An effective design system lies at the heart of all successful enterprises. Design processes shape not only products and services, but also businesses, educational institutions and entire societies.
Good design is fundamental to product success and improvements in people and processes are just as vital for the health of a business as developments in technology.

The Cambridge Engineering Design Centre delivers practical tools and methods to industry, based on rigorous research and a deep understanding of engineering design.

*Geoff Kirk, former Chief Design Engineer, Rolls-Royce, 2016*
For more than twenty-five years the Cambridge Engineering Design Centre has undertaken fundamental and applied research to generate knowledge that improves the design process.

This book provides an introduction to the diversity of people, activities and collaborators that have contributed so effectively to this endeavour.

John Clarkson, 2016
Cambridge Engineering Design Centre

A simple history
The University of Cambridge is one of the world’s oldest universities and leading academic centres, founded in 1209 when scholars taking refuge from hostile towns- men in Oxford migrated to Cambridge.
Addressing the world’s most pressing problems

- 1209 University of Cambridge
- 1440 Gutenberg printing press
- 1642 Pascal mechanical calculator
- 1875 Department of Engineering
- 1937 Frank Whittle jet engine
- 1991 Engineering Design Centre
- 2009 University celebrates 800 years
The Department of Engineering is the largest department in the University, housing nearly 200 faculty, 300 contract research staff, 900 research students and 1200 undergraduates of all disciplines.
The Engineering Design Centre (EDC) was founded in 1991 by Professors Wallace, Ashby and Newland to undertake research to create understanding, methods and tools that would improve the design process.
Improving the Design Process

- 1991  Engineering Design Centre
- 1993  Housed in lower drawing office
- 1998  University Technology Partnership
- 2001  Integrated Manufacturing Research Centre
- 2006  Relocation to EDC Loft
- 2011  Opening of Ashby Laboratory
- 2016  EDC celebrates 25 years

25+
Engineering Design Centre

**Academic Staff (discipline)**

Professor John Clarkson (systems)
Mr Aylmer Johnson (mechanisms)
Dr Geoff Parks (nuclear)
Dr James Moultrie (manufacturing)
Dr Digby Symons (mechanics)
Dr Jerome Jarrett (aerospace)
Dr Nathan Crilly (product)
Dr Per Ola Kristensson (interaction)
Professor Steve Evans (sustainability)
Professor Emeritus Ken Wallace (mechanics)
Professor Emeritus Michael Ashby (materials)
Professor Emeritus David Newland (mechanics)
Cambridge Engineering Design Centre

The design process
**Dictionary Definitions**

**design, n.** The art of drawing or sketching; the process, practice, or art of devising, planning, or constructing something according to aesthetic or functional criteria.

*Oxford English Dictionary*
process, n. A continuous and regular action or succession of actions occurring or performed in a definite manner, and having a particular result or outcome, a sustained operation or series of operations.

*Oxford English Dictionary*
The Design Squiggle
The process of design from a great height. My father told me that the design process started with the abstract, moved to the concept and then finally the design.

_Damian Newman, Central Office of Design_
The Double Diamond

Discover Define Develop Deliver
Every design specialism has a different approach and ways of working, but there are some commonalities ...

... a number of possible ideas are created before narrowing down to the best idea.

*The Design Council*
The Design Spiral
At each spoke in the spiral, a little bit of information is created, details drawn, engineering calculations done. Work proceeds around the design spiral until the design is finished.

*Eric W. Sponberg, Naval Architect*
The Design Cycle

- ACCEPT
- ANALYSIS
- DESIGN
- TEST DESIGN
- TEST
- BUILD
- REWORK

Flow:
- ACCEPT to ANALYSIS
- ANALYSIS to DESIGN
- DESIGN to TEST DESIGN
- TEST DESIGN to TEST
- TEST to BUILD
- BUILD to REWORK
- REWORK to ACCEPT
Engineering design is the systematic, intelligent generation and evaluation of specifications for artefacts whose form and functions achieve stated objectives and satisfy specified constraints.

Clive Dym, Harvey Mudd College
Cambridge Engineering Design Centre

Research groups
The Knowledge Management Group researches the role of engineering knowledge, and in particular design rationale, within ever-changing organisations:

- by embedding methods for the capture of design rationale into design practice;
- by developing appropriate techniques for the long-term storage of design rationale;
- by understanding how the timely retrieval of design rationale impacts design practice.
The Computational Design Group researches the potential of computational synthesis, search, optimisation and analysis tools to support design:

- by applying simulated annealing and genetic algorithms to difficult real-world problems;
- by developing multi-objective optimisation methods to support engineering design;
- by investigating the analysis and design of nuclear reactor systems.
The Process Management Group researches the role and nature of process modelling in the successful delivery of new products and services:

- by generating a greater understanding of the nature and demands of complex system design;
- by challenging current planning practice and risk management in complex system design;
- by developing novel and useful design process improvement tools.
The Healthcare Design Group researches the role of systems thinking in the UK Health Service as a means to deliver safe, effective and affordable care:

• by developing new models of innovation practice for healthcare practitioners and providers;

• by delivering a framework and tools for safety management into the UK Health Service;

• by establishing a centre for quality and safety research in the UK.
The Inclusive Design Group researches the interplay between the demands products make of their users and the diverse range of capabilities of those users:

- by understanding the impact of user diversity in product and service interaction;
- by developing models of good design practice for design and retail professionals;
- by embedding good design practice in the design and retail community.
The Change Management Group researches the impact of change propagation in complex systems made up of components, activities or people:

- by generating a better understanding of the nature of change in complex systems;
- by challenging current management of change practice in product and service design;
- by developing novel and useful design change management tools.
The Design Practice Group researches the relationships between designers, artefacts and users by studying practices that impact on

- the specification of artefacts by designers and how designers consider users in that process,
- the interaction between users and artefacts, and how users consider designers during those interactions, and
- the communication between designers and users, and how artefacts mediate those communications.
The Design Management Group researches the role of understanding and improving the ways in which design and new product development are managed:

- in creating sustainable, desirable, usable and producible new products and services;
- in acting as an integrator between technology and users;
- in promoting the importance of design at firm and national levels.
The Intelligent Interactive Systems Group researches the role of design in the delivery of interactive systems that amplify people’s ability:

- by extending our current understanding of human-computer interaction;
- by understanding the importance of accessibility, inclusive design and augmentation;
- by utilising machine learning, signal processing and human-computation to infer people’s actions.
The Aeronautical Design Group researches the role of computational models in the delivery of highly interactive technical systems:

- by developing high performance design optimisation approaches;
- by studying the use of robust computational design in aerospace systems;
- by investigating the aerodynamic design of shock control bumps for swept transonic flows.
The Industrial Sustainability Group researches how industry develops solutions that move us towards a sustainable future:

- by understanding methods to rapidly scale resource efficiency;
- by developing effective business model design tools;
- by challenging current trajectories and preparing for a restorative industrial future.
The Automotive Design Group researches the role of interaction design in the delivery of increasingly sophisticated vehicles:

- by modelling driver behaviour to assist the design of inclusive, user-centred interfaces;
- by reducing the impact of vibration on the use of interactive display devices;
- by investigating the challenge of changing demands on driver attention.
The Product Design Group researches the application of engineering science to challenging mechanical design problems:

- by developing relevant analytical numerical models to provide fundamental insights;
- by translating engineering insights into practical design guidelines;
- by developing optimal designs for the health, process and sports industries.
Capture, storage and retrieval of Engineering knowledge
We used DRed in the first weeks of the Qantas Flight 32 investigation to explore possible failure scenarios and to formally capture evidence from hardware and data analysis.

*Chief Engineer, Rolls-Royce Civil Aerospace, 2013*
Integrated optimisation methods and tools
Most large, real-world design problems are inherently multidisciplinary and multi-objective. Therefore, it is valuable to address multi-objective problems from a multidisciplinary perspective.

*Geoff Parks, 2015*
Improving design process performance
As a research student I met some inspirational people that combined a questioning mind with a healthy sense of pragmatism that I believe marks the EDC out from other design schools.

*Jamie Hamilton, Monitor Group, 2012*
Design for quality and safety

Healthcare Design Toolkit
The EDC’s innovative and proactive approach provided a clear framework to look at the complexity of managing medical records and has been widely welcomed at the hospital.

*Glenn Pascoe, Cambridge University Hospitals, 2010*
Countering design exclusion
Oval commissioned the EDC to undertake a User Study to validate its autoinjector designs, enabling them Oval to better understand the requirements and limitations of future products.

Mathew Young, Oval Medical Technologies Ltd., 2010
Modelling change in products
Laing O’Rourke are investing in new technologies and design methods. This creates a strong need for better ways of managing the dependencies between products and delivery processes.

*Adam Locke, Laing O’Rourke, 2014*
Relating designers, artefacts and users
Research conducted on the way in which people respond to product design featured throughout an *amici curiae* brief for the United States Court of Appeals case of Apple versus Samsung Electronics.

*United States District Court, Case No. 11-CV-1846, 2014*
Managing design to create better products
A design audit tool that assesses the maturity of 25 key design activities, covering design execution and design management, has been created based on insights from literature and real cases.

James Moultrie, 2004
Designing, building and studying interactive systems
This is one of the best examples I have seen that demonstrates how design, science, engineering, and empirical studies can work together on both the machine and human sides of the equation.

*Bill Buxton, Microsoft Research, 2014*
Faster, cleaner safer flight
The design of complex systems demands a balance between the selection of an optimal configuration and the refinement of the detail. Careful management of this process can greatly reduce design time.

*Jerome Jarrett, 2012*
Creating a sustainable future
The Cambridge Value Mapping Tool adopts a multi-stakeholder perspective to systematically analyse various forms of value in a business and its network to stimulate innovation for value creation.

*Steve Evans, 2016*
Driving new vehicle designs
Cars that can drive themselves will soon be on public roads. It is imperative to understand how drivers will react to this new technology and how best to design the driver-automation interaction.

*Patrick Langdon and Mike Bradley, 2016*
Innovative mechanical design
Questioning tradition in design of systems, both at a hardware and at a process level, has lead to significant performance gain for our track team. I bless the day I walked into the Engineering Department.

Tony Purnell, British Cycling, 2016
Cambridge Engineering Design Centre
Members and supporters
People

People

Industry Collaborators

Academic Collaborators

Belarusian State University  Bond University  Brunel University London  Cardiff University  Chalmers Tekniska Högskola  Cranfield University  Danmarks Tekniske Universitet  Durham University  École Polytechnique de Montréal  Griffith University  Heriot-Watt University  Imperial College London  King’s College London  Kungliga Tekniska Högskolan  Lancaster University  Loughborough University  Luleå University of Technology  Massachusetts Institute of Technology  Monash University  Newcastle University  Otto-von-Guericke Universität Magdeburg  Queen's University Belfast  Royal College of Art  Sheffield Hallam University  Stanford University  Sveučilište u Zagrebu  Technische Universität Berlin  Technische Universität Darmstadt  Technische Universiteit Delft  Technische Universität München  Tel Aviv University  The Open University  Texas Christian University  Università degli Studi di Padova  Universität der Bundeswehr München  Universität Karlsruhe  Universität Paderborn  University College London  University of Auckland  University of Bath  University of Birmingham  University of Bristol  University of Cagliari  University of Dundee  University of East Anglia  University of Edinburgh  University of Glasgow  University of Hertfordshire  University of Huddersfield  University of Leeds  University of Leicester  University of Liverpool  University of Manchester  University of Nottingham  University of Oxford  University of Queensland  University of Reading  University of Salford  University of St Andrews  University of Sheffield  University of Southampton  University of Strathclyde  University of Surrey  University of Sydney  University of the Arts London  University of Tokyo  University of Ulster  University of York  Worcester Polytechnic Institute
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15 https://revisionlab.wordpress.com/that-squiggle-of-the-design-process/
16 The Design Council
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61 Conversation with Mathew Young, Oval Medical Technologies Ltd, 2010
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64 http://www.slideshare.net/ajovalasit/nathan-crilly-hcdi-talk-when-users-thing-about-design
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