Institution:
University of Cambridge

Unit of Assessment:
UoA15

Title of case study:
Granta Design – Eco Audit Technology

1. Summary of the impact (indicative maximum 100 words)

Research work in the University of Cambridge Department of Engineering (DoEng) created a formal methodology for eco-design, based on lifecycle thinking that can be implemented during product design. This methodology and supporting reference data have been commercialised by DoEng spin-off company, Granta Design Limited, within Granta's software solutions: for engineering and product design in industry, integrating with the CAD environment; and for materials education. These products are incorporated in software suites that have over 200,000 users. Industry case studies demonstrate their value to end customers.

2. Underpinning research (indicative maximum 500 words)

Research on materials selection in the DoEng started in 1986 under the leadership of Professors Mike Ashby (appointed as Professor of Materials in the DoEng in 1974, retired from the DoEng in 2001, but still employed as the Chairman of Granta Design Limited, undertaking research in the DoEng and designated Category C staff in both RAE2008 and REF2014) and David Cebon (appointed as a Lecturer in the DoEng in 1985 and promoted to Professor in 2006). Initially, the research focussed on methodologies for selecting materials to optimise conventional engineering performance in service, for example, a beam to support a specified load in bending at the lowest cost. Once this research was largely complete and technology transfer was underway, Ashby and Cebon turned their attention to methodologies for minimising the environmental impact of engineered products over their entire lifetime.

The DoEng "Cambridge Engineering Design Centre" EPSRC award fom 1993 helped support their research [a]. In 1996, Ashby outlined the research challenge, which was to find a suitable methodology, construct appropriate charts for presenting the results, and devise the necessary quantitative measures of environmental impact that would be compatible with measures of more conventional engineering performance [1]. Ashby then won a three-year EPSRC grant on the "Selection of structural materials for eco-sensitive design" in 1998 [b]. In this grant, Ashby developed the methodology, while Technical University of Delft, the University of Gothenberg and the Swiss Bundesamt fur Umvelt provided raw data, and Panasonic provided case studies. Details of these grants are given in section 3.

Ashby and Cebon's research from 1993 to 2001 made four important breakthroughs:

(i) Ashby built a principled and generalised understanding of the limits of shape efficiency based on both empirical and theoretical analyses [2] e.g. which shape of cross-section of a beam can support a given load using lowest mass of material given the constraints of the material and processing on the thickness of its elements. This research step was essential for this case study because minimising the mass of material used in an application by selecting the best shape is a foundation of optimising environment impact.

(ii) There are many different types of environmental impact. This creates multiple objectives. Ashby researched the problem of multi-objective optimisation in material design and selection, both theoretically and through worked examples, to create a method using trade-off plots that guides designers through a rigorous selection process [3].

(iii) Ashby created a systematic methodology and associated extensive database for selecting materials and processes during engineering design, so as to minimise lifecycle environmental impact [4, 5], drawing on the work described above. Database development involved collection of data from a wide range of data sources for approximately 3000 materials and 200 manufacturing processes, normalization, statistical analysis, modelling to fill gaps, and independent validation.

(iv) Ashby also devised a method for assessing the lifecycle impact of products using information available during the design phase along with an enhanced database of reference information [4, 5]. This method guides designers as to where it is most productive to focus their design-for-environment efforts. Derivation of the method involved model development, model testing, validation against existing models where possible, and trials by independent experts.

The research findings were consolidated into a formal process for eco-design and published as a

book by Ashby in 2009 [6].

3. References to the research (indicative maximum of six references)

1. *Ashby, M.F., Burgess, S.C., Shibaike, N. and Weaver, P.M., 'Selection of Materials to Reduce Environmental Impact', Materials and Design, Vol. 17, No. 1, pp. 11-17, DOI: 10.1016/0261-3069(96)00024-6, (1996).
2. *Weaver, P.M. and Ashby, M.F., 'Material Limits for Shape Efficiency', Progress in Materials Science, Vol. 41, pp. 61-128, DOI: 10.1016/S0079-6425(97)00034-0, (1997).
3. *Ashby, M.F., 'Multi-objective Optimization in Material Design and Selection', Acta Mat. Millennium Issue, 48, pp 359 – 369, DOI: 10.1016/S1359-6454(99)00304-3, (2000).
4. Wegst, U.G.K and Ashby, M.F., 'Eco-criteria for Materials Selection', Engineering Designer, Vol. 24, No. 2, pp. 8-12, (1998).
5. Wegst, U.G.K. and Ashby, M.F., 'Materials Selection and Design of Products with Low Environmental Impact', *Advanced Engineering Materials,* Vol. 4 , No. 6, pp. 378-383, DOI: 10.1002/1527-2648(20020605)4:6<378::AID-ADEM378>3.0.CO;2-#, (2002)
6. Ashby, M.F., 'Materials and the Environment: Eco-informed Material Choice', Butterworth-Heinemann, 2009, 400pp, second edition 2013, 611pp (ISBN 978-0-12-385971-6).

*Research outputs that best represent the quality of the research.

Research grants:

- EPSRC "Cambridge Engineering Design Centre" (GR/J08515/01, 1 July 1993 to 31 December 1994; GR/K47368/01, 1 January 1995 to 30 September 1997 and GR/M23236/01, 1 October 1997 to 30 September 2001) – Professor Ken Wallace of the DoEng was the original Principal Investigator in the DoEng with Professor John Clarkson of the DoEng taking this role for the subsequent awards. Ashby was a Co-Investigator on all three. The funding of GBP6.5M grant was used on subprojects led by specialist academic investigators including Ashby and Cebon.
- EPSRC "Selection of Structural Materials for Eco-Sensitive Design" (GR/L74859/01, 1 April 1998 to 31 July 2001, GBP180K). Ashby was the Principal Investigator.

The quality of the research is indicated by it being a significant factor in the award of the Morris Cohen Award of the TMS (the US Minerals, Metals and Materials Society) to Ashby in 2011.

4. Details of the impact (indicative maximum 750 words)

Granta Design Limited was founded in 1994 to commercialise the results from Ashby and Cebon's research collaboration in the DoEng by producing software for industry. Granta remains an independent, private company owned by its founders, employees, the University of Cambridge and ASM International. Ashby is the Chairman and Cebon is the Managing Director. The company is now the World's largest firm specialising in materials information software, with 110 staff in Cambridge, Germany, and the USA. Granta has grown organically by approximately 30% per annum since 2008 [7].

As part of the original intellectual property (IP) assignment by the University in 1994 (in exchange for the University's shareholding), all relevant IP created by Ashby and Cebon in their University employment has been channelled into Granta since its foundation. This has resulted in a stream of products for the company. In this case study, the focus is on Ashby and Cebon's research results on eco-design, transferred to Granta in 2001. Granta first used this IP to create a data product for eco-design in 2004 and has developed a number of products based on the original IP:

1. MaterialUniverse Eco Data (launched 2004, originally as 'Eco Selector') provides life cycle data for raw materials, their processing/forming, their use and disposal/reuse including energy consumption, CO2 emissions, water use, toxicity, compliance with regulations, biodegradability, and other parameters required to analyse eco performance over the lifecycle [8]. This data product was first released within CES EduPack, Granta's teaching product [9], subsequently for industry in the CES Selector and GRANTA MI systems. While launched prior to 2008, it has been developed continuously by Granta since, and underpins sales and use of all eco-design products from 2008 onwards.
2. Eco Audit Tool (launched 2007) is used during the design process, drawing on MaterialUniverse Eco Data to estimate product life cycle impact. It quantifies the most important environmental impacts and guides designers in their selection of material and process technologies to minimize these impacts. It was first released with CES EduPack and subsequently as an add-on to the CES Selector software for industry [10]. Nearly all of its sales and use have been in 2008 and onwards.

3. Eco Materials Advisor (launched in 2011) is incorporated directly in Autodesk Inventor, a digital design and prototyping application supplied by leading CAD software company, Autodesk. It provides access to a cloud-hosted version of the MaterialUniverse Eco Data from within Autodesk Inventor. Any user can apply this data to their CAD model and then use Eco Audit technology to compute the eco impact of their design [11].
4. MI:Eco Audit (EMIT Member Version, launched 2012) enables users at organizations with the GRANTA MI software to access MaterialUniverse Eco Data within their enterprise materials information management system, together with in-house materials data, and to apply Eco Audit calculations using that data. The first version is available to members of the Environmental Materials Information Technology (EMIT) Consortium, a collaborative project co-ordinated by Granta. The members of the Consortium include: Boeing, EADS Astrium Satellites, Emerson Electric, Eurocopter, Honeywell, Lockheed Martin, NASA, NPL, Rolls-Royce, Thales, United Technologies Corporation, and US Army Research Labs [12].

Granta invested GBP0.5M in developing the MaterialUniverse Eco Data prior to 2008. GBP1M was invested in the Eco Audit Tool (which includes Granta capital, EC FP7 and TSB funds) prior to 2008. GBP1.3M was invested in Eco Materials Advisor CAD integration (Granta capital, contributions from strategic partner Autodesk and from EC Framework Pro in some supporting functions) after 2008. The MaterialUniverse Eco Data and Eco Audit Tool are an optional part of the GRANTA MI and CES Selector systems. For organizations licensing these options, they are a key component of the business case when adopting and using Granta software. These organizations licensed software generating over GBP2M of revenue for Granta in financial year 2012.

Use of these technologies, based on data provided by Granta in May 2013, is as follows:

- 120 companies worldwide hold licenses for MaterialUniverse Eco Data and Eco Audit Tool within the CES Selector software
- Eco Materials Adviser is available to 200,000 individual users of Autodesk Inventor
- MI:Eco Audit (EMIT Member Version) is licensed as an enterprise application to 6 corporate members of the EMIT Consortium
- 570 universities and colleges worldwide hold licenses for MaterialUniverse Eco Data and Eco Audit Tool for teaching or research.

Commenting on the relationship between Autodesk and Granta Design, the Senior Vice President, Manufacturing Industry Group at Autodesk said in 2011: *"Autodesk is committed to providing the best 3D design and engineering software to address the world's environmental challenges, making sustainable design easy and accessible for manufacturers and designers. Through the Eco Materials Adviser and our partnership with Granta, we are helping make environmentally preferred material selections a reality for enterprises of all sizes."* [13]

The Editor of CAD magazine, 'Develop 3D', said in an editorial in 2011: *"Autodesk and Granta Design have done an excellent job with the first release of Eco Materials Adviser. It's not a mainstream type of tool as yet, the rise of this type of design-system integrated tool has yet to happen. That said, economic, business and legislative pressures relating to sustainability and compliance are only going to increase, all across the globe. As a result, being able to load up a digital product model, even in its nascent form, and gaining insight into the environmental impacts of that product is going to become more and more critical for the design and engineering community. As we move towards an era in which design and engineering is not only about function, form and cost, but also environmental impact, having this type of capability built into your workhorse design tool will soon turn from a 'nice to have' to an 'absolutely essential.'"* [14]

Examples of end users gaining benefit from the use of the tools in the REF period include:

- **Eco3 Design Consultancy** published information about its use of the Eco Audit Tool in April 2012, which it had used to advise Zodian on how to improve the environmental impact of its lighting control product by the: inclusion of recycled materials, reduction of materials used and use of alternative electronics. The analysis suggested that these design changes would lead to CO2e (carbon dioxide equivalent) savings of over 9kg per unit over each unit's life. Zodian produces 125,000 units per year, so the annual emission saving is well over 1,000 tonnes of CO2e. The reduction in energy consumption of the products to which this lighting control unit is attached has been calculated at 2,053MWh over the 125,000 units and their 15 year life cycle. This would equate to overall cost savings for the user of the product of over GBP200,000. [15].
- A global design consultancy applied the Eco Audit Tool, in combination with CES Selector

materials selection, to support re-design of a train seat for their client, one of the World's leading engineering companies. The work took place over a period of 6 weeks and was completed in early 2013. Through light-weighting and selection of low embodied energy materials a lifecycle reduction in energy and CO2 emissions of 35% was achieved. One of the designers in the Munich office said: *"I think Granta is a great tool for supporting designers' thoughts on using the right materials and guiding the design direction".* According to a member of the design team in Los Angeles: *"Granta (EcoAudit) gives a designer confidence to pursue a new concept rather than guessing up front if it even would make sense from manufacture materials perspective. The design can be tuned and optimized by plugging in multiple materials and processes...and CAD can be plugged in to compare pros and cons"* [7].

Teaching staff from institutions around the world have downloaded and used the teaching resources relating to Eco Audit from the Granta Design web. During just the 3 months to 1 June 2013, there were 239 unique downloads of such teaching resources. There is a considerable body of evidence illustrating effectiveness of Granta's Eco-Design system in teaching and its uptake. For instance, the Associate Professor in the Mechanical Engineering program at the University of North Florida stated in 2013, *"For the vast majority of engineering programs in the U.S., ABET accreditation remains the standard of validation of their degree offerings…CES EduPack has been incorporated into existing courses in the mechanical engineering curriculum at the University of North Florida…Direct assessment of the presentation of methodology and demonstration of attention to eco factors, [using EcoAudit] permits a direct assessment tool for many of the 'h' through 'k' outcomes* [that are defined by ABET]." [16]

5. Sources to corroborate the impact (indicative maximum of 10 references)

7. Head of Marketing, Granta Design
8. MaterialUniverse Eco Data page on the Granta Design website, http://www.grantadesign.com/products/data/ecoselectorprops.htm
9. CES EduPack page on the Granta Design website, http://www.grantadesign.com/education/
10. Eco Audit Tool page on the Granta Design website, http://www.grantadesign.com/products/ecoaudit/
11. Eco Materials Adviser page on the Granta Design website, http://inventor.grantadesign.com
12. Granta MI:Eco Audit (EMIT Member version) page on the Granta website, http://www.grantadesign.com/products/mi/eco.htm
13. "Granta Featured in Autodesk Inventor Software's New Sustainable Design Solution", press release on the Granta website, 25 March 2011, http://www.grantadesign.com/news/news/2011/ema-mar2011.shtml
14. "Eco Materials Adviser", article in Develop3D, 4 April 2011 http://www.develop3d.com/sustainability/eco-materials-adviser
15. "Adapting to a modern design challenge", article on the Design, Products & Applications website, 2 April 2012, http://www.dpaonthenet.net/article/51322/Adapting-to-a-modern-design-challenge.aspx
16. "Supporting accreditation criteria for engineering programs", by the Associate Professor in the Mechanical Engineering program at the University of North Florida, on the Granta website, http://www.grantadesign.com/education/events/2013/us.htm