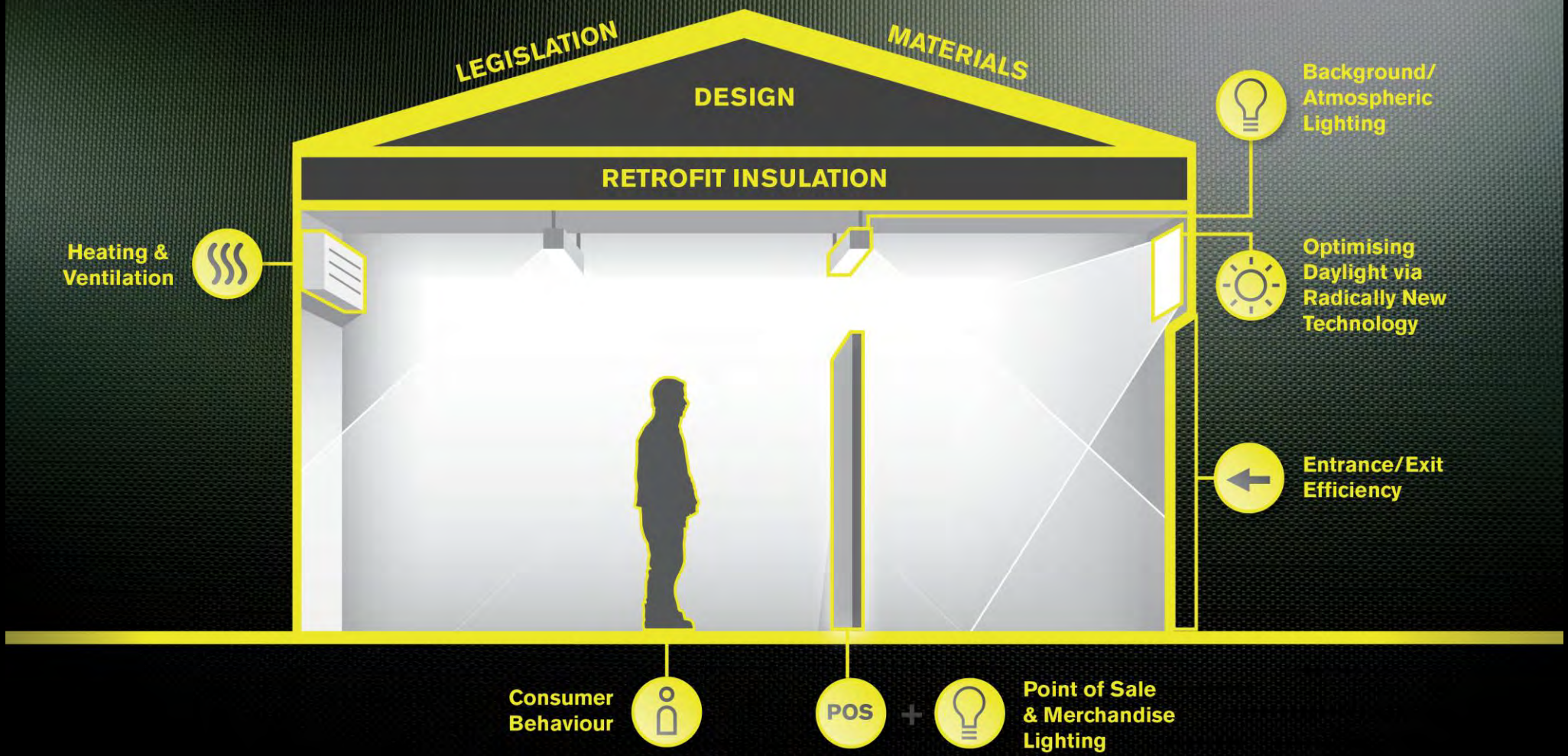
Heating and Ventilation

Product Offer and Marketing

Positioning vs. ROI

Built

RETAIL LAB



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RETAIL LAB


RETAIL LAB


RETAIL LAB

Short Life, Sustainable Retail Display for the Robert Horn Group (Retail Ready)

This design research (a £30,000 commission from the Robert Horn Group), builds on the work for Comet (Antone), but is designed for companies wanting to experiment High Street Retail without taking the risk of investing heavily in retail ‘fit out’ in the current volatile economy.

This system forms the basis on an on-line retail display design and ordering system. The system embodies all the design features of the Comet (Antone) system and at about 15% of the cost of a conventional full retail ‘fit out’.

The Robert Horn Group – Short Life, Sustainable, Retail Display System
RETAIL READY

The Robert Horn Group – Short Life, Sustainable, Retail Display System
retail ready

The Robert Horn Group – Short Life, Sustainable, Retail Display System
RETAIL READY

The Retail Ready System

The Retail Ready System

Tensioning System Patent Application

COPY

INTELLECTUAL PROPERTY OFFICE

Patents Form 1
Patents Act 1977 *(Rule 12)*

Request for grant of a patent

Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

Application number GB1216474.5

1.	Your reference	**D108.035.00**
2.	Full name, address and postcode of the applicant or of each applicant Patents ADP number *(if you know it)*	**De Montfort University** **Innovation Centre** **49 Oxford Street** **Leicester LE1 5XY** **Leicestershire** **United Kingdom**
3.	Title of the invention	**A Tensioning Device**
4.	Name of your agent *(if you have one)* "Address for service" to which all correspondence should be sent. This may be in the European Economic area or Channel Islands (see warning note below) *(including the postcode)* Patents ADP number *(if you know it)*	**Cadman, Mr Tim** **Serjeants** **25 The Crescent** **King Street** **Leicester LE1 6RX** **Leicestershire** **United Kingdom**

5. Priority declaration: Are you claiming priority from one or more earlier-filed patent applications? If so, please give details of the application(s)

Country	Application number	Date of filing	Date available on PDAS

6.	Divisionals etc: Is this application a divisional application, or being made following resolution of an entitlement dispute about an earlier application. If so, please give the application number and filing date of the earlier application	Number of earlier UK application	Date of filing *(day / month / year)*
7.	Inventorship: (Inventors must be individuals not companies) Are all the applicants named above also inventors?	**No**	
8.	Are you paying the application fee with this form?	**Yes**	

COPY

Your reference:	D108.035.00

List of Inventors

Title:	Professor
Last (Family Name):	Ford
First Name:	Peter
Middle Name(s):	
Patents ADP Number:	
Address:	De Montfort University
	The Gateway
City (Town):	Leicester
County:	Leicestershire
Postal code:	LE1 9BH
Country:	United Kingdom

COPY

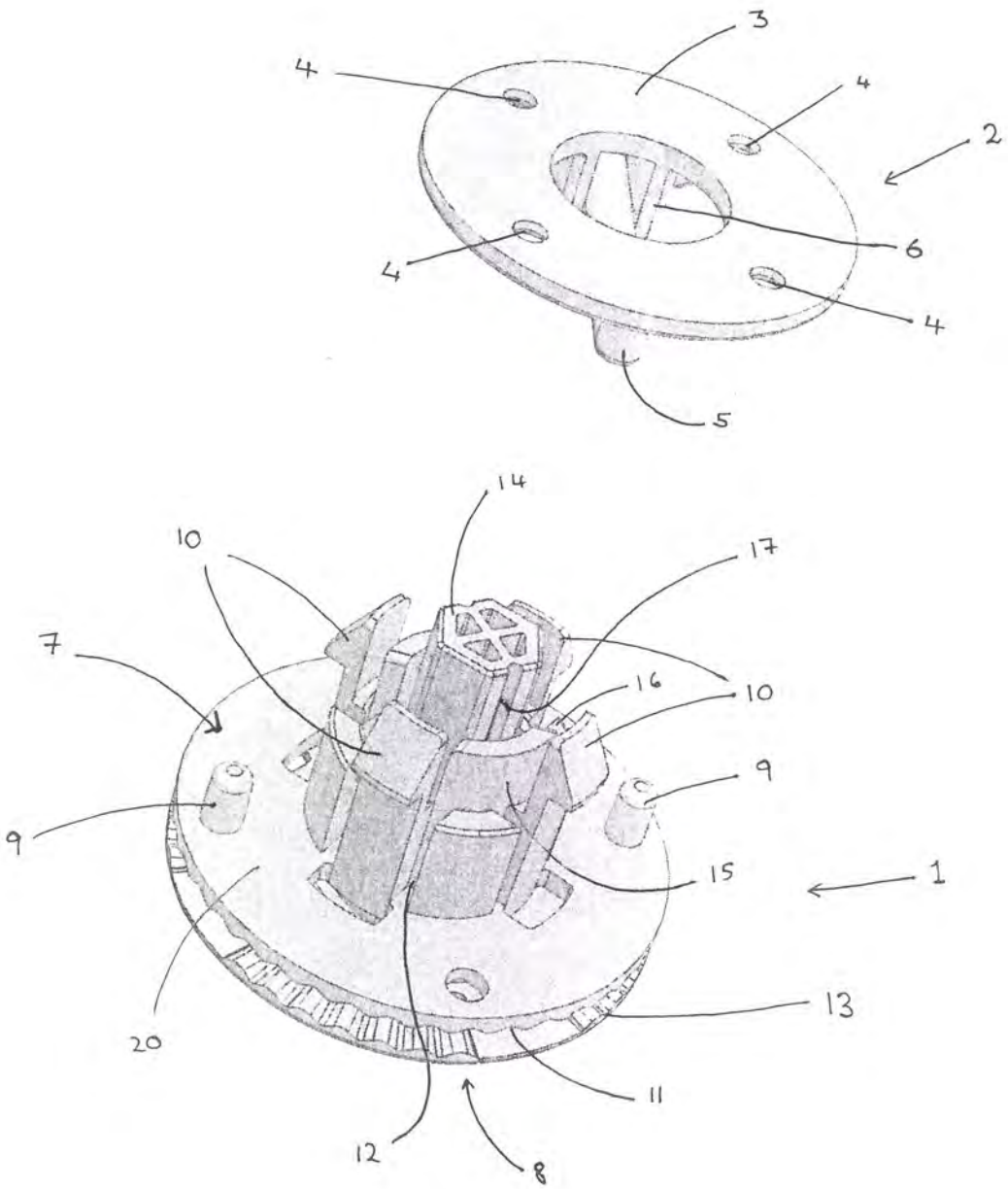

Figure 1

SECTION 3

Resource Efficient Design in the Supply Chain (Deep RED) – Report Summary
(Full Report can be Supplied if Needed)

INNOVATION, ADVICE AND GUIDANCE

RESOURCE EFFICIENT DESIGN IN THE SUPPLY CHAIN (DEEP RED)

PROJECT REPORT

Project funded by:	East Midlands Development Agency (£250,000 single programme) De Montfort University (£70,000 match funding)
Project Value:	£320,000
Project delivered by:	De Montfort University
Project number:	EMX05764, CRN919
Project Start Date:	3rd September 2009
Project end Date:	31st July 2011
Overall Time Span:	35 months
Report Submitted:	31st December 2011

OVERVIEW OF FINDINGS

Undertaking 4 ‘in depth’ design research interventions within the East Midlands over a 35 month period has led to a number of key findings; these are summarised as follows:

- Very few companies within the supply chains for Travis Perkins, Scott Bader, Primarius UK and ANTONE were actually within the East Midlands.
- Very little integration takes place within these supply chains with regard to improving sustainability and environmental impact
- Cost and financial impact is the main ‘driver’ in new product development unless legislation dictates a particular environmental performance
- Very few companies and their suppliers employ experts in manufacturing for minimising environmental impact
- Very few design consultancies employ experts in manufacturing for minimising environmental impact
- There is a need for design consultants to work closely alongside experts in environmental impact at all stages of the new product development cycle
- Establishing and embedding robust environmental credentials at the earliest stages of the new product development cycle is critical in the development of sustainable products. At present this will have more impact than integrated environmental thinking in supply chain management
- Designing for improved sustainability and minimising environmental impact does NOT necessarily increase cost but can REDUCE it
- There is growing interest (but very variable at present) within manufactures for environmental training in supply chain management
- There is positive demand for environmental training within design groups, particularly within the Design for Retail sector

SUMMARY OF PROJECT OUTCOMES

(See individual case studies for the details on each project)

ANTONE – Retail Check Out

A highly successful intervention with potential for significant reductions in CO2, transport cost, material and manufacturing cost and improvement in end of life impact. This method will almost certainly find its way to manufacture (downturn in retail is having a negative impact on this at present).

An overall comparison of the current and proposed design is as follows:

- A 49% reduction in weight
- An increase in recyclability
- A total of a 45% reduction in shipping volume
- A reduction of 50% in shipping carbon impact (weight based)
- A reduction of almost 12% in embodied carbon impact.
- 15% reduction in manufacturing cost

The sales units per year for a particular customer could be 500. If the concept was rolled out across the whole of the UK this could increase to 12,500 units.

If these sales figures were achieved the following savings could result:

	500 units per year	**12,500 units per year**
Savings in raw materials (t)	27.6	690
Diversion from landfill (t)	7.5	187.5
Transport carbon savings (t)	4.8	120
Embodied carbon savings (t)	9.75	243.8

Total carbon footprint savings of up to 363.8 tonnes.

Primarius UK – Light Weight Train Seat

A successful project where the 10kg weight reduction per train seat has been achieved, reducing the weight of a 'typical' train by 1600kg resulting in significant fuel savings and reductions on CO2

This concept is to be developed to manufacture, however Primarius UK have had to re structure recently due to problems with Bombardier. An R for SME research application is in development which will be submitted in 2012.

Figures for Old Primarius Design

Phase	**Energy (MJ)**	**Energy (%)**	**CO2 (kg)**	**CO2 (%)**
Material	1.4e+03	3.4	72.2	2.5
Manufacture	179	0.4	14	0.5
Transport	0	0.0	0	0.0
Use	3.93e+04	96.1	2.79e+03	97.0
Disposal	18.1	0.0	1.27	0.0
Total (for first life)	**4.09e+04**	**100**	**2.88e+03**	**100**
End of life potential	-248		-16.1	

Figures for New Primarius Design

Phase	Energy (MJ)	Energy (%)	CO2 (kg)	CO2 (%)
Material	2.66e+03	8.1	167	7.2
Manufacture	200	0.6	15.1	0.7
Transport	0	0.0	0	0.0
Use	3.01e+04	91.3	2.14e+03	92.1
Disposal	16.9	0.1	1.18	0.1
Total (for first life)	**3.3e+04**	**100**	**2.32e+03**	**100**
End of life potential	-1.83e+03		-107	

Fuel savings estimated at 1124 litres of fuel saved per train per year

Energy savings equate to 0.08e+04MJ per year

CO2 reductions equate to 0.056e+03kg per year

Scott Bader – Natural Fibre Reinforced Composites

An interesting exercise which has proven that natural fibre reinforced composites do not compare to glass reinforced composites with regard to strength. Other than a filler this approach is unlikely to yield useful results; potential weight reductions being severely offset by reduction in strength.

Travis Perkins – Packaging for Screws and Nails

The new design is a significant improvement over the existing packaging concept.

	Packaging Weight (kg)	Shipping Volume (m^3)	Embodied Carbon (kg CO_2e)	Shipping Carbon (kg CO_2e)
Current	480	11.13	1526	140
New PET	390	2.956	1239	110
New Card	320	2.956	821	90

Overall a move to the new pack design made from card would give the following benefits over the current package:

- An overall reduction of 33% in packaging weight
- A 46% reduction in embodied carbon footprint
- A total of a 63% reduction in shipping volume
- A reduction of over 35% in shipping carbon impact.

The use of a PET window in the card pack does compromise its recyclability somewhat and therefore alternatives should be considered. If recyclability is key then the new pack design in PET would be the way to go, this would give 100% recyclability whilst still giving the following benefits:

- An overall reduction of 18% in packaging weight
- A 19% reduction in embodied carbon footprint
- A total of a 63% reduction in shipping volume
- A reduction of over 21% in shipping carbon impact.

Further embodied carbon savings could be made through the use of recycled materials in either of the new designs.

The concept of this design could be extended to many more products within the range and therefore the overall saving could be increased considerably.

In parallel with this exercise Travis Perkins were considering investing in the Euro Bag approach (simple, printed Polyethylene bags).

The new design is clear and displays the product well (the Euro Bag is translucent which obscures the content), in addition the new product is moderately resistant to damage from the screws and nails contained (Euro Bags are not strong and can be easily punctured). However the Euro Bag is less expensive than the proposed new design (even though it is less expensive than the current packaging). Despite the benefits of the new design, Travis Perkins will be adopting the Euro Bag system on the basis of cost rather than performance.

SECTION 4

Design, Sustainability and the Supply Chain: Design Underpinning Sustainability and Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative on Current Practices and Opinions. International Conference Papers, Vancouver 2012

Design, Sustainability and the Supply Chain: Design Underpinning Sustainability. International Journal Article 2012

Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative on Current Practices and Opinions. International Journal Article 2012

Design, Sustainability and the Supply Chain: Design Underpinning Sustainability.

Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative on Current Practices and Opinions.

International Conference Papers Vancouver 2012

Eighth International Conference on Environmental, Cultural, Economic and Social

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Canada

Room 9 *ACCOUNTS AND REPORTING PRACTICES*	**The Techniques and Benefits of Environmental Management Accounting** ***Olatunji Aliu Ahmed**, University of Southern Queensland, , Malaysia Overview*: This paper discusses environmental management accounting as a means to separately identify, quantify, analyse, and interpret corporate actions affecting the environment. *Stream: Economic Sustainability* **Practical Sustainability Assessment and Reporting for Nonprofit Organizations: Accountability "For the Public Good"** ***Kevin Jones**, Dorothy Day Social Work Program Department of Social and Behavioral Sciences, Portland, USA, **Lauren Mucha**, University of Portland* *Overview*: This paper makes the case that sustainability assessment and reporting are possible, practical, and ethically imperative for nonprofit organizations of all types and sizes. Case examples are provided. *Stream: Other* **The Future Role of Accounting: Sustainability Reporting and Environmental Labeling** ***Mark Connolly**, University of Connecticut, Northford, USA* *Overview*: An exploration into whether accounting firms can get into the area of environmental labeling by investigating current practices in the industry. *Stream: Environmental Sustainability* **Ideological Barriers to Sustainability: A Comparison of Business and Non-business Views** ***Dr. Janet Spitz**, School of Business, The College of Saint Rose, Albany, USA* *Overview*: Ideological values regarding aspects of economic, political, social and environmental sustainability differ between those engaged in business expansion and those engaged in other work, suggesting the importance of regulatory oversight. *Stream: Social Sustainability* **The Interactions within the Finance-growth Nexus in the European Union: Evidence from Error Correction-based Panel Cointegration** ***Dr. Han Hou, Lunghwa** University of Science and Technology, Taiwan**, Dr. Su-Yin Cheng,** Kainan University , Taiwan, **Dr. Chin-Ping Yu,** Taiwan. Overview* This paper investigates the interactions between banking, stock markets, and economic development via utilizing error correction-based panel cointegration methodology. *Stream: Economic Sustainability*
11:10-11:20	**BREAK**
11:20-12:20	**PARALLEL SESSION #5** **(15 min presentation followed by Q&A and group discussion)**
Room 1 *REGIONAL SUSTAINABILITY: EUROPE AND ASIA*	**Sustainable Community Development: A Case Study of Proposing Economic and Social Sustainability Projects in Sahmuratli Village in Turkey Inspired by Hagaby Village in Sweden** ***Derya Eryilmaz**, College of Food, Agriculture and Natural Resource Sciences Department of Forest Resources, University of Minnesota, Minneapolis, USA* *Overview*: This practice focus study desires to present the various sustainability practices, which were proposed for a rural community in Turkey inspired by an eco-village in Sweden. *Stream: Social Sustainability* **Tokyo Cycling Practices: Environmental, Social and Symbolic Settings of a Non-motorized Urban Transport** ***Papa Elimane Faye**, School of Urban Environmental Sciences, Tokyo Metropolitan University, Tokyo, Japan* *Overview*: This study is focusing on the symbolic, environmental and social meaning of cycling in Tokyo. *Stream: Environmental Sustainability* **Collaboration Barriers in the Implementation of Design for Environment: Case Studies from UK Small and Medium Enterprises** ***Philippe Francois Marius Radlovic**, The Design Unit Department of Product and Spatial Design, **Prof. Peter Ford**, The Design Unit Department of Product and Spatial Design, De Montfort University, UK* *Overview*: This paper presents findings of case study based research and exploration regarding issues that relate to collaboration in the implementation of design for environment principles. *Stream: Economic Sustainability*

14:25-15:40	**PARALLEL SESSION #7** **(15 min presentation followed by Q&A and group discussion)**
Room 1 *SUPPLY CHAIN ISSUES IN SUSTAINABILITY*	**Evaluating the Sustainability of Global Water Supply Chains** ***Dr. Benita Beamon***, ***Katherine Anderegg***, *Department of Industrial and Systems Engineering, University of Washington, Seattle, USA* *Overview*: This paper identifies the different structural types of global water supply chain systems and evaluates the sustainability of each supply chain type. *Stream: Environmental Sustainability* **Design, Sustainability and the Supply Chain: Design Underpinning Sustainability** ***Prof. Peter Ford***, *The Design Unit Department of Product and Spatial Design, De Montfort University, Leicester,* ***Philippe Francois Marius Radlovic***, *Design for Environment, UK* *Overview*: This paper presents the findings of a UK, local Government research project investigating how the concept design of a product establishes its resource efficiency credentials. *Stream: Economic Sustainability* **Definition into Action: Implementing Environmental Sustainability in Global Supply Chains** ***Alison Louise Ashby***, *University of Plymouth,* ***Dr Melanie Hudson Smith***, ***Dr Mike Leat***, *UK* *Overview*: This paper reviews current environmental sustainability literature, and researches how the concept is implemented and practised in global supply chains. *Stream: Environmental Sustainability* **Modeling Food Supply Chain Sustainability Using Multi-agent Simulation** ***Caroline Krejci***, ***Dr. Benita Beamon***, *Department of Industrial and Systems Engineering, University of Washington, Seattle, USA* *Overview*: This paper describes a new multi-agent simulation model of a food supply chain. Model outputs include energy consumption, quantity of toxic outputs, and productive yield. *Stream: Environmental Sustainability*
Room 2 *URBAN AGRICULTURE*	**Exploring Urban Agriculture in Delhi, India** ***Kate Oviatt***, ***Jessica Cook***, *Department of Health and Behavioral Sciences,* ***John Brett***, *Department of Anthropology,* ***Debbi Main***, *Department of Health and Behavioral Sciences, University of Colorado Denver, Denver, USA* *Overview*: This project presents a detailed on-the-ground description of UA in Delhi, India in terms of its potential social, environmental, and economic benefits. *Stream: Social Sustainability* **Entreprenurial Urban Farms: An Urban Farming Census of Vancouver, British Columbia** ***Marc Howard Schutzbank***, *Faculty of Land and Food Systems Integrated Studies in Land and Food Systems, Vancouver,* ***Andrew Riseman***, *Applied Biology Faculty of Land and Food Systems, University of British Columbia, Canada* *Overview*: As the public increasingly demands local food, many entrepreneurs have begun to "grow" local urban food businesses. This research assesses the financial and social sustainability of Vancouver"s urban farming businesses. *Stream: Economic Sustainability* **Sustainably Integrated Infrastructure: Synergies between Water Management and Agricultural Practices** ***Gundula Proksch***, *Department of Architecture, University of Washington, Seattle, WA, USA,* ***Magdalena Celinska***, *University of Washington, Seattle, WA, USA Overview*: The integration of urban agriculture as part of low impact water management strategies supports more sustainable urban water cycles in addition to local food production.

Design, Sustainability and the Supply Chain: Design Underpinning Sustainability.

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Design, Sustainability and the Supply Chain: Design Underpinning Sustainability

Peter Ford, De Montfort University, UK
Philippe Francois Marius Radlovic, De Montfort University, UK

Abstract: From the point of view of sustainability, new product development has come to consider not just the resource utilisation, waste and recycling issue immediately around the product, but also dimensions of the supply chain antecedent to product use. This paper reviews a two-year research study, funded by the Government of the United Kingdom, into the role and influence of design, and of supply chain integration, in five very different NPD projects. These projects embraced three large and two small-to-medium sized enterprises within the UK's East Midlands: enterprises included a large energy utility company, a supplier of construction products and a large adhesives manufacturer. In the majority of the five, the project proved to be the first time that the enterprise had undertaken a design exercise for which sustainability was a primary criterion. Each project therefore focussed on maximising sustainability and resource efficiency, and on the relationship of design to five distinct models of supply chain. These focuses did not mean, however, compromising other major design criteria–most typically, the criteria of cost effectiveness and user acceptance. By considering real-life, commercial projects, the paper tracks the intimate relationship between research methodologies, design for the environment, the appropriate timing and use of 'eco' tools, and supply chain management. It discusses how initial design conceptions of products had a major impact on final outcomes, with regard both to resource efficiency and, perhaps more importantly, to the effective coordination of a 'sympathetic' supply chain.

Keywords: Design for Environment, Concept Design, Product Development, Case Study, Supply Chain, Sustainability

INTRODUCTION: THE NEED TO LINK UP DESIGN, SUSTAINABILITY AND SUPPLY CHAIN MANAGEMENT

In Britain, policy debate on emissions of greenhouse gases (GHGs) is likely to alter the context in which design for new product development (NPD) goes on. While design for resource utilisation, waste and recycling has long been a vital matter for NPD, there are signs that design must also now take account of the green dimensions of the global supply chains that precede product use.

The UK Energy Research Council (UKERC) is just one of several voices suggesting that Britain now account for GHGs not just in terms of those produced on the territory of the UK, but also on an imported products basis. For the UKERC, Britain shares with other nations the problem of 'carbon leakage', in which domestic demand for consumer goods and services is met increasingly by imports from countries without binding GHG emissions reduction targets (Morgan, 2011). In this kind of geopolitical framework, decisions about green NPD cannot help but consider how national and international supply chains are likely affect the overall sustainability of the product. The supply chain therefore has growing salience to sustainability in NPD.

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Next to a diagram, based on work by www.Sourcemap.org, of the origins, weight and GHGs associated with no fewer than 49 electronic components in a laptop, the urban strategist Scott Burnham has written:

> 'To weave sustainable relationships into sustainable products, we need to question whether the products and services we use also contain values beyond literal functionality: new design values of transparency, relevance, understanding, and traceability.
> 'We have historically measured design according to its literal function–whether it serves its direct purpose and responds to our needs. But our needs have grown and become more complex, both personally and collectively, and sustainability is not the entirety of those needs (Burnham, 2010).

As a result there is a need to consider NPD that takes into account, more than has been done in the past, that is, the supply–chain implications of NPD.

Based on the findings of a UK Government funded research project, this paper investigates the reality of resource efficiency and supply chain integration within one of the UK's major manufacturing regions, it seeks to identify how design can play its part in the sustainability agenda and how well it is or is not being integrated into supply chain management.

Relevant Themes in the Surrounding Literature

A decade ago, some authors complained that, in what they called green product development, very little empirical testing of approaches to sustainability was occurring (Bauman et al. 2002). The field of product development contained too many normative suggestions. It was characterised by the development of eco–tools, including Life Cycle Assessment (LCA); but there were too many eco–tools, which were rarely evaluated beyond the phase of pilot studies. There was also too little recognition of systems perspectives: in public policy, most discussion was about individual policy instruments, and there was little holistic perspective on the network of actors and the material flows involved (Bauman et al. 2002).

In recent years, other authors have argued new points. Millet et al. (2007) suggest that, in product design, specialist environmental actors should handle eco–tools, and in particular take responsibility for LCA. For Boks (2008), the paths toward sustainability taken by academia and by industry have diverged: while tools and manuals have been developed by academia, most firms have remained content simply to exhibit showcase products, or to publish audits of their environmental efforts. What we may have with sustainability in NPD, then, is a particular case of the imponderables captured in the phrase 'fuzzy front' end of innovation projects. Here, note Boks et al. (2009), tools exist to support designers, but these tools do not systematically yield workable product ideas. Likewise, it has been suggested that while many think that sustainability is a good thing, few know how to implement it in practice (Athalye et al 2009).

One of the enduring themes in discussions on sustainability is the triple bottom line, which refers to social, economic and environmental measures of corporate performance (Elkington 1997). Calling, in a similar vein, for an integrated approach to sustainability, Gibson (2006) acknowledges that such integration is often made difficult by the different kinds of training—social, economic, ecological—of those collaborating on an integrated approach. He also describes how, in achieving the best balance of these three factors, compromises should be minimised, even if trade–offs will always be made between the three. Going further, Athalye et al. (2009) suggest that it may be neither possible nor ideal to adopt a 'one size fits all' approach to sustainability. Because designers always have to adapt to a wide variety of project scenarios and client needs, they are ideally suited to take on the challenge of sustainability, where one size does not fit all.

Designers, it has been contended, bring 'crucial competencies' to successful initiatives in design for the environment (Lindahl 2005, p. 5). More profoundly, perhaps, ''a shift is in sight.

Sustainable is becoming a synonym of smart and intelligent, e.g. Google gives over 600,000 hits that contain all the three words sustainable, smart and intelligent" (Karlsson et al. 2006 p. 1293). If these authors are right, the pivotal role that design can play in NPD will be acknowledged more in the future, not least because of its ability to handle NPD's sustainability aspects.

Research Setting and Methodology

This paper presents the findings of a research project aiming to further the understanding of issues in the implementation of Resource Efficient Design (RED) within both product development and supply chain activities in NPD. The research setting was a project funded by the UK government and entitled Deep RED. Deep RED provided researchers with an opportunity to observe five lead companies and their respective supply chains; in each case, companies worked for two years in partnership with a university, to research, develop and implement a resource–efficient product. This paper reports on the process undertaken and on the technical and organisational issues encountered across these five cases. Also, the paper reflects on current thinking on NPD, sustainability and supply chain issues or RED.

Deep RED was an East Midlands Development Agency (EMDA) funded research project that was devised and undertaken by De Montfort University, Leicester. The project investigated how best to integrate RED within the different process stages involved in both NPD and supply chains. Deep RED objectives were to:

- Implement RED within the NPD and the supply chain processes of five lead companies
- Use RED to develop regional economic strengths and low–carbon supply chains
- Identifying RED options for materials, components and suppliers
- Enhance knowledge of RED NPD and supply chain across the cases.

On top of this local, interventionist interest, on the part of state, in recent years, a number of researchers have made empirical investigations into green supply chain management projects, typically including NPD (Pagell et al. 2009, Holt et al. 2009, and Michelsen et al. 2009). The research reported in this current paper, however, provides insights from a UK regional angle with a university research partnership. The observation was conducted by the project manager of Deep RED and another researcher external to this project. Over a period of two years, and on a nearly daily basis, the project manager gathered several types of data: live observation as well as records of meetings, emails, project briefs, drawings and CAD, documentation, environmental data and analysis, etc. In the meantime, the researcher external to this project gathered data through meetings records and interviewing members of the project. Collecting both sets of data provided the research not only with richer findings, but also with the opportunity to confront and be more critical about the data.

The Outset of Deep RED

The team began by analysing those among EMDA's industrial priority sectors that would most likely offer the opportunity for collaboration and impact. The team used more than 40 regional business networks to contact both large enterprises (LEs) and small–to–medium enterprises (SMEs) in these sectors and to invite them to a number of regional events to promote and explain the Deep RED project. Altogether, 55 companies attended and answered simple questionnaires about sustainability and NPD, 13 subsequently submitted detailed project applications for consideration. Using a dedicated project selection tool, these 13 applications were narrowed down to five. These formed Deep RED's five NPD case studies, and, vindicating the proposition of Athalye et al. (2009), each generated very different project briefs and very different project approaches.

An Early Change of Emphasis

For all members of the first sample of 55 companies, by far and away the main criterion governing supply chain relationships was cost, closely followed by reliability of supply and by supplier quality. While all believed that RED was a good idea, none wanted to trade that off at the expense of market competitiveness. These companies wanted to save money in the NPD process. If that goal could be achieved by developing products and supply chains that lowered the stress they put on the environment, and which improved end–of–life credentials, this would be positive. However, companies were rather sceptical about whether savings could be achieved just though the efficient use of resources. Here they seemed to agree with the literature on product cost and sustainability, in which scholars maintain both that the 'low hanging fruit' of easily–engineered cuts in product costs has largely been addressed (van Hemel, C. et al. 2002, Boks, C. 2008, Boks, C. et al. 2009), and that eco–design has a reputation, at least, for increasing product costs (Loriot, C. 2003, and Karlsson, R. et al. 2006).

The early hypothesis had been that most of the companies Deep RED encountered would have made some progress toward communicating with their supply chains in order to improve aspects of sustainability. However, given the interpretation of costs described above, this hypothesis proved largely unfounded. As a result, with little evidence of good practice in the sustainable management of supply chains to disseminate, the Deep RED team decided to change the project's emphasis–toward the logically prior task of attempting to cut the cost of NPD, while still minimising environmental impact and maximising end–of–life performance.

Deep Red's Five Case Studies

The five case study companies are referred to as Energy Utility Company (EUC), Adhesives Manufacturer (AM), Construction Products Manufacturer (CPM), Train Components Manufacturer (TCM) and Retail Fixtures and Fittings Manufacturer (RFFM).

Energy Utility Company (EUC)

EUC is a very large European supplier of energy. In 2010, it achieved a pre–tax profit of more than £800 million. The environmental champion (Boks et al. 2009) on this project was the company's UK Responsible Procurement Manager.

The project aimed to develop an online tool for the selection of sustainable products. The tool was meant to assess the environmental credentials and carbon footprints of products made by both established suppliers and potential new ones. This project had much merit and, among Deep RED's five case studies, was uniquely relevant to supply–chain issues. However, half–way through the project, EUC's UK Responsible Procurement Manager became aware that such a tool was also under development at the company's head office, outside the UK.

Bauman et al. (2002) argue that there is often very little linkage between top–down strategic approaches to environmental issues with actual bottom–up delivery. Loriot (2003) also states that, in companies that develop products, there is little evidence to show how lower and middle management make a contribution to sustainability. Although these problems did not strictly characterise those found within EUC, the company did present a further example of problematic relations within a large organisation–in this case, involving two environmental champions within the same company working toward the same goal.

Adhesives Manufacturer (AM)

AM is a large, international enterprise specialising in the manufacture of adhesives and resins; it employs more than 600 people and has an annual turnover of about £200 million. Here the environmental champion was the company's Senior Applications Engineer.

This project probed the use of natural fibres as an alternative to glass in the reinforcing of resin–based composites. Such a substitution can reduce weight, and so, in transport applications, cut emissions of CO_2. It was also hoped that embedded carbon and energy would be lower for natural fibre production than they would be for glass. The prospect of being able to use natural fibres in composites applied in transport applications for example, could open up a complete new way of organising supply chain chains in the adhesives industry.

The aim was to manufacture a number of sample textiles produced from natural materials, including flax from the UK, and hemp and ramie sourced from abroad. AM would provide the resin and undertake performance testing. Results would provide evidence of the best fibre, best yarn and best structure for composite materials and provide, too, a guide for potential end–uses.

Figure 1: Typical Natural Fibre Mat Sample

Figure 1 shows a typical sample used for testing; Tables 1 and 2 compare the tensile strength and modulus of solid resin and E–glass in the tests conducted by AM against the four different types of natural fibre combinations evaluated.

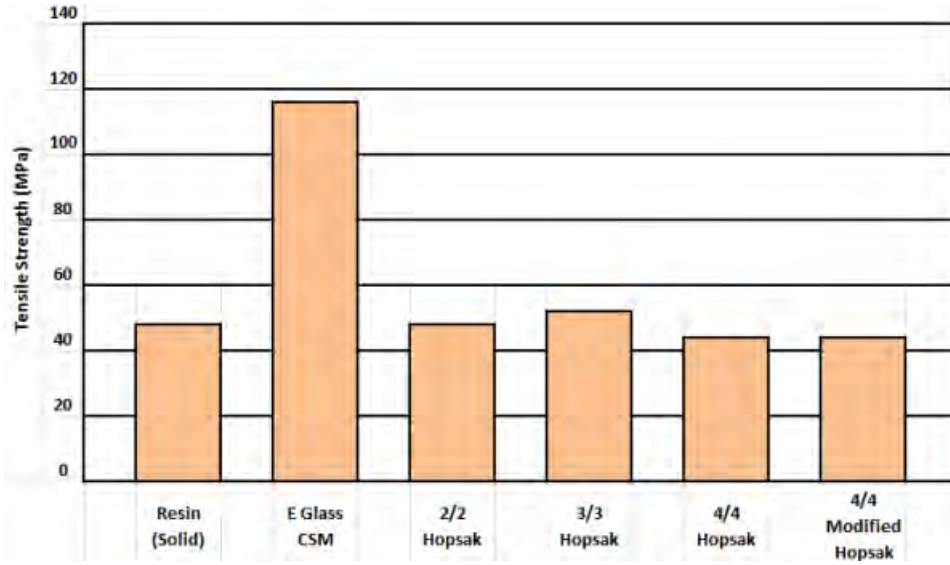

Table 1: Tensile Strength Results

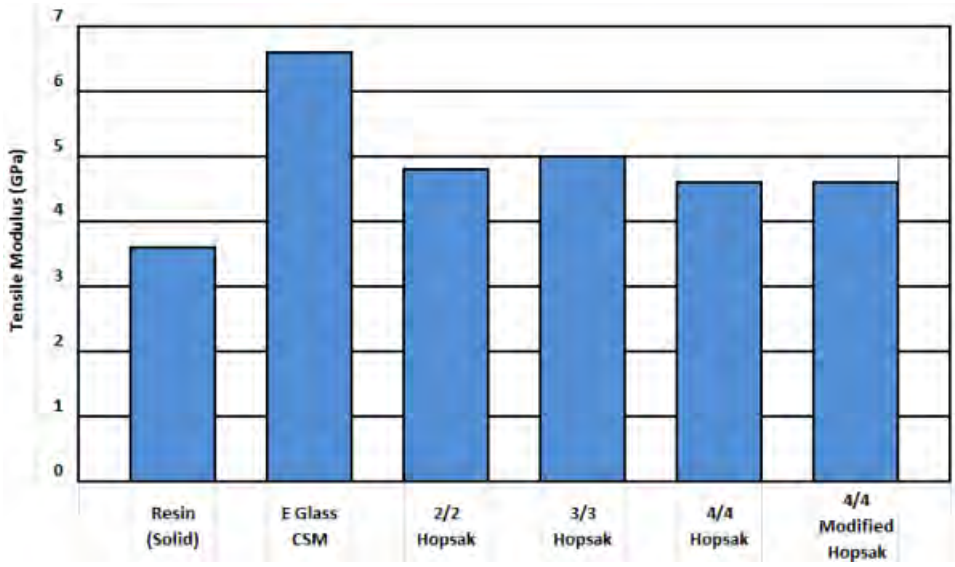

Table 2: Tensile Modulus Results

In terms of both tensile strength and tensile modulus, it became clear that none of the samples reinforced with natural fibres compared well with the E–glass. With regard to tensile strength, the pure resin sample actually performs better than two of the fibre–reinforced samples.

As a 'filler', natural fibres can reduce the amount of resin material needed in the composite, and can therefore reduce weight in conditions which are not structurally demanding. However, the fact that these fibres are encased in resin makes for poor end–of–life recyclability.

The conclusion from this project was simple. While access to a broad range of sustainable materials will be critical to the success of NPD in years to come, cases like this illustrate how difficult it is to achieve viable solutions. Unlike the EC case study, in which problematic communication within a large organisation had impeded progress, difficulties with this exercise were technical.

Construction Products Manufacturer (CPM)

A large supplier of construction materials to the building trade, CPM employs more than 5000 people and had an annual turnover of more than £1.3 billion in 2009. The environmental champion on this project was the company's Environmental Manager.

The goal of the project was to make the packaging for CPM's screws and nails more volume–efficient, in line with legislation, policed by the UK's trading standards body, relating to the excessive use of packaging. With CPM's existing packaging for screws and nails, there could be as much as 75% empty space in each pack.

The four main design requirements in this project surrounded:

- The cost, volume and weight of the packs
- Provision of enough surface on the packs to display contents or images of contents
- Preventing screws and nails protruding from the packs
- The capital investment and the energy required to produce the packs.

Figure 2 shows CPM's existing packaging and Figure 3, the two, more efficient designs. Two versions of the new design were proposed: one in card with only a window made in recyclable PET (polyethylene terephthalate), and the second constructed entirely from PET.

Table 3 compares the current product and the two contending designs by weight of the packaging, volume of the pack during shipping, carbon embodied in the pack and carbon emitted in the course of shipping the pack.

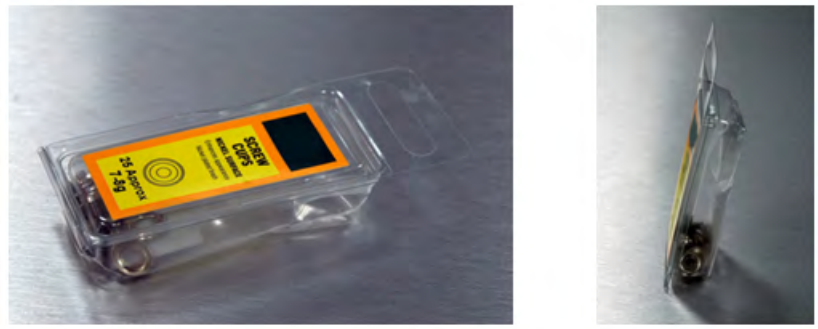

Figure 2: Existing Packaging for CPM's Screw Cups

Figure 3: The Proposed, more Efficient Pack Design

Table 3: How the Current and the Two Proposed Packs Compared, A cross Four Measures of Efficiency

	Packaging Weight (kg)	Shipping Volume (m^3)	Embodied Carbon (kg CO_2e)	Shipping Carbon (kg CO_2e)
Current	480	11.13	1526	140
New PET	390	2.956	1239	110
New Card	320	2.956	821	90

Overall, a move to a new pack design made from card promised the following benefits over the existing pack:

- A drop of 33% in packaging weight
- A 63% cut in shipping volume
- A 46% reduction in embodied carbon

- Elimination of more than 35% of shipping carbon emissions.

The use of a PET window in the card pack does compromise recyclability, making it difficult to separate the card from the PET. If 100% recyclability is paramount, an all–PET pack is unavoidable. This kind of design would give the following benefits:

- A drop of 18% in packaging weight
- A 63% cut in shipping volume
- A 19% reduction in embodied carbon
- Elimination of more than 21% of shipping carbon emissions

In both of the proposed designs, further savings in embodied carbon could be made through the use of recycled material. Obviously, too, CPM could make further savings by applying the design principles in the new packs to products beyond screws and nails.

These figures were very encouraging. Nevertheless, although costs were significantly reduced, CPM preferred to opt for simple polyethylene bags. These, though as resource–efficient as the Deep RED design proposal, are even less expensive, chiefly because they do not pretend to meet the third of the four main design requirements that surrounded alternative packs for CC screws and nails–namely that these items should not protrude from their packs.

Here is a telling example of the significance of the trade–offs mentioned by Gibson (2006). Simply by ridding one of the project's design requirements, much can be achieved. At the same time, there appears to be a compromise with good health and safety, with sharp objects piercing more, perhaps, than their plastics packs. On other design projects, it may be possible to make design compromises more suitable than this rather drastic kind. But that remains a rather open question for design practice.

Train Components Manufacturer (TCM)

TCM is an SME with 40 employees and an annual turnover of about £3 million. It specialises in the design and manufacture of train seats.

Undertaken with TCM's managing director as environmental champion, the project intended to cut the weight of a typical pair of train seats from 35kg to about 25kg–an ambitious target while maintaining flame retardency, seat strength and security, passenger comfort and so on.

Existing construction was largely based on steel tubing and a sheet–moulded polyester seat back, with polyurethane foam padding for passenger's buttocks and back. The alternative approach was to substitute aluminium for the steel and innovative a patentable, 'flat spring' system to replace the majority of the polyurethane; this spring systems being made from either polycarbonate or an appropriate laminated timber. Aluminium would cut weight, and at the same time allow for features to be introduced that would significantly ease both initial assembly and end–of–life disassembly. The flat spring system would greatly cut the amount and weight of polyurethane; in addition, end–of–life credentials would be improved.

Detailed calculations revealed that the 10kg weight reduction could be achieved. Deep RED's design researchers had the skills to field realistic proposals, and performed Finite Element Analysis (FEA) to determine, for example, how particular aluminium sections could equal the mechanical performance of steel and still reduce weight. However the team did not have enough experience to determine the carbon, energy and life cycle impact of its concepts.

In the opening phase of the project, Deep RED hired an independent consultant in environmental matters to advise on materials and LCA. This environmental actor's access to information on materials proved useful. In most cases, however, databases on materials had only limited information, and especially on current costs. Usually, Deep RED design researchers could only

acquire more current and relevant information by identifying suppliers and contacting them directly.

One important point that came out of the research with TCM was that many materials were simply not available in volumes high enough to bring about economies of scale.

It turned out to be the design researchers, not the environmental actor, who made the key decisions on how best to meet design requirements within cost constraints and to determine the optimal approach. However the environmental actor's use of eco–tools proved very helpful in validating both early concepts and later, developed solutions. In particular, the environmental actor's tool–based appraisal of concepts generated data that played a key role in design development, speeding up the process of deciding which design direction to take. Typically the environmental actor was able to highlight the difference in embedded carbon between recycled and non recycled aluminium. On top of this, the environmental actor could produce clearly quantified and unequivocal evidence of environmental improvements and cost savings.

Reducing the weight of a pair of train seats by 10kg amounts to losing 1250kg on a typical train; if a fleet of 125 such trains covers typical distances over a period of 10 years, lighter seats will allow the fleet to save around 1.4 million litres of diesel fuel (and similarly, energy consumption reductions for electric powered trains). In turn, and over the same 10 years, that would mean a cut in emissions of CO_2 of about 11,200 tonnes.

Retail Fixtures and Fittings Manufacturer (RFFM)

RFFM is an SME employing 80 staff. With an annual turnover of more than £6 million, it specialises in designing and manufacturing merchandise display units for leading, branded high street chains. It also makes checkout counters for retailers throughout the UK.

Being largely traditional in nature, the retail systems and components market represents a significant opportunity for environmental improvement. A particular feature of this case study was that the environmental champion was RFFM's Chairman. He was obviously well placed to overcome resistance to change within the company.

The project looked at retail checkout counters in the hopes of devising new ways of building them. Typically, such counters are constructed offsite, away from the store where they are to be installed. Made from medium density fibreboard (MDF) and then finished by laminating or spray–painting, they are usually delivered and fitted overnight, so as to minimise disruptions within normal store hours. Units are bulky in volume, weighing about 100kg each.

It was clear that RFFM's clients would only consider new kinds of checkout counters if the price of was no more than the existing ones. Maintaining or reducing manufacturing costs was therefore essential. The project brief was to:

- Use materials that would reduce environmental impact
- Improve end–of–life recyclability
- Reduce volume and weight, to assist installation
- Maintain or reduce manufacturing cost.

As with the train seat project, there was a need to employ an environmental actor–and it turned out that the actor brought a pattern of positives and negatives that was surprisingly similar to that which accompanied the train seat case. With retail fixtures and fittings as with train components, plenty of information on materials was forthcoming, but it was largely devoid of useful data on cost. In a number of cases, if materials selected for the checkout counters were 'attractive' (aesthetically, technically and environmentally), they were often simply not available in enough volume to allow economies of scale. As with the train seat project, the environmental actor and the eco–tools worked best in validating concepts and developed solutions.

Figure 4 illustrates the final designs that were proposed. These were based on the use of a triple corrugated cardboard to replace a large proportion of the MDF. Three key innovations allowed weight and shipping volume to be more than halved: the ability to 'flat–pack', the use of thin, rigid external cladding which is held loose against the card to form both a protective and cosmetic layer, and the development of a series of fittings that allowed counters to be assembled and disassembled on site, and within minutes.

In their new, lighter configuration, RFFM checkout counters are shipped in flat–pack form. The fact that they can be disassembled in situ has made them very easy to recycle at end–of–life. For example, the corrugated card in the new counters has inherent value (unlike painted MDF), making it sensible for RFFM to buy it back from clients at end of life.

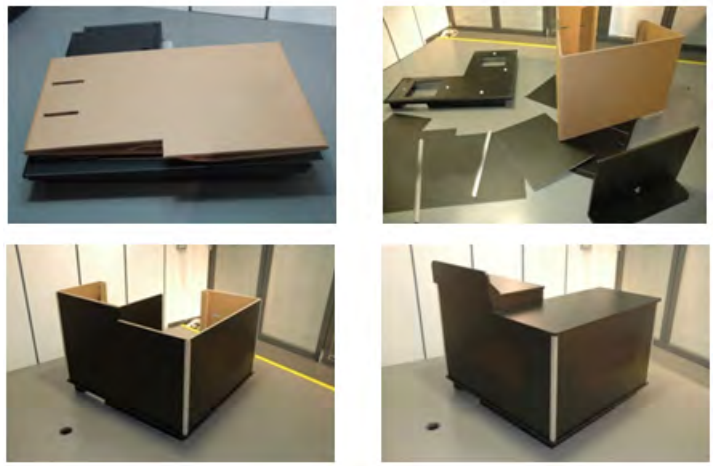

Figure 4: The New Retail Checkout Counter System

A typical customer of RFFM buys 500 checkout counters a year. If other customer chose to do the same and apply the new design in stores across the whole of the UK, customer purchases could increase to 12,500 units a year. Table 4 summarises the environmental savings that could be made in each of these two eventualities:

Table 4: Difference to the Environment made by New Retail Checkout Counters

	500 Units Per Year	12,500 Units Per Year
Savings in Raw Materials (t)	27.6	690
Dibersion From Landfill (t)	7.5	187.5
Transport Carbon Savings (t)	4.8	120
Embodied Carbon Savings (t)	9.75	243.8

Design impacts were as follows:

- A 49% cut in weight
- Improved ability to disassemble
- A 45% cut in shipping volume
- A reduction of 50% in shipping carbon
- A reduction of almost 12% in embodied carbon
- A 15% reduction in manufacturing cost.

It should be noted that, in its first iteration, this project allowed the continued deployment of MDF for both the base plinth of the counter and the top. For these components, the design researchers were unable to source a cheaper, satisfactory alternative to MDF. Given the substantial cost and environmental savings with this design, the survival of MDF formed a clear example of a trade–off worth making (Gibson 2006), or of what has elsewhere been termed a balanced compromise (Millet et al. 2007).

Continued deployment of MDF has also provided the Deep RED team, time to work with manufacturers of alternative materials for the top and the plinth. It has given the team the time, too, to establish the demand and therefore the economy of scale to manufacture these materials.

Overall, this design exercise proved to have significant commercial potential, on top of its achievements in the environmental domain.

Conclusions

In Environmental Terms, Supply Chains have a Long Way to Go

Among the 55 company attendees at the initial Deep RED regional events and in particular among the 13 companies that submitted project proposals and the five that were eventually selected, very few efforts were being made to minimise the environmental impact of supply chains. It is clear that changes in attitude to supply chain integration will be long term. None of these companies employed designers with training or experience in environmental design; none employed specialised environmental actors.

Materials Suppliers need to Convey their Riches

Databases on materials were not comprehensive enough to provide the very latest information on availability, cost or wider economic context. Yet the ability to obtain relevant and current information from materials suppliers was critical. A number of enquiries revealed the existence of environmentally attractive materials with potential for low environmental impact. These simply needed to be produced in larger volumes for them to become cost–effective in use, a significant factor in influencing supply chain change.

In the Fuzzy Front end of Innovation Projects, Environmental Actors use Eco–tools, While Designers Work Out Trade–offs

Confirming the analysis of Bauman and others, tools and databases for selecting materials proved to be of limited use–especially in the early, conceptual stages of design. LCA became useful in those circumstances when concepts had been proposed, but then required validation in order to determine development directions. In particular LCA proved helpful in validating developed designs. Environmental actors proved essential in extracting and presenting information about the environment, but it was the design researchers who were more able to consider costs when finding and choosing materials. Designers were the best at working out trade–offs.

In NPD, there are Good Compromises to be made between Environmental Benefit and Cost Constraints

This research has highlighted the tension between environmental benefits and cost constraints. Yet it has also provided evidence that the two criteria are not necessarily mutually exclusive; in fact the need to achieve cost savings can drive greater environmental efficiency. Conversely, as Dearing (2000) highlighted, design that reduces environmental impact can be used to achieve competitive advantage through innovation.

In Companies, Environmental Champions Deal with more than just the Environment

Environmental champions ranged from staff within large organisations enjoying dedicated environmental roles, to an SME Chairman personally driving a project on behalf of his company. The best results transpired where there was enthusiasm (Boks et al. 2009), and where effective rather than prohibitive corporate systems were in place to enable both top–down and bottom–up communication and action within companies (Bauman et al. 2002 and Loriot 2003). In all cases, however, environmental champions did not just champion the environment: cost savings were always on the top of the agenda, whatever the force of legislation demanding better use of resources in packaging.

In NPD, Designers Bent on Resource Efficiency can make a Big Difference

Of the five projects undertaken, two have yielded extremely positive results. The literature on environmentally conscious NPD is correct to suggest that when designers are brought in at the fuzzy front end of a project, they can significantly improve its outcome–in particular when resource efficiency is the main driving criterion. Above all, designers can perform trade–offs and reach wise compromises in ways that are truly innovatory. Throughout the supply chain and throughout the NPD process, they can bring about whole new ways of doing things.

Further Research

The projects for TCM and RFFM are being progressed to the stage of volume manufacture. The possibility exists, too, of developing the project for CPM in the same direction. An important feature of these ongoing exercises will be to investigate fully how supply chain integration and communication can be fully utilised in order to bring about even greater reductions in environmental impact and manufacturing cost as part of RED.

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Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative on Current Practices and Opinions.

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Design for the Environment in UK Product Design Consultancies and In-house Design Teams

An Explorative Case Study on Current Practices and Opinions

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COMMON GROUND

Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative Case Study on Current Practices and Opinions

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Abstract: This paper considers the perceptions of design consultancies and in house design teams about design for environment (DfE) and its implementation. The research reported investigates the current design for the environment practices, if any, that are evident within twenty British product development teams. Semi-structured interviews were undertaken where possible with designers, engineers, production managers and managing directors about their current projects in order to generate a state of the art picture about the adoption of DfE in product development. The paper presents an overview of the preliminary analysis of these case studies and proceeds to highlight the difficulties that design for the environment faces within product development teams; these include low reputation, recognition and adoption of DfE, as well as a lack of cohesive direction across the process. The need for further research that focuses on how these difficulties could be overcome in different parts of product development and the wider context of operations management is highlighted.

Keywords: Design for Environment, Eco-tools, Product Development, Design Team, Case Study, Sustainability

THE DEVELOPMENT OF DESIGN FOR ENVIRONMENT FROM ACADEMIA TO INDUSTRY

Design for Environment (DfE) is mainly concerned with designing out or reducing the environmental impacts of products or services-carbon footprint, recyclability, weight reduction, etc; (House of Lords, Science and Technology Committee 2008). The process under its various headings (eco-design, green design, sustainable design, etc...) has evolved as a discipline over the last two decades (Baumann et al., 2002; Boks 2008). Baumann et al., in their 2002 review of the green product development literature explain that research in the area has focused on eco-tools: "*finding ways of describing environmental aspects of material selection and generalised ways of dealing with environmental information*" (p.415). Other research concentrates on case studies illustrating the potential of DfE applications for industry and of DfE tools developed by academics.

Baumann et al., add that research presents "*a fragmented approach to the issue*", lacks a business focus and conclude that: "*few references deal with the integration of management issues, environmental issues and product development activities*." (2002, p.415). Although the need for DfE to refocus on organisational issues, capabilities, communication and structure is not new (Bras 1997), Karlsson and Luttropp (2006) argue that many researchers have been more

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interested in introducing new tools than evaluating or adapting existing ones. Boks and McAloone (2009) broadly agree but add that research since the review by Baumann et al., (2002) has started to focus more on organisational issues and to move away from the creation of eco-tools.

In industry there remains a more limited appreciation of DfE (Tukker et al., 2001; Boks & McAloone 2009) and generating an understanding of the problems associated with DfE and its implementation in British product development teams is an under-researched area. The DfE scene has however evolved considerably over the last decade and an appreciation of the current state of the art of British product development teams, with regards to DfE practices and perceptions of the drivers and barriers to the process, can support recommendations about how to move it forward.

Developing a Better Understanding of DfE Perceptions and Practices

The research undertaken and presented in this paper has explored the perceptions of British product development teams about the concept and implementation of DfE. It has also investigated the current DfE practices that are evident within these teams without any particular emphasis being paid to success stories.

Methodology

This research adopted a multiple case study approach in twenty 'in house' teams and design consultancies. The study encompasses small, medium and large enterprises, the sample covering over 80% of the British product design consultancies in terms of market share (Relph-Knight 2011, p.39). 65 semi-structured interviews were undertaken with 55 interviewees fulfilling various roles in the organisation (designers, engineers, production managers, managing directors, etc). Interviewees were asked about their current and recent DfE projects, being defined by a DfE intent, where environmental criteria are part of the brief.

Table 1: Cases and Interviews Spread

	Design Consultancies	In-House Design Teams	Total
Number of Interviews	18	47	65
Number of Cases	7	13	20

This multiple case study design enabled the gathering of a greater variety of findings. Moreover, the use of a larger sample size and of comparative cases from different settings enabled this research to corroborate patterns of association and therefore to offer potential for contextualised generalisation and theory building. Multiple case studies also support a high generation of findings without drawing upon too much resource from each case participant in an industry where time is very precious.

The interviews provided a rich and personalised picture of distinctive cases. Each participant offered an account with their own perspective informed by their different backgrounds and positions in the company. Respondents were guided by the researcher through the introduction of broad topics which allowed more freedom to express their views (Bryman 2008). The topics included 'design process', 'DfE views and approach', 'communication', 'collaboration', etc... These views were then compared, looking at company, sector or job type as variables.

This descriptive research is ongoing with current projects being tracked by the lead researcher. The purpose of this paper is to provide researchers and practitioners with the insights of the current stage of the analysis and to generate a dialogue on the issues raised. Further collection of data and analysis is underway, which will complete this work along with the feedback from both industry and the academic world.

Comparative Analysis

While the research is ongoing, the data collected underwent an initial stage of comparative analysis; this is presented below. The preliminary findings focus on issues affecting the adoption and implementation of DfE across the twenty research cases. Also, to illustrate these findings, each section presents quotes from interviews conducted across two cases and seven participants. The first case is a design consultancy where three participants were interviewed (DC1, DC2 and DC3). The second case is an SME designing and manufacturing in house where four participants were interviewed (IH1, IH2, IH3 and IH4). All participants work within the product development team.

Eco-tools and Methods of DfE Implementation

Interviewees were asked about the methods and tools for DfE implementation that they and their company used. As mentioned earlier, the use of eco-tools by industry has been identified as quite limited (Tukker et al., 2001; Boks & McAloone 2009), and concurrently the research identified that there was a total absence of eco-design tools across all cases. Moreover, there were no projects driven by DfE principles and only a few where the implementation of DfE principles was considered.

> Interviewer: Do you have any examples where you worked with clients to make a product more sustainable?
>
> DC1: We have, but to be honest, we don't particularly get that kind of project.

The cases that consciously looked at DfE were primarily driven by the potential for cost benefit. Interviewees however stated, that although based on cost, some of their brief's criteria did relate to DfE and were considered in that respect; typically saving on material, minimising packaging or the housing of components, reducing weight, increasing recyclability, etc. Consequently, interviews focused on gathering data from those projects that had the intention in some form to lower environmental impacts.

In only one case had a design consultancy (the same one quoted here) developed a spreadsheet linking environmental impact data to a bill of materials. Within this company, one person was fully aware of, and able to use the tool.

> DC2: We have created our own excel spreadsheet, that's based on the eco-indicator 99 model. [...] I am the only one that could use it. I had aspirations to make it available company wide, but we've had no time for that yet.

In other cases, designers would follow principles of DfE without any methods for measuring environmental impact or at best use rules of thumb and peer advice.

> About the use of Eco-tools:
>
> IH3: It was on the agenda, but it didn't happen, it didn't fit with what we do. It was more creating a marketing tool than a tool to move towards sustainability. I don't think we have enough operations to warrant the use of it. A lot of it is common sense and also making everybody aware of what they could, should be doing.

Efficiency, DfE and 'Good Design'

Across the different cases, interviewees were asked about their views on DfE as a discipline. There was a concurring opinion that in most cases, the practice of DfE and the use of principles

and methods for DfE were largely similar in terms of 'good design' practice and methods. This term, shared by the interviewees, defined the best practice in design and what design should be.

> DC2: We don't actively do Eco Design, but try and do what I would classify as good design, and part of that has naturally an element of it.

> DC2: Sustainable design is just good design, it's part of it. We don't have to wait for a client to ask, we should be doing it anyway.

> DC3: There's this set of good design principles that ultimately make things environmentally better but it wasn't necessarily the driver for doing that.

As mentioned above, the majority of interviewees stated that DfE principles were taken on only if it made financial sense. In most cases, DfE is limited to efficiency where the product development team aims to reduce material use, energy consumption or packaging for economic motive. The environmental benefit is sometimes only a lucky by-product or in some cases a potential marketing tool.

> DC1: On the FMCG [fast-moving consumer goods] side, they want to use as little material as possible anyway and most of them are recyclable. And for their own profitability, they tend to be very efficient on transport and manufacturing, etc. I'm not saying they're environmentally friendly companies, but being efficient is their business.

> About DfE and efficiency:

> DC1: From a design point of view, you always try to use as little plastic as possible, because you're often designing down to a cost. And if we have a European material that's more environmentally friendly, you can bet your life the client is not going to go for that and is going to choose a cheap one that's probably been made in a very bad way.

> DC3: It's possibly a marketing focus to differentiate themselves. I've seen that before. I don't know many do it for the environment and how many just want to do it just because it makes financial sense. I think they would phrase that as efficiency now. I just think it's moving away from just being green, to being efficient, I think that word efficient is what is taking over. Resource efficiency is about good design, about good engineering, that's why they come to consultancies, for those services. I don't think they even know in their own head that they're trying to be sustainable, but they want to be the most efficient.

In some of the cases, interviewees explained that the opposite is also true. Inefficiencies in the product development process can make a product worse from a DfE point of view. In house design teams expressed this view the most, stating that short timelines for example, had negative repercussions on the environmental aspects of their projects.

> About DfE barriers:

> IH4: we're lacking the time to develop or integrate the sustainable solutions we want to do. [...] Going fast make it less sustainable when you have to reach tight deadlines.

'Green Champions' and doing the 'Right Thing'

Participants most interested in DfE explained that they spend some of their time looking at the DfE field and that while the gathering of information is regarded as commendable by senior management, the learning is in most cases self-driven.

They also explained that they only transfer small amounts of knowledge to their team; in some cases, they or their teams do not feel the need to gather knowledge, let alone transfer it. In addition, when DfE aware employees leave their company, their knowledge goes with them since there are in most cases no systems in place to capture knowledge and transfer it to the product development team or company. This problem of knowledge retention was experienced by the majority of cases.

> DC2: I'm sort of, the unofficial sustainability champion here.

> DC3: It's my passion, environmental stuff; therefore I do it in everything I do in life.

Some participants also express a wish for more DfE criteria and that DfE is the 'right thing' to do. They empathise with environmental problems and in some cases even criticise the fact that their work is contributing to those problems.

> DC1: I've been to China, I've seen the way they make things, to be honest with you, it fills me with horror. But, I'm hoping there is more legislation coming over there, in terms of recycling and all that sort of thing.

> DC3: I think it's scary, I think it's shocking people aren't coming here asking about it. I assumed there would be loads saying they want to be green and asking us about how to be green.

In one of the cases (an SME designing and manufacturing in house), the Managing Director explains that he took on the role of 'green champion' and is seen across his company to be driving the green agenda. However, regardless of his position in the company, he still experiences the problems of implementation described below.

Out of Our Control, not Part of My Responsibility

The majority of the interviewees felt that DfE implementation was out of their control. They explained that they are restricted by working for a client or market that does not ask for DfE to be addressed.

> DC1: Ultimately, it's down to the client, we can suggest things, but sustainability is really something they have to ask for, because obviously we are a consultancy and we have to get paid for the hours we do.

It is interesting to note that while there was a distinctive group of interviewees motivated by DfE; another group felt that 'pushing' or investigating into it was not part of their responsibility. Employees' time is not accounted for in expanding DfE knowledge in any of the cases and this second group explained that they do not have the time, or bear the responsibility to gather knowledge on DfE.

> IH1: I feel there are two types of designers; there are the ones that feel passionately about the environment and there are the ones that feel passionate about not being environmental in a way. From his perspective, why bother using bamboo if it's the same as vinyl. From my perspective it's the same but better for the environment so: yay!

Interviewer: Any DfE changes made to the product?

IH2: Not 100% sure. Could be.

Interviewer: I know of an example where you used bamboo?

IH2: Was that for a panel or something? Could have been.

[…]

About alternative materials:

IH2: Not in relation to sustainability. The materials we've got are pretty set. It's down to what we have in the workshop. It's not my part to deal with that.

Senior level staff also thought that DfE was not asked for enough by clients to be worth investing in. Few knew what they would do next if they had to develop this part of their offer and would have to look into it further if the need arose.

Lack of Time and Trust in Implementing Environmental Alternatives

According to the majority of interviewees, DfE is seen as a discipline with conflicting opinions. There is confusion as to why different environmental alternatives and strategies seem sometimes to contradict each other. There is also a general lack in confidence and sometimes, even trust with DfE, in particular regarding products' environmental claims and DfE implementation methods such as eco-tools and software. In some cases, there is a belief or concern that DfE alternatives will hinder the products' functions, properties or another part of the design.

IH3 explained that they use virgin aluminium and have looked at using 100% recycled aluminium but they want to spend more time looking at it. They fear the material may fail while in use although the supplier guarantees that it has the same properties. They are however constrained by time and cannot afford to look into it at the moment.

IH3: It's not really a case of I don't care, I do care, it's just a case that there are other things that need to happen so it's quite difficult to put it in.

Communication and Knowledge: Information not Driven Down

The research highlighted a clear lack of cohesion between design briefs' environmental objectives and the overall environmental objectives of a company. The interviewees directly involved in product development were usually not aware of the environmental objectives set by the companies selling the products nor do these generally appear in the briefs. If design briefs include environmental objectives, these are again usually set without any knowledge of the environmental management teams. In effect, it seems companies' overall environmental strategies are not driven down to product briefs and design teams.

It is interesting to note that the only case using an eco-tool (the design consultancy quoted here) was also the one appearing to use the most communication or collaboration tools. This company uses forums on their internal computer network to share information and interests, ask questions to peers and diffuse knowledge. However, even in this lone case where systems are in place for communication and knowledge transfer, the actual use of DfE is low. Interviewees talked about communication and collaboration examples relating to industry sectors or more general product design aspects, but only a few meetings take place on the subject of DfE. Knowledge of internal DfE resources is also very limited in the company. Contrary to the majority,

they feel very satisfied with their communication and collaboration tools. However, the use of those in terms of DfE still remains relatively very low.

Interviewer: How do you transfer knowledge and DfE knowledge?

DC2: We have a series of forums, engineering forum, design forum, usability forum, but there isn't one for sustainability per se.

About developed DfE knowledge:

IH4: [The employee] built up a lot of background information which was quite useful, could have been quite good but practically didn't communicate it, it is within files in a computer, you know, and I think that would be my, my fault.

There is a level of frustration, mostly from designers in more junior positions regarding communication and collaboration. They are in many cases negative about the ability of their company to learn from previous projects and to transfer knowledge and information.

About communication methods:

IH4: The only time, sadly, that information is spread really through the company is within projects.

Respondent were generally negative about the lack of collaboration and communication within projects. They explained that internally within the design team, information filters down with loss from senior levels and from the client companies. Externally, they also experience difficulties (such as time constraints and retention of information) in gathering information from the supply chain. Loss of information regarding environmental criteria also seems much more affected by the different hierarchical layers of project structure when comparing the views from job types in cases. Overall, it seems that the companies' environmental strategies as well as the products' environmental objectives are not communicated effectively down to the design team.

The problem of communication and collaboration affecting interviewees was not confined to DfE oriented projects but applied to all project types. However, in DfE oriented projects, interviewees express how constraining these problems can become and how they affect the capacity to achieve best performance. In many cases, interviewees reflecting on their practice felt that the lack of information, communication and collaboration often makes it impossible to achieve the desired environmental objectives.

IH1: It's a constant frustration, especially regarding materials. It really is, because I had samples, I've categorised them in a library, I've got people to look at them and they've been quite excited, they've designed them in once. And then, I don't know, it's like it never happened, forgotten.

About client handlers (not) selling environmental alternatives:

IH1: Unless they were specifically asked for an environmental solution they wouldn't do it and they wouldn't be promoting it. However, if you asked them they would say to me that they do promote that!

Internally and in most cases, communication and collaboration on DfE is said to happen through emails and few formal meetings but more usually, it occurs through informal interaction by "bumping into" or around an impromptu "cup of tea".

Driving and Sustaining Implementation

In the majority of cases, there is no process to drive DfE across the product development team. This is usually explained by a lack of time and resource. Isolated employees develop their DfE knowledge mostly through personal interest and in turn try to drive DfE implementation but believe it needs to be led by senior staff to be successful.

> About implementing ways to develop DfE knowledge:
>
> Interviewer: Is the push coming from you or from higher management?
>
> DC2: The idea came from me, my manager agrees it would be quite a useful thing to do, but like everything else, it fits into a hierarchy of importance, and he's left it to me to act on it when I can. But we don't have the time luxury to do this at the moment.
>
> DC2: what would be fantastic would be it being driven from the top. Either top within here dedicating budget and time to it, or clients saying they really want it. But it's very difficult because we're a consultancy.

In most cases, sustaining DfE implementation seems as difficult as the implementation itself. Interviewees encountering the problem explained that implementing an environmental alternative on one project provides little benefit for the following one. The knowledge and experience gained on the one project is consequently lost as there are no methods to store or build upon it. This provides DfE with one of its biggest barriers that is the management and therefore the development of this knowledge for future use.

> Interviewer: How would you see this continue if you left the company?
>
> DC2: I think it would slow down, then it would stop. [...] It's really much in the realms of knowledge management and of how a company capture its intellectual property that's generated and recycle that in an accessible form.
>
> IH1: You get to see it but you know that it's made an impact that one time; but hasn't made an impact on the design team. I know because it's happened before that, let's say you've got bamboo instead of vinyl, it would be the same price. We've always used vinyl, but we were asked to use bamboo for that project. Next time they do a design for someone else they will revert straight back to vinyl. It's the way they've always done it. It's not embedded because it won't happen again.

Conclusions and Future Research

Although DfE has received a lot of attention from the academic world, especially in the last twenty years, the take up in British industry is still far from being at the same level.

The ongoing research presented in this paper highlights the difficulties that DfE implementation faces within product development teams, such as low reputation and recognition, as well as a lack of cohesive direction. This lack of cohesive direction creates problems of transfer of information, communication and collaboration that hinder the development of sustainable DfE knowledge, the management of which is also critical at a company level in order to sustain and build on success. While communication and collaboration issues are not seen to be unique to DfE, they are significant to the success or failure of DfE product development. The research carried out so far shows that the role of eco-tools has little place in the implementation of DfE. 'Green champions' seem to offer the main driver in this process although their influence remains rather limited.

This paper has highlighted the need for further research to focus on the development of collaboration, knowledge management methods and sustaining knowledge acquisition in DfE. It has also suggested the importance of developing systemic knowledge and knowledge transfer mechanisms at the level of design team, between the team and the wider organisation and throughout the product development chain.

SECTION 5

House of Lords Science and Technology Committee
Waste Reduction Report 2008

HOUSE OF LORDS

Science and Technology Committee

6th Report of Session 2007–08

Waste Reduction

Volume I: Report

Ordered to be printed 21 July 2008 and published 20 August 2008

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£price

HL Paper 163–I

CHAPTER 3: DESIGN, INNOVATION AND TECHNOLOGY

Sustainable design

3.1. Witnesses suggested that around 80 per cent of a product's environmental impact can be eliminated through better design (pp 86, 96, 177). The Resource Efficient Design (RED) Initiative at De Montfort University commented that these environmental impacts can include "environmental damage in sourcing materials, emissions and waste in production and wasted energy in use, in addition to the environmental impacts of disposal" (p 204). So strategies to enable the reduction of waste are often linked to measures which have other beneficial environmental consequences such as savings in the amount of carbon, energy or water used. Together, these feed into a general notion of sustainability, a concept which is now receiving growing attention from businesses and governments.

3.2. In order to design waste out of a product or system at the development stage, the RED Initiative identified six different design strategies, which we explore in more detail below. None of the strategies can be used in isolation and we recognise that waste reduction must be considered against other concerns as part of the larger aim of environmental and economic sustainability.

Design for disassembly

3.3. Designing products for disassembly at the end of their lives enables useful materials and components to be removed easily with minimal effort and energy. In order to do this, consideration must be taken of the fasteners or adhesives used to bond parts together, the modularity of a product and the robustness of its parts.

3.4. There has been some suggestion that "smart materials" could be utilised to assist product disassembly, in which the properties can be significantly altered in a controlled manner by factors such as heat, moisture, stress or electric currents. "The smart material aspect is an interesting one," commented Dr Jonathan Chapman, Senior Lecturer in 3D Design at the University of Brighton. He cited the example of a polymer which could be used in a mobile phone which, when exposed to a certain frequency of sound or light, "expands slightly which forces the chassis of a mobile phone to pop apart." There are still challenges to be overcome and Miss Holly McCain from the RED Initiative commented that "there needs to be a lot more research into the practicalities of using these materials" such as the stimuli which trigger them to disassemble. Her colleague Miss Lizzie Dutton agreed, adding that there "would be a trust issue for the designers" of unexpected disassembly which would need to be overcome before smart materials could be used (Q 418).

3.5. It was also suggested that the tagging of certain components could be used to assist the automatic sorting of materials once products have been disassembled. This would require thought at the design stage to ensure that the tag contained the necessary information. Professor Sue Grimes from the Centre for Environmental Control and Waste Management at Imperial College London, said that to begin with a tag such as a radio frequency identification (RFID) tag could be used, but moving on from this she supported the development of a "conducting polymer type tag, which

HOUSE OF LORDS

Science and Technology Committee

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HL Paper 163–II

Minutes of Evidence

TAKEN BEFORE THE SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY (SUB-COMMITTEE I)

TUESDAY 27 NOVEMBER 2007

Present	Crickhowell, L	O'Neill of Clackmannan, L (Chairman)
	Haskel, L	Platt of Writtle, B
	Howie of Troon, L	Selborne, E of
	Methuen, L	Sharp of Guildford, B
	Lewis of Newnham, L	

Joint memorandum by The Department for Environment, Food and Rural Affairs (Defra); The Department for Business, Enterprise & Regulatory Reform (BERR); and The Department for Innovation, Universities and Skills (DIUS)

Introduction

1. The Government welcomes the Sub-Committee's inquiry into ways in which products and production processes can be made more sustainable and therefore produce less waste. Given the main focus of the inquiry is waste reduction, this evidence sets down the policy and regulatory framework that the Government has put in place to achieve this.

2. The Government's role in addressing the issue of waste reduction can be broadly summarised as follows:

- to put in place overarching policies focusing on waste prevention and waste reduction;
- within this, to introduce specific product regulation, focusing on reducing waste arising from certain products;
- to introduce voluntary agreements in place of legislation to reduce waste where appropriate;
- to provide incentives for consumers to reduce waste, thereby indirectly applying pressure on manufacturers to produce less waste in their products or packaging; and
- to introduce wider initiatives that encourage waste reduction.

3. This memorandum will discuss the measures that the Government has put in place to fulfil this role.

Overarching Policies

The Waste Strategy

4. The Government published the Waste Strategy for England 2007[1] on 24 May. One of the key objectives set out in the Strategy is to decouple waste growth (in all sectors) from economic growth and to place more emphasis on waste prevention and re-use. The charts below demonstrate recent progress in achieving this aim.

5. These charts demonstrate that waste has grown significantly less than GDP since 2000. Of the main waste streams, both municipal and business waste are growing at a rate slower than GDP; municipal waste increased at about 3.5 per cent per year up to the millennium but average growth over the last five years has been less than 0.5 per cent per year.

[1] http://www.defra.gov.uk/environment/waste/strategy/index.htm

Google it and find out. In the context of this morning's discussion I kept thinking about that sort of thing. I am too young to really remember it. I have a vague recollection! Some of these grey beards around here will probably be able to provide me with graphic information. You have been very fulsome in your responses this morning. You have taken longer than we had anticipated, but we are very grateful. If there is anything else you feel that you would like to add afterwards, please feel free to send it to us. Equally, we may be in touch with you when we look at the evidence if there is something that we would like to take up with you again. Thank you very much for your time this morning.

Memorandum by The RED Initiative, De Montfort University

Summary

1. This submission discusses the various needs and requirements of product-, commercial interior- and industrial design consultancies in developing their practice of eco-design.

2. The evidence focuses on the existing business practise of small UK design consultancies with regard to sustainability, and highlights current industry opinions about legislation, levels of eco-design implementation, and the barriers cited of why eco-design strategies are not currently integral to every-design design practise.

3. Designers learn from project work and evolving experience. Whilst there are numerous academic publications in the field of eco-design, these are invariably not accessed by designers, who adopt a "hands on" practical approach in learning and skills development.

4. The research concluded that SME design consultancies feel they are small fry in ability to implement eco-design and waste-minimalisation strategies, due to their clients—often large organisations—enforcing time and cost restrictions on the small enterprises they outsource design work to.

5. Design consultancies often state that the only way to ensure that design for environment strategies are enforced is through more concise, practical legislation, that can integrated into the design process.

6. In the current UK design sectors, designers state they lack information—be it knowledge about environmentally-preferable materials, eco-design strategies or general business support initiatives.

7. The evidence concludes with a need for a higher level of innovation within the design industry. Rather than slowly making incremental changes in developing products and services that are marginally less environmentally-less damaging, designers need assistance in becoming better at innovation. The innovation of new products and service systems has the potential to change consumer behaviour and move more quickly towards a sustainable society.

Background

8. De Montfort University's Faculty of Art and Design is distinguished in producing industry-relevant design education. Engaging with the industry that the faculty feeds is fundamental to achieving this capability. A strong component of this collaboration is **dmu***design*—a design consultancy based within the University that also works in supporting and developing the design and manufacturing industry within the East Midlands region.

9. Beginning with *Improving Business by Design in 2003,* **dmu***design* has been charged with enabling SMEs to develop their businesses through innovative product design by both Leicestershire Economic Partnership and the East Midlands Development Agency. The focus throughout all programmes has been identifying opportunities for innovation within the East Midlands' design and manufacturing sector.

10. Our most recent programme, *The Resource Efficient Design (RED) Initiative* assists businesses in minimising the negative environmental impact of their products as well as identifying opportunities for innovation that can have a significant impact on resource efficiency. The key focus of The RED Initiative is to demonstrate the opportunities that resource-efficient design can deliver for businesses.

11. The RED Initiative works with the commercial interior design and industrial design sectors. 93 per cent of product and industrial design consultancies in the UK are SMEs, of which 82 per cent have less than 10 employees. 98 per cent of interior and exhibition design companies in the UK are SMEs of which 94 per cent have less than 10 employees. Collectively, the UK's design consultancies have a large influence over the environmental impact of products in the UK and with 16 per cent of SME design consultancies having overseas clients, this impact stretches worldwide.

12. The following evidence outlines the experiences of **dmu***design* programmes in relation to eco-design practice in SME design consultancies in the East Midlands.

Can better designed products offset the increase in consumption?

Yes

13. It is widely recognised amongst eco-design practitioners that over 80 per cent of all product-related environmental impacts are determined during the design phase. In any given product this can include environmental damage in sourcing materials, emissions and waste in production and wasted energy in use, in addition to the environmental impacts of disposal.

14. Eco-design can assist in waste reduction through minimising the use of materials or selecting alternative materials, however, design has a pivotal and potentially more critical role to play in changing consumption patterns. In order to achieve a sustainable society it is critical that alternative lifestyle solutions are designed, developed and adopted.

15. The various levels of eco-design implementation can be broadly grouped into two levels: development and innovation. The development of existing products can lead to a reduction in their impact. The innovation of products and services has the potential to adapt consumer behaviour and move more quickly towards an environmental and social equilibrium.

How can better product design be used to effect a change in consumption patterns and behaviour?

16. The role of the designer differs from the engineer in the focus on human interface. "Human-factors" is a core skill of the design discipline. The designer is therefore well placed to understand, interpret and influence the consumption patterns and lifestyles of consumers.

17. A simple example of an innovative environmentally-preferable solution is the eco-kettle. The designers recognised that the major environmental impact throughout the life-cycle of a kettle is the excessive energy use due to users over-filling the product. The solution: a kettle that boils the required amount of water and reserves the remaining water for subsequent uses. The Department of Environment, Food and Rural Affairs say that "If everyone boiled only the water they needed instead of 'filling' the kettle every time, we could save enough electricity to run practically all the street lighting in the UK".[30]

18. An example of "forward thinking" by eco-innovators can be found in transportation. As opposed to the minimal reductions that can be made through reducing materials in production (such as the SMART car) or reducing the energy in use (for example the Toyota Prius), a significantly greater environmental benefit can be gained from vehicle sharing schemes. One such scheme is the UCR Intellishare project[31] where users select vehicles that suit their needs for each individual transportation requirement only when they are needed.

What role can better design play in minimising the creation of waste?

19. At a more superficial level designers can develop products with waste minimisation in mind. Where affecting consumption patterns is not possible, designers can use various strategies to minimise the creation of waste.

20. There are various strategies for waste reduction including:

(i) design for disassembly;

(ii) light weighting;

[30] http://www.nigelsecostore.com/acatalog/eco-kettle.html
[31] http://world.honda.com/ICVS/about/intellishare/inte.html

(iii) design for durability;

(iv) recyclability;

(v) reusability; and

(vi) life cycle/Cradle to Cradle design.

21. The initial reaction to minimising waste is often to focus on the end of a product's life cycle; however, the major impacts of a product may be elsewhere.

22. In energy-using products the highest environmental impact is typically the use stage. In this case efforts should be focused on energy reduction in use. An interesting example of this is Procter and Gamble's latest campaign, initiated in conjunction with *Forum for the Future*, that encourages their washing product users to turn their washing machines from 40 to 30 degrees.

Eco-design practice within industrial and commercial interior design consultancies

23. The RED Initiative supports the concept that the most effective way to progress design towards sustainability is to focus on the opportunities for innovation. Unfortunately the present focus of most organisations is on incremental improvement and redesign of existing products. There was found to be limited understanding of the opportunities that eco-design can bring for both design consultants and their clients.

The Use of Materials

Challenges facing designers in adopting eco-design in everyday design practice.

Material selection

24. The experience of The RED Initiative is that the main eco-design strategy that designers focus on is materials selection. This is supported by their clients who, where eco-design issues are considered, are reported to focus their requests for consideration of material selection.

25. Material selection amongst designers is normally experience-based. The majority of products will be designed in relation to their predecessors or similar products.

26. Designers indicated that the main barrier to selection of environmentally-preferable materials is a perceived additional cost. This is combined with a lack of confidence in the quality and performance of eco-materials, as they are often perceived as inferior alternatives.

Materials availability

27. The RED Initiative has experienced limited application of alternative materials (such as biopolymers and smart materials) by SME designers due to the potential limited availability in sourcing such materials. However, designers often mention materials featuring a high recycled content when considering eco-design alternatives.

28. One area in which material scarcity is regularly considered is when selecting Forestry Stewardship Council (FSC)-approved wood based products. The labelling scheme is well-known and commercial interiors designers often specify FSC-approved woods.

29. In most cases however, the selection of environmentally-preferable materials based on material availability is limited, with the majority of enquiries based on the selection of materials that have the appearance of "environmental friendliness".

End of life impacts of raw materials

30. Information on the potential end-of-life routes for products is not well understood by designers. This reflects the disparate recycling systems that products may face both within the UK and abroad. Apart from reuse, opportunities for product disassembly or even recycling of many products are limited. This lack of coherent systems restricts the potential for development of products in relation to end of life strategies.

31. There is potential for the development of more sophisticated and consistent recycling systems as legislation such as Waste Electronic and Electrical Equipment regulations (WEEE) bring a larger quantity of materials together.

What impact does the development of new materials have on design?

32. The development of new materials has limited impact on "everyday design" due to the need for materials to be proved and costs and supply chain issues to be reduced and resolved.

33. With limited time and money for product development, designers indicate that they are rarely given the opportunity to experiment with alternative materials. Where they do try alternative materials it is likely to be in conjunction with a manufacturer, who will be more knowledgeable about the behaviour of that material in production.

34. In general, designers are more interested in which of the conventional, readily available materials are the least damaging. Constraints of time and demands on producing workable outcomes with limited testing often prevent even this level of alternative materials selection.

35. Where designers are looking to select an alternative material, they often remark that they find it difficult to select alternatives due to the lack of information about environmental benefits. Designers want a "quick fix" solution due to limited time for a full study of the material options. Providing information that simplistically ranks materials can be misleading, as environmental superiority is often situation specific. Further understanding and time to consider the overall lifecycle impacts of materials is required.

Demand (Business Framework)

How central is sustainable design to business thinking?

36. Amongst SME design consultancies, their directors and their staff, there is a general desire to respond to environmental concerns in their business practice, and in the design and production of products. Unfortunately this desire is not met by a tangible/financial demand. Eco-design practice is limited, with most small organisations rarely including eco-design considerations.

37. Even (as is often the case) when SME design consultancies and manufacturers produce work for larger organisations, there is little to no legal requirement for eco-design considerations.

38. Currently, resource-efficient design is viewed as a specialist or retrospective discipline. Enterprises of all sizes tend to only actively apply strategies of eco-design when they perceive that there are benefits to be gained from "green marketing" resulting from the applied eco-design.

39. However, a perceived fear of being left behind other enterprises who may already be implementing approaches is starting to alert businesses to the need to take action. According to Paaru Chauhan-Pancholi from retail design consultancy Briggs Hillier Design LTD, SMEs can not afford to lose clients if they can not prove their knowledge about sustainability issues.

40. Where businesses genuinely do wish to implement sustainable design strategies into their everyday business practice, they are often ill-informed about the methodology of establishing such strategies and find it difficult to identify good starting points for eco-innovation.

What initiatives are in place to encourage this and are they meeting business needs?

41. There are number of national government-funded environmental support programmes made available to businesses, such as The Carbon Trust, Business Link and Envirowise, as well as a host of regional development agency-funded local organisations open to SMEs—for example The RED Initiative, The BEST Network, and Carbon Action Yorkshire.

42. When consulting with SME design groups about the value of both local government programmes and national environmental-support programmes in assisting businesses in improving their environmental performance, it was discovered that SMEs found regional business-support units more accessible and effective in conveying practical advice. Design SMEs particularly found programmes such as The RED Initiative to be of high value, due to the programme offering services specifically focused on the design industry, allowing support tailored to the precise needs of the SME to be communicated to businesses.[32] However, most design SMEs still feel that more engagement is needed between businesses and environmental- and business support organisations.

[32] Paaru Chauhan-Pancholi from Briggs Hillier Design LTD stated she valued local, sector-specific business support programmes more highly over national, general environmental advice bureaus because the local programmes are accessible, and easy to develop good relationship with.

43. It is the view of many SMEs that the Design Council is currently very London-centric and should be more proactive in disseminating information, training and research conclusions into the design industry. According to Associate Director Kate Shepard from retail design and branding agency Checkland Kindleysides,

> "The Design Council should play a larger and more significant part in informing design businesses about legislation and incorporating sustainability into SMEs' every day practise".

44. The Design Council-run programme *"Design of The Times"* (DOTT) and "Designing Demand" is already attempting to fulfil this need, although here there is less of a focus on eco design. Instead the project appears to consider general sustainability and cultural innovation issues, rather than directly engaging with design groups to assist them in employing practical eco-design techniques.

Does the current policy, regulatory and legal framework support incentivise the development of better, more sustainable products and processes? How is the framework communicated to businesses and what is the level of awareness and understanding among businesses?

45. There are national organisations such as the Design Business Association (DBA) and The British Design Innovation (BDI) offering services to design businesses such as information on legislation, legal advice and training packages. However, research carried out by The Design Council concluded that "architects are more than twice as likely as designers to be doing job-related training" and "the proportion of people engaged in job related training is far lower among designers than for all other similar occupational groups".[33] There is therefore a need to communicate with design consultancies and in-house designers the need and benefits of continual training and skills development of employees, and to create stronger links between design businesses and organisations offering training services.

46. Other creative industries such as architecture and engineering have governing bodies such as the Royal Institute of British Architects (RIBA) and the Institution of Mechanical Engineers (ImechE) that oversee and regulate practitioners. These bodies offer an acreditation service where the members become Chartered or professionally qualified to work in the sector, and which is recognised by both the industry and their clients. In contrast, the governing body for the design industry is the Design Council; however, this is not seen by designers or the larger organisations that they produce work for as being regulatory or having any real control in implementing legislation. Similarly, The Charted Society of Designers, Royal Society of Arts and the Institute of Engineering Designers are less well recognised in the industry than RIBA, for example.

47. There is therefore a need for a more recognised regulatory body in the design industry, to ensure strategies such as eco-design are successfully implemented in businesses.

48. The Design Skills Advisory Panel document, *Higher Skills For Higher Value*, written by the Sector Skills Council, Creative and Cultural Skills and the Design Council highlights an urgent need for more continual professional development in the design industry with regard to sustainability in design. It proposes that this should be a priority for the National Design Academy proposal in its report; however, progress on this recommendation has yet to come into fruition.

Design Industry Needs

What are the gaps in knowledge and how are they being addressed?

49. There is a need to provide in-depth support in Resource Efficient Design throughout the design cycle, where actual environmentally-considered, commercial products are generated. In addition, resource efficient design must be mainstreamed into the various sectors of the design industry whilst providing a step change in skills and accelerated development of environmental products and services.

50. At present, design consultancies and manufacturers' in-house designers have little awareness of eco-design approaches. The current perception of most designers is that products and services can be designed from an environmental approach simply by using eco-preferable materials. There is very little understanding of what life-cycle design methodology entails, nor how to apply it.

51. SME Designers often state they have little time to research traditional academic sources on subjects such as eco-design strategies; instead they invariably prefer to adopt practical, "hands-on" approaches to design.

52. Designers learn from experience, and so often an effective way of learning new skills and applying new approaches to design is through establishing exploratory design projects that allow true innovation and creativity, and that are not bound by the needs and demands of a client. For example, Creative id*a ltd are in

[33] The Design Council, 2007. *Training and skills: The business of design*. http://www.design-council.org.uk/en/About-Design/Research/The-Business-of-Design2/Training-and-skills/

the process of generating a showcase sustainable point of sale stand, to develop their designers' understanding and capabilities in the field of eco-design and to demonstrate to their clients the opportunities of eco-innovation within a commercial environment.

53. With regard to environmentally-preferable materials for use within 3D design, designers for the most part know of few specific examples of such materials, and also have little understanding about what different factors make one material more environmentally-preferable than another. There is therefore a need for more communication between materials scientists, materials suppliers and designers, and collaboration on development "showcase" projects where new materials can be utilised.

Impact of legislation

54. Legislation such as WEEE and Packaging (Essential Requirements) Regulations rarely influence the design practice of designers in consultancies. The legislation is normally dealt with in a reactive way making it of limited use in influencing designers' mentalities to waste minimisation. An example of the types of barriers faced can be seen in the WEEE legislation. The WEEE Directive will cause an inherent cost to manufacturers but this will generally be accepted as an unavoidable, additional cost. It does not encourage designers to find alternative materials or design solutions.

55. Soft requirements that are often included in regulations, such as "…packaging shall be manufactured that the packaging volume and weight be limited . . ."[34] have limited effect on moving the industry.

56. In light of this difficulty, "The Government wants the European Commission to reform the Packaging (Essential Requirements) Regulations, saying criteria such as 'consumer acceptance' make the laws difficult to enforce . . ."[35]

57. Some retail design consultancies are trying to establish take-back systems but these need to be joined-up with the retailers and should ideally be driven by their customers.

The need for legislation

58. There are requests from certain sectors to legislate against specific materials and practices. For example, the retail design industry, a highly competitive, high turnover, highly wasteful sector sees legislation as the necessary driving force for their industry to change its current practice.

59. However, The RED Initiative has seen that there are opportunities for the industry to develop towards more sustainable solutions, in a more productive and rewarding way.

60. For example, Sheridan and Co—an established retail design consultancy—are producing a showcase, eco-design concept solution, to market the opportunities for resource efficient design. They are exploring alternative materials as well as innovation in the design. DIAM UK (part of a larger international organisation) has been trying to develop a system to return their display units for recycling and appropriate disposal.

61. When asking SMEs their opinions about the effectiveness of current and new legislation from an environmental improvement perspective, Paaru Chauhan-Pancholi from Briggs Hillier Design replied:—

> "There is a need for more legislation to force design groups and their clients to apply eco-design strategies, as the issues and need for sustainability, plus the methods and technologies to deal with the problems are already in existence. However, the Government needs to bear in mind the practicalities of implementing eco-design legislation in businesses, such as the cost implications, and availability and communications about eco-materials and systems in the supply chain".

62. Any new legislation should ensure that resource efficient design (eco-design) is a mainstream, normal, accepted principle in every day design practice, not just a specialist or retrospective application.

63. Existing legislation is of limited value. Encouraging solutions to definable problems does not stimulate the creativity that designers can bring in providing innovative, radical solutions. For example, defining a requirement for materials reduction does not encourage the use of alternative materials. Demanding use of biodegradable materials, for example, may restrict the development of a more durable, reusable solution.

64. Need to stimulate demand amongst consumers, demonstrate the opportunities to businesses, support SMEs, legislate where possible to abolish the worst and encourage development of eco-designed products.

[34] Packaging Essential Requirement Legislation.
[35] *Packaging News*, 1 September 2007, http://www.packagingnews.co.uk/news/736868/pack-minimisation-laws-reformed/

65. Legislation needs to include systems considerations, for example, the requirements on designers to improve recyclability must be met by improved recycling systems. A momentum is needed in the demonstration of functional and saleable materials' properties in order for them to be taken up by the design industry.

Conclusions

66. The ideal scenario is for eco-design to be incorporated as a natural part of the everyday design process. To designers, good design should mean that eco-design considerations are an integral factor.

67. Designers are not typically in control of what they design. Generally designers operate in very small businesses that sell skills to large corporations, who generally undervalue design.

68. The creative capability of the UK's design industry is not lacking, nor is its desire to reduce the environmental impact of product and retail design. As an industry dominated by small businesses, its ability to drive change in this area is limited as it relies heavily on clients for day to day turnover of business. Conversely, SME design consultancies have an invaluable capacity for innovation. Organisations that contract designers must recognise the value of design in order to produce design solutions that are exceptional in all aspects, including their environmental impact.

69. A level of momentum should be expected from the design industry as it must demonstrate the opportunities to clients. Some design consultancies are taking the lead and differentiating themselves. Some designers have remarked on the need for designers to be proactive in demonstrating the potential of eco-design.

70. "Try to promote the advantages of eco design to our clients and focus their minds on the advantages it can bring to their business."[36]

71. Design in the UK is at risk from the development of the cheaper overseas market.[37] Value added services are an opportunity for UK consultancies to maintain a cutting edge.

> "... Accepting that resource-efficient design or eco-design is becoming part of the design & manufacturing landscape, design consultancies have to be proactive and include it as part of their package of research, design & development services—not least because it is adding value to their own consultancy work as well as to that of their clients. Only a short-termist could argue otherwise."[38]

72. There is a need to enable SMEs to keep abreast of environmental requirements and industry trends. Larger organisations have the time to invest in developing their knowledge and strategies in this area. However the overwhelming trend to outsource design means that these skills are not developed within the design function of the product development process. Environmental considerations in relation to products or environments tend to stay within company policy and corporate and social responsibility (CSR) reports, rather than being implemented as the design function.[38]

73. It is important that the value of the SME design industry is recognised and supported in developing invaluable eco-design skills and knowledge.

October 2007

Memorandum by Vitsœ

A Philosophy for Production

Vitsœ was founded in 1959 to realise the furniture designs of Dieter Rams. The proposition was to create furniture that would last as long as possible. Accordingly, built-in obsolescence would be avoided by making the furniture discreet and adaptable while not pandering to fashion.

The intention was to encourage customers to start by buying less; to add to, rearrange and repair when needed so that a commitment would build between customer and company, to their mutual benefit.