SYSTEMS CENTRE

Leading in the application of Systems Thinking
to create value within socio-technical complexity

Report 2010

University of BRISTOL

Foreword

Contents

Acknowledgements

Report compiled by
Oksana Kasyutich
Sophie Causon-Wood
Peter Ereaut

Design by Warren Mitchell
www.wmdesign.biz

Print by
www.portisheadpress.co.uk

It is my pleasure to present the Systems Centre Report 2010.

The Industrial Doctorate Centre in Systems, established in 2009 from its pre-cursor EngD in Systems Centre, a part of the Systems Centre, is a continuing success story and this year reached a 'critical mass' of 60 Research Engineers (RE) in Systems from 35 companies with more than 30 academic staff involved; and supported by an EPSRC and industry funding to 2017 at least.

Over the past year we have been:

- consolidating on our strengths
- developing understanding of what Systems Thinking means
- developing a strategic vision for research in Systems with our stakeholders
- expanding our collaborative relationships with Systems communities within the UK and internationally.

We are leading in the application of Systems Thinking to create value within socio-technical complexity!

"Creating systems for enhanced performance" is about getting the parts to work together so that better outcomes emerge from the whole. This is equally true for our EngD and MRes. The taught components, the research, consultancy work and networking integrate to create synergy, which is why we believe that learning together is a critical element of the journey we are on.

Our success would not be possible without the commitment and support of the Centre's full time staff, the Management Committee and Strategic Advisory Board, and our Visiting Professors and Fellows who contribute greatly to teaching and training across undergraduate (Sustainable Systems) and postgraduate (Engineering Doctorate and Masters) programmes in Systems. We thank all the people and organisations that are supporting the Centre. Our industrial partners in particular contribute strongly to the strategic development of the Centre as well as collaborating in our research and teaching.

Professor Patrick Godfrey
Systems Centre and EngD Systems Programme Director.

The Systems Approach

Systems Engineering and related interdisciplinary engineering technologies are now recognised as essential for underpinning future societal development, economic growth and sustainability.

The Systems Centre is a centre of excellence in Engineering Systems research and teaching: a widely recognised focal point for fruitful collaboration between academia and industry in the UK, and a portal to Systems activity internationally. Through innovative teaching, training and fostering of leaders in industry, the Centre has become recognised by both large multinational corporations and SMEs for its 'value added'. The study of, and research into Systems, is now a key focus for the University's Engineering Faculty.

In 2008 the University celebrated huge success with the award of four EPSRC Centres for Doctoral Training, adding to the already established Doctoral Training Centre in Complexity. Each of these Centres provides innovative multidisciplinary teaching and training of Doctoral students. Three of these Centres, which includes the Industrial Doctorate Centre (IDC) in Systems, are in the Faculty of Engineering.

The IDC in Systems, particularly, provides a unique research and training environment designed using Systems Engineering principles to develop tomorrow's leaders in the heart of the UK industry, and delivers industrially relevant research and commercially successful innovation.

Prof Alan Champneys
Head of Queens School
Faculty of Engineering

Highly complex capability engineering challenges are found everywhere in the modern world: energy, air and rail transport, large complex IT networks, the built environment, medicine and health care, defence and security. A Systems approach is essential to create and sustain the solutions that the UK will need in the twenty-first century.

Designing systems that can cope with risk and uncertainty is a core research and teaching activity, both of which the Systems Centre is renowned for. Through problem-focused industry-based research, the Centre has become a leader in the application of Systems Thinking to engineering problems across a broad range of topics in defence and airspace, safety and risk, security, sustainable built environments, product and process development, organisational change and decision-making.

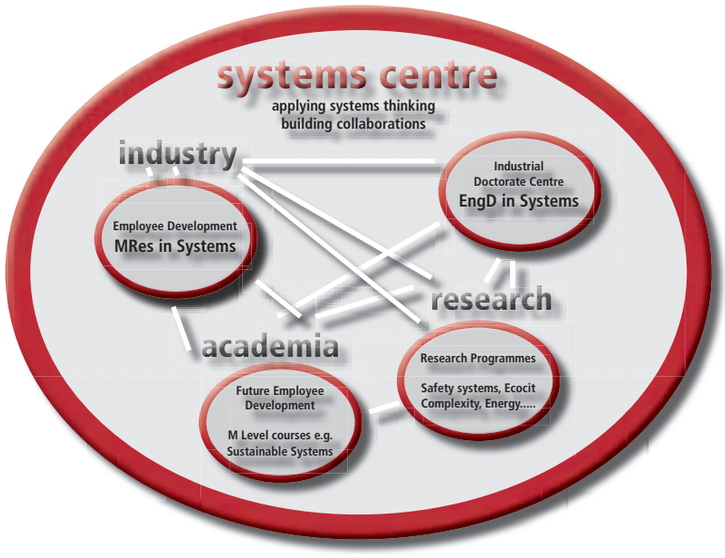
It is a common understanding now that the next generation of leaders and engineers - practitioners in both Civil and Defence industries – are, and more increasingly will be, presented with at least four next great Systems Thinking challenges: coping with complexity producing sustainable solutions; making engineering more agile and responsive and working with many disciplines, not just other engineers, in a multidisciplinary environment. Overcoming all of these will require innovation in research and the development of new Systems Engineering and Systems Thinking practices.

The Systems Centre is pioneering this approach in the UK.

Prof David Oxenham
DSTL Chief Systems Engineer
Visiting Professor in Systems, University of Bristol
Chair, Systems Centre Strategic Advisory Board

Introduction

The Systems Centre was launched in November 2009. The launch was a statement of the Centre's success in its collaborative and multidisciplinary approach to teaching and research. Our bespoke postgraduate research EngD in Systems programme, initially designed and delivered through the EngD in Systems Centre (between 2006-2009) became highly credible to UK Industry. This led to continued support from EPSRC and our 30 industrial partners and the award of the Industrial Doctorate Centre (IDC) in Systems lasting through to 2017.



The Centre key activities are:

- Working with industry to enhance performance. The Centre works with industry to create competitive advantage, collaborate on leading-edge research, deliver innovative solutions, and motivate and develop future leaders. Our world-class expertise and state-of-the-art facilities bring Systems Thinking into the heart of our partner organisations.

- Training future leaders of industry. The Centre hosts an EPSRC sponsored Industrial Doctorate Centre (IDC) in Systems joint with the University of Bath. We invite applications from high-calibre graduates in engineering or closely related disciples to join our EngD programme working with industry on industry-led research projects. We also offer a 2-year Masters in Systems aimed principally at graduates already employed in business and industry.

- Developing Systems Thinking through research. The Centre coordinates the University's research in Systems, involving a wide range of subject areas and industry sectors. Our position at the leading edge of Systems Thinking in the UK provides a repository of expertise for industry and training through our MRes and EngD programmes. We maintain an international presence through industrial and research conferences, publications, workshops and our seminar programme.

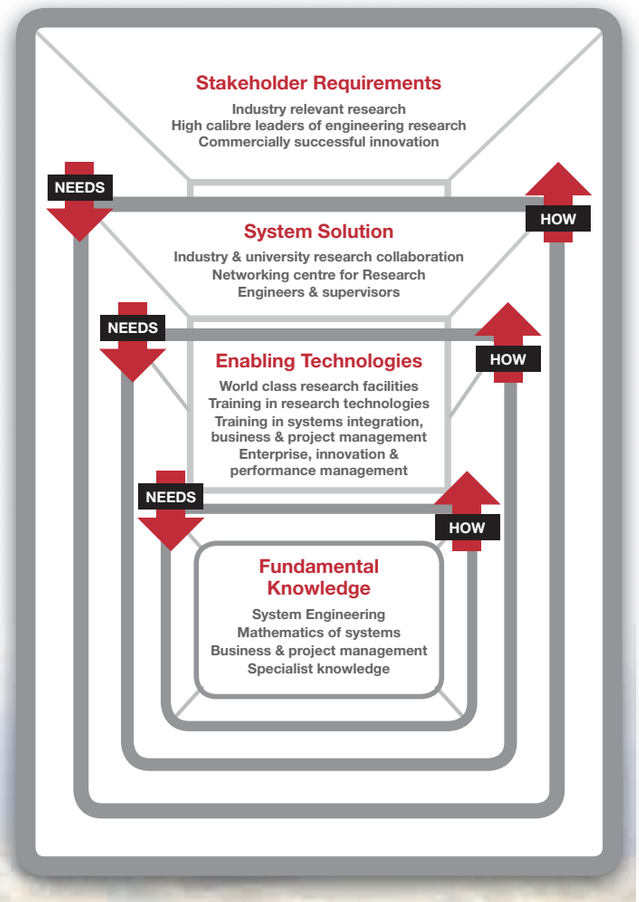
- Working with academics to develop industrial collaborations. The Centre offers support to academics to build relationships with industry for knowledge exchange, technology transfer, exploration of novel ideas and industrial sponsorship.

Bristol Systems Generic Model

A Systems approach can provide a vital competitive edge in developing new products and services and in creating flexible, responsive and efficient organisations. The Systems Centre undertakes fundamental and applied research with companies from a range of different industry sectors.

Systems Thinking can be applied to any organisation or any project, regardless of size, and companies in almost any sector can benefit from adopting a Systems approach to their operations.

Using Systems methods, underpinned by research expertise, allows organisations to maximise the value of people and technology, functions and performance. New techniques in Systems Engineering, and the ability to integrate both 'hard' and 'soft' aspects of Systems, are providing exciting opportunities for innovation. The Systems Centre currently collaborates on more than 60 projects with more than 37 companies, teaching and developing approaches that address the requirement for design and enhanced performance of Systems.



Systems Centre and Industrial Doctorate Centre in Systems Staff

Prof Patrick Godfrey

Systems centre & EngD in Systems Programme Director (Bristol)
Unit Director: Integration and Engineering Management Systems

Research: Systems Thinking applied to complex engineering topics such as: infrastructure design, operations and management; uncertainty, risk, value and safety management; systems for the built environment and sustainability.

Prof John Davis

Deputy Systems Centre Director (Bristol)

Research: Theory of socio-technical interactions; civil engineering systems, coastal engineering, field monitoring, fluid mechanics.

Prof Andrew Graves

EngD in Systems Programme Director (Bath)

Research: Manufacturing & engineering in the aerospace, automotive and construction industries.

Prof Patrick Keogh

Deputy IDC in Systems Director (Bath)

Research: Machine systems, mechatronics

Dr Mike Yearworth

Units Director: RM1&2, Advanced Systems

Research: Development and application of systems based methodologies for working with complex socio-technical problems.

Dr Theo Tryfonas

Unit Director: Introduction to Systems

Research: Systems Engineering and Information assurance within transportation, utilities, healthcare and government; Systems for maritime safety and port security, public transport security, protection of UAVs, telecom revenue and system assurance, computer crimes research.

Dr Steve Cayzer

Course Tutor for MSc in Innovation and Technology Management, University of Bath

Research: Information management, artificial intelligence and sustainability

University of BRISTOL

UNIVERSITY OF BATH

Dr David Barton

Unit Director: Maths for Systems

Research: Mathematical engineering related modelling; nonlinear systems and their dynamics; numerical methods for dynamical system; stochastic (noisy) systems.

Dr Oksana Kasyutich

Systems Centre Manager
& Deputy Programme Director
(Bristol)

Key responsibilities: Strategic development; all operations (academic and administration); best practice, duty of care to REs, continuous improvement.
Research: Systemic approach to integration of new materials in modern technologies.

Dr Ges Rosenberg

Systems Research
Development Manager

Key responsibilities: Systems research agenda development; Industry engagement
Research: Systems practice in engineering.

Dr Peter Ereaut

Systems Centre
Business Manager

Key responsibilities: Collaboration agreements; business analysis and reporting.

Ms Sarah Tauwhare

IDC in Systems Coordinator

Key responsibilities: First point of contact for all EngD Systems enquiries; EngD programme administration and REs records

Mrs. Suzanne Swallow

EngD in Systems Programme
Administrator (Bath)

Key responsibilities: first point of contact for all EngD in Systems queries at the University of Bath; students records, progress monitoring.

Ms. Sophie Causon-Wood

Systems Centre Administrator

Key responsibilities: Marketing and engagement; events coordinator, technical support; databases and e-learning.

Fundamental and Applied Research in Systems

Systems Practice in Engineering

Dr Mike Yearworth, Dr Ges Rosenberg

The purpose of this project is to research what we collectively know about systems practice in engineering and make a theoretical contribution to the field of Systems Thinking.

Most of the Systems research for industry conducted by Research Engineers (REs) on the EngD programme has been generally application - or - domain - specific, and the REs learn about Systems Thinking largely by doing. The IDC in Systems portfolio of projects involves more than 60 REs in 30 plus companies and spans application domains of sustainability, process improvement and decision support, safety, and new product development. All of the projects deal with problems of socio-technical complexity and use a systemic process of enquiry. The pedagogy of Systems Thinking emerges from the process of learning together; it is enquiry driven. Pedagogic development is itself needs driven, based on feedback from REs and industrial partner organisations. However, generic systems knowledge coming out of the EngD projects currently tends to get diffused into the application domains; we do not at this stage have a coherent and well-theorised description of the higher-level systems learning that we have achieved through this programme. Therefore, we are conducting a rigorous programme of research using the EngD projects themselves as the data source in order to discover the generic issues that are inhibiting the wider uptake of Systems Thinking processes in industry. Data collection will be across the entire RE population, industrial and academic supervisors. The project will investigate both methodological developments to improve Systems practices in engineering, as well as developments to Systems pedagogy. It will seek to abstract that body of Systems knowledge that is independent of the application domains, and which therefore has the potential for much higher leverage through widespread application.

Systems Research in the Defence & Security sector, Safety-critical Systems and Risk

Prof David Blockley, Dr Theo Tryfonas, Dr John May, Dr Jitendra Agarwal, Dr Mike Yearworth, Prof John Davis, Prof Derek Hitchins, Prof Hillary Sillitto, Prof David Oxenham, Prof Patrick Godfrey

Recent engineering failures and our inability to respond effectively to major natural disasters have highlighted the importance of Safety Systems, the right culture towards natural hazards and accidental risk, the deployment and use of appropriate early warning and mitigation technologies and the associated learning from incidents. Emerging unintended consequences in engineering systems go usually undetected until a stage where response is effective to a lesser extent, than could have been, had a deep understanding of risk and its associated issues existed in the first place.

Besides, over the last decade global security and defence requirements have evolved in nature and have become more complex and challenging in both analysing the sources of threat and in delivering systems that can mitigate the risks those represent. Organised crime, global networks of terrorism, insurgency, piracy and foreign states alike are likely to make increasing use of technologies widely available to promote their interests, protect their assets and operatives and cause deliberate targeted or indiscriminate damage.

Contemporary threats such as improvised explosive devices or the rise of computerised crimes and cyber-warfare are parts of an emerging, complex risk landscape that requires a combination of intelligence, technology and action to be effectively controlled.

As such, the study of accidental or deliberate risk is fundamental within the field of Systems and in particular for the study of engineering systems. Our work in this area is underpinned by a rigorous understanding of the concept of risk in context and by a broad, system-level view of the problematic situations. We use tools such as stakeholder analysis, hierarchical process modelling and system dynamics to understand and model the interactions of key actors with technology. We produce both qualitative and quantitative models and simulations of risk, uncertainty and other key parameters that are grounded on a deep understanding of stakeholder needs in order to improve processes and deliver innovation and technology.

Combined with the individual expertise of our skilled Research Engineers in respective domains, such as nuclear engineering, weapon systems, dynamics and control, IT and communications, etc, this approach provides an effective means for the study and mitigation of risk in engineering systems from a holistic, socio-technical perspective.

Related EngD in Systems research projects deepen an understanding and tackling risk in novel environments, such as autonomous personal rapid transit systems. For example, Alan Peters has conducted a thorough analysis of hazards and their potential impact to UltraPRT's novel concept for personalised public transport deployed at Heathrow's Terminal 5.

Other examples demonstrate the nature of work that systems engineers do when coping with the accidental or deliberate risk that is inherent in engineering systems:

- Neil Carhart has studied how organisational learning and Systems Thinking in EDF Energy Existing Nulcear can improve the safety and reliability performance of nuclear energy production
- Rhys Evans has been studying how best to combine information from multiple sources to increase the relevance and quality of intelligence, taking into account the vast amount of information that requires such processing
- Allan Cannon works in MBDA improving antenna technology for defence systems, whilst Duncan Tait in Thales into the broader area of secure system architectures for establishing and maintaining network enabled capabilities.

Theory of Socio-Technical Interactions

Prof John Davis, Prof Patrick Godfrey, Dr Mike Yearworth - Systems Centre, University of Bristol
Dr Ruth Deakin-Crick – Graduate School of Education, University of Bristol
Prof Leroy White – School of Management, University of Bristol
Stephen Barr -PA Consulting; Renica Mapfunde – BalfourBeatty; Emma Langman - Progression Partnership; Jonathan Rees - Rees and England; Alasdair MacDonald - Parsons Brinkerhoff

The socio-technical interface is a war zone of conflicting philosophies and approaches, tools and methodologies. It is ill understood. That it is an interface at all is bad news because increasingly we all work in this domain. We speak of hard systems embedded in soft systems - a dichotomy rather than a unity.

The practical problem can be illustrated by recent attempts to get mathematicians and sociologists working together, which could be characterised by "You toss your data over the wall, we'll work them for you and toss them back".

There is a sense too that if this complexity wasn't enough, the social and technical systems are only two out of a possible five or six as in the conventional PESTEL model.

The challenges often revolve around two main issues:

1. Modelling for prediction

As engineers we want to make interventions to make things better. In order to choose the interventions we need to know what will happen. This requires models for prediction. However, that assumes that social behaviour can be predicted.

2. Verification and validation

Validation - "Are you building the right thing?" and Verification - "Are you building it right?". This revolves around the system specification. Was the client able to truly express what they wanted/ needed? In hard systems we can build models which are testable and which we can get data to cross refer. This also then links into the discussion of verification and falsification. Is something that is not testable scientific? (Popper)

This discussion leads to a number of generic systems research challenges:

- Having tools which explore the domain rather then coming up with the answer (begun with Juniper and Perimeta)
- Having common language sets for all systems (begun with process understanding)
- Having better methods of handling imprecise probabilities
- Having better communication/ visualisation tools for cross - disciplinary activity
- Understanding the issues of dependency vs truth in the verification process.

The Performance of Complex Socio-Technical Systems - Process Improvement and Decision Support

Dr Mike Yearworth, Prof Patrick Godfrey, Prof John Davis, Dr Theo Tryfonas, Dr Chris Preist, Dr Ges Rosenberg

This research thematic area covers approximately 30% of the IDC in Systems portfolio of EngD research projects, 50% of the employed REs, and close to half of our industrial collaborators. The largest industry sector represented is defence and aerospace but also includes sustainability, nuclear and civil engineering consultancy. These projects are primarily focussed on change within our industry partners through developing better ways of delivering processes, making better decisions and ultimately bringing about the organisational changes necessary to achieve sustained competitive advantage. Whilst new technology development is not the primary focus of this research theme, understanding the relationship between technology and the wider business processes within the organisation is crucial. Frequently this requires the development of models of processes, or models to support customer engagements. Strategic risk management, recognition and response to uncertainty, value for money studies, collaborative procurement process, capability trading, lean and agile delivery - these are all examples of where this thematic area is making a considerable contributions to economic improvement.

Teaching and Learning Together – Developing Future Industry Leaders

Sustainable Systems – Undergraduate M-level Unit

At global, national, corporate and individual levels, it is essential that we learn how to integrate complex socio-technical systems and measure their performance in a way that will achieve a substantial improvement in sustainability, whilst avoiding the unintended consequences that have frustrated much well meaning development. Our national and global economic future depends upon it.

This taught unit is developing a generic approach to the multidisciplinary integration of sustainable systems, which is taught to M Level Engineering undergraduates and Engineering Doctorate postgraduates. It is underpinned by the principle that we are all Learning Together.

The course is providing the input for far wider dissemination of this principle through journal publications of pedagogic case histories and as Open Educational Resources.

Sponsored by The Royal Academy of Engineering the project has brought together a world-class team of Visiting Professors, practitioners and academics with experience from a diverse set of backgrounds, including engineering, environmental science, architecture, urban planning, the oil and gas industry, ITC, aerospace, and defence, and Forum for the Future.

It uses Systems Thinking to develop and teach an integrated approach to designing sustainable systems, recognising the complex socio-technical nature of the issues. Using Systems Thinking principles, the course is designed to be an experience- led, highly interactive week of learning for the students and teachers. Lectures are interspersed with debate, role-play, a sustainability game and coached formative exercises. It is followed up with an uncompromisingly challenging assignment to use Systems Thinking to improve the sustainability of a major project or industry.

Overall student satisfaction levels have been exceedingly high and outstanding performance has been shown by some. The marking system is designed to not only reflect success in meeting the assignment objectives, but to also measure attainment of the learning outcomes, provide formative feedback to the students and enable year-on-year improvement of the course itself. External recognition is already being proven through our VPs' and partners' international business contacts, who are reporting strong interest in the course from as far afield as Adelaide, Auckland, Singapore and Utrecht.

Postgraduate Taught – Masters in Systems

The Systems Centre is a leader in the application of Systems Thinking to create value within socio-technical complexity.

We offer cross-disciplinary training in Systems Thinking and Engineering, which is recognised by our industrial partners as the skill in demand for engineers of the 21st century. *"...better application of the systems approach will be of wide benefit across the whole of the UK."* – Rolls-Royce

We provide a specially designed two-year Masters of Research in Systems programme. It is run in close collaboration with industry and alongside the EngD in Systems.

Aimed primarily at engineers already working in industry, the programme has the overall aim of graduating individuals who will be capable of leading innovation in the application of Systems Thinking and Systems Engineering.

Case Study:

Richard Curson, Thales UK

Systems Engineering Co-ordinator

I was considering an MBA when I was introduced to the idea of a Masters in Systems at the Systems Centre by my supervisor in the company. The programme allows me to stay in my post whilst I receive an "injection" of knowledge and training in system thinking methods and skills.

The Systems Centre and the programme provide a safe environment to enhance and fine tune the way I solve problems by considering industrial challenges in a holistic way. I am finding that there are powerful techniques that can be applied when it comes to complex and 'wicked' problems.

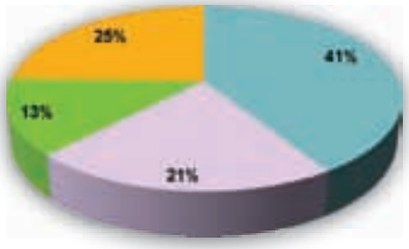
As the world becomes more connected, so the systems around us and which we create become more complex, hence the level of uncertainty gets harder to quantify. Through use of the Centre's resourses and the expert Systems Thinking teaching on this programme I will be able to learn how to manage such problems.

I used to think that the technical problems in industry are the most challenging, but it seems to me now that I was missing the point, that techno/social problems are equally if not more challenging. This course is designed to equip me with the skills to bound and manage these challenges and I believe I will be a better professional for it.

Applying Systems Thinking to Complex Engineering Problems

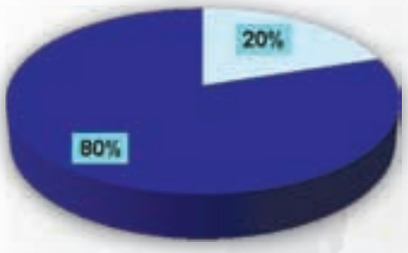
Companies Sponsors EngDs	**37**
With more than one RE	**11**

EngD in Systems research themes

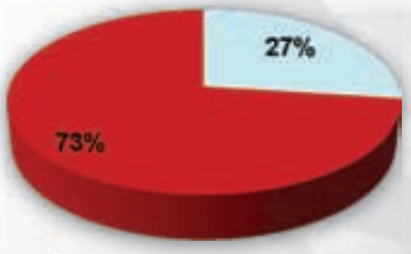


- Product/technology development
- Sustainability
- Decision support
- Process development/ organisational change

Active EngDs (Oct 2010)	**62**
Funding available	**till 2017 at least**



- Employed REs
- Stipend REs



- University of Bath registerd REs
- University of Bristol registerd REs

Postgraduate Research – Engineering Doctorate in Systems

The Engineering Doctorate in Systems is a postgraduate research programme funded by EPSRC UK, and delivered collaboratively by the University of Bristol and the University of Bath. The EngD degree is an alternative to the traditional PhD, which providing a unique opportunity to undertake industry - driven, problem - focused research.

The EngD in Systems includes a specially designed taught component, comprising of 10 accredited Units, which provides the Research Engineers with knowledge in Systems and Systems Engineering disciplines, develops problem solving skills and addresses the needs of professional development of future industry leaders.

The EngD in Systems is for those who aspire to:

- Develop the knowledge and skills to become a leader in Systems
- Acquire excellent career prospects
- Join an international research network in Systems
- Gain experience of using the latest Systems techniques in industry sponsored research projects.

Industrial Doctorate Centre in Systems

The IDC in Systems is at heart of the Systems Centre, and each year attracts high calibre research engineers, keen to push boundaries and lead innovation in various companies across the country. Through industrial needs-driven research in Systems we generate real and strong collaborative links between academia and industry, and create a focal point at the University where academic researchers from various disciplines (physical and social sciences, engineering, industrial maths, management) have an opportunity to interact and to exchange their ideas with industry practitioners and to work together creatively to address problems and challenges of the 21st century.

Industry Sponsors	Stipend + Employed
Advanced Transport Systems	2+0
Airbus	2+1
Arup	1+0
ASL Vision	1+0
Gatwick Airport	0+1
BAE Systems	2+1
Balfour Beatty	0+1
British Energy	2+0
Boeing Defence UK	1+0
Broadcom	1+0
Buro Happold	6+0
Capgemini	0+1
CFMS	1+0
DRTS	1+0
Dstl	0+1
Frazer-Nash Consultancy	3+1
Fujitsu Microelectronics	1+0
GCHQ	0+1
Halcrow	4+0

Industry Sponsors	Stipend + Employed
Imetrum	2+0
IT Power	1+0
MBDA	0+1
Met Office	1+0
Motor Design	1+0
PCIP	3+0
ProVision	1+0
Ramboll Whitbybird	2+0
Rencol	1+0
Renishaw	2+0
Rolls-Royce	4+0
Sustain	1+0
Thales	1+1
Toshiba	1+0
Tidal Generation	1+0
Triumph	1+0
TWI	1+0
Westland Helicopters	1+0

Case Studies

Alan Peters

Research Engineer Cohort 1 (2006-10)
MEng (Hons), University of Bristol

Alan joined the EngD in Systems programme in 2006, after completing a MEng in Knowledge Engineering.

Alan works with ULTraPRT Ltd (formally Advanced Transport Systems Ltd) and his current research interests include risk modelling and sensor systems for a driverless transport system.

EngD research title: The Safety of Personal Rapid Transit Systems

Supervisors: Dr Alin Achim, University of Bristol; Dr Torquil Ross-Martin, ULTraPRT Ltd; Dr John May, University of Bristol.

Personal Rapid Transit (PRT) is a new mode of transport designed to provide a viable alternative to the private car that is more sustainable, safer and more pleasant to travel in. PRT uses small driverless autonomous vehicles, travelling on segregated guideways, to provide an on-demand, non-stop service in urban environments. Currently a first system is being tested at Heathrow Airport.
The long-term PRT vision is to have large complex networks in urban areas such as city centres. Routing algorithms will optimise the movement of vehicles to maximise passenger capacity using less substantial architecture than alternative transport forms. PRT, or a similar system, is necessary to reduce traffic congestion in large cities.

The EngD research has centred upon analysing and improving safety in PRT systems. This work includes risk modelling as part of the system safety case, design of an occupancy detection system, design of a visual method for navigation and design of a wireless collision avoidance system.

Publications: A. Peters,T. Achim, (2008), 'Image Change Detection for a Personal

Rapid Transit Application', Proc of 16th European Signal Processing Conf., Lausanne, Switzerland.

A. Peters, T. Achim, (2009), 'Vision-Based Detection of Personal Rapid Transit Guideway', Proc of 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria, pp. 164-169.

Membership: The Institute of Engineering and Technology (IET)

Charlotte Dunford

Research Engineer Cohort 4 (2009-13)
Bachelor of Applied Science in Mechanical Engineering
University of British Columbia

I first learned about Engineering Doctorates when doing my undergraduate course in Canada. I liked the concept as I felt, with its grounding in industry, it stayed true to the spirit of engineering as the application of scientific theory to real world problems. Upon moving to the UK (I have dual-nationality) I started my search for the EngD project that was right for me. 6 years and 2 jobs later I have finally found it! I am looking at the Use and Embedding of Systems practice in the Rolls-Royce Defence Aerospace Product Lifecycle, which builds on my experience as an engineer in the defence sector and in change management in the public sector. The EngD in Systems particularly interested me as I found in my work on international space missions that it was people, not technical, issues that were the greatest challenge. I hope that by applying the holistic approach advocated as part of the Systems EngD I will learn to better cope with these soft issues.

Industry Views on the EngD in Systems

Advancing Systems Thinking at Frazer-Nash

How does a 380-strong Systems and Engineering technology business stay ahead of the competition? At Frazer-Nash we believe that it is crucial to support the brightest and best Systems Thinkers in the country, by developing our own staff and collaborating with world leading systems thinkers in other organisations.

For this reason we offered the support of our parent company, one of the UK's biggest engineering businesses, to the original Bristol University application to host an Engineering Doctoral Centre in Systems in 2006. At the time, we were excited at the prospect of helping to create a centre of excellence, which would bring together systems thinkers from a range of industries across the South West of England.

The EngD Centre launched with its first cohort in 2006, and we decided to place a full time staff member into this cohort. We hoped that in addition to furthering his professional education, we would meet other systems thinkers in other organisations, and identify opportunities to work together in new ways.

It quickly became apparent that the Centre offered a recognised centre of excellence not only in the South West, but across the UK, and increasingly worldwide. We were keen to carry on supporting the growth and development of the Centre, and hence we recruited another student into the second cohort, and offered practitioner lectures on the EngD taught courses.

However we felt that the true strength of the Centre as an academic centre of excellence would be judged by its publication record. Our own students had told us that they wished they had published more, earlier in the course of their EngDs. We discussed this with the Centre, and decided to offer a prize for the best conference or journal paper written and submitted during the first 24 months of study. This prize has now been awarded twice; the first recipient Yin Yun went on to be the first person to graduate from the Centre.

Frazer-Nash continues to support the now IDC in Systems, and to date has placed four students on the course. We see the value in investing in guest lectures, the Frazer-Nash prize, supporting the Centre's Strategic Advisory Board and, not least, funding our students across our business. We have developed new services based on our EngD research, but have also made a wide range of valuable new contacts, and cemented others within the walls of the IDC. As a systems and engineering technology organisation, our collaboration with the IDC is central to our business, and we continue to seek new ways to help the Systems Centre to grow and spread its influence.

Rupert Bridges
Head of Systems Engineering
Frazer-Nash Consultancy

Awards

FNC prize winner 2010 – Best Paper Award

Paul Gibbons

Research Engineer Cohort 2 (2007-2011)
Asset Stewardship Delivery Manager, Gatwick Airport

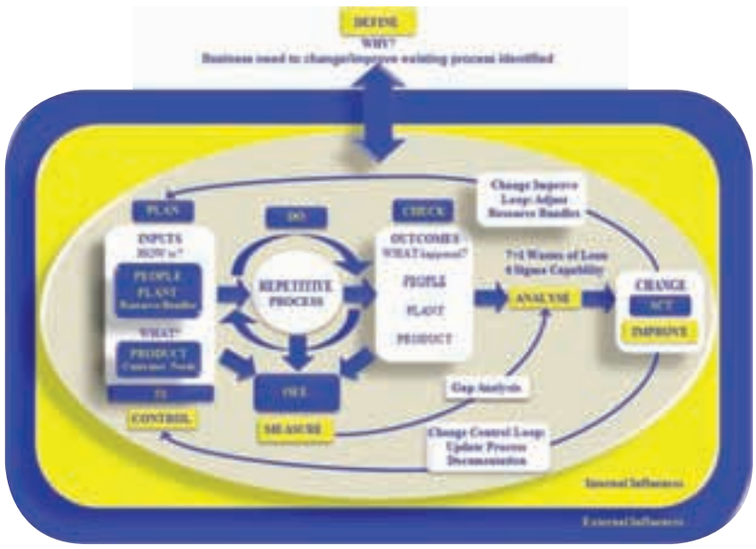
Picture: Paul Gibbons receives the Best Paper Award, presented by Rupert Bridges, FNC

Value Improvement Model for Repetitive Processes

This research has developed a visual and systematic framework that enables managers to understand, analyse and improve repetitive processes within their businesses.

The diagram introduces a value improvement model (VIM) for repetitive processes applicable to any business where people and/or plant provide a service to support the overall business objective. Arguing competitive advantage can be realised through different amalgams of productive and strategic resources, the VIM focuses on aligning resource bundles and influencing factors creating efficient and effective processes.

The internal elements of the model focus on identifying resource bundles and process control mechanisms matched to product/process requirements. After mapping the repetitive process and measuring outcomes, gap analysis is used to identify potential value improvements. Resource bundles are then changed and control mechanisms are updated to ensure sustainability. Also influencing the repetitive process, are internal and external environmental factors, which can be negative or positive. Internal factors are more easily changed and the gap analysis may lead to a change requirement of an internal factor (examples include: tangential processes, culture, plant condition, technical standards). External factors are very difficult to influence but may impact the process (examples include: weather, economy, legislation).



Paul Gibbons, publications in 2010:

P. M. Gibbons, Incorporating six sigma thinking and asset management strategy performance indicators into the overall equipment effectiveness measure (OEE). Conference Proceedings, Second European Research Conference on Continuous Improvement & Lean Six Sigma, 18-20th January 2010, Strathclyde University.

P. M. Gibbons, Introducing a value improvement model for repetitive processes. INCOSE UK Annual Systems Engineering Conference. Oxfordshire, UK.

P. M. Gibbons, & S. C. Burgess, 'Introducing OEE as a measure of lean six sigma capability'. International Journal of Lean Six Sigma, Vol. 1, No. 2, pp.134-156.

P. M. Gibbons, & C. Kennedy, Delivering stakeholder value through sustainable asset management. IET Seminar, Asset Management in the New Economy: Sustainable Whole Life Decisions. IET London

Awards

Best Presentations at the EngD Conference 2010

Ice Pigging in Narrow Bore Ducts

Dominic Ash

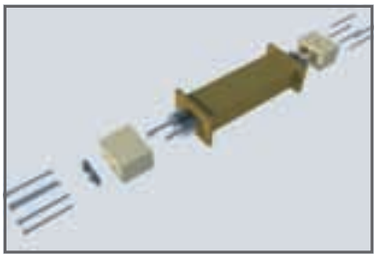
Research Engineer with PCIP, Cohort 3 (2008-2012)
Supervisors: Prof G. Quarini, Industrial Supervisor (PCIP)
Dr H. Saidani-Scott, Academic Supervisor (University of Bristol)

Ice pigging is the patented process of using a thick slurry of ice particles to clean pipelines. The properties of the 'ice pig' allow it to negotiate bends, valves, instrumentation or any other complex pipework topology, that conventional pipeline pigs could not, whilst continuing to clean the pipe.

Whilst the process is being utilised in large diameter pipes (25-450mm), there exists opportunities for use in medical and drinks dispensing applications with diameters less than 10 mm.

This presents new challenges for the 'ice pig', with increased melting rates and hygiene requirements.

The development of a self contained unit for producing small quantities of ice pig from a product, such as beer, is the focus of my work. When perfected, the unit will be capable of quickly and hygenically generating an ice pig and delivering it into a pressurised line.



Multiple-Core Control for Real-Time Metrology Applications

Stephen Bryant

Research Engineer with Renishaw, Cohort 3 (2008-2012)
Supervisors: Dr Kerstin Eder, Academic Supervisor (Univeristy of Bristol)
Stephen Davies, Industrial Supervisor (Renishaw Plc)
Dr Theo Tryfonas, Systems Supervisor (Univeristy of Bristol)

Cost-efficient processing power is moving from single- to multiple-core processors. Therefore, to keep costs down, applications that have taken advantage of the increasing power of single-core processors in the past may now need to transfer to multiple-core architectures.

Unfortunately, while concurrency can provide more overall processing power, it also introduces the possibility of various problems unique to parallel systems, including poor resource sharing and deadlock. The arbitration required to deal with these problems can use significant resources itself, as well as causing unpredictable performance.

8-core processors are currently possible with 32-nm technology

Our research is focused on analysing an existing real-time system, designed at Renishaw, which was initially running on a single-core processor. The hope is to adapt it for the many-core processors that are likely to emerge soon in the consumer market. Formal methods are being used to analyse and re-design the communication structure and data flow of the application, aiming to minimise arbitration. While this is underway it is also necessary to consider how the final result, and the methods used to achieve it, will integrate into existing applications, processes and company culture

First EngD in Systems Graduate

Dr Yun Yin graduated in July 2010.

Graduation day - Dr Yun Yin with his family, Supervisors and the Systems Centre staff.

Yun Yin completed his Engineering Doctorate in Systems in February 2010 and is the first RE to graduate from the IDC. Yin's research addressed risk from uncertainty and complexity perspectives using Systems theory. He also has a Masters in Research from the University of Bath and a BSc from Harbin Institute of Technology. He has co-authored a number of conference and journal papers on risk and won the Frazer-Nash Best Paper Prize in 2009.

"My EngD Life"

It was great to be a part of the EngD in Systems course. During this time I learnt problem solving skills, from which I believe I will benefit for the rest of my life.

Although real world applications of fundamental knowledge are perceived as important outputs from the EngD in Systems programme, I do not believe they are the most important aspect. What really matters is the thinking style and approaches to problem identifications and solutions. Without an appropriate approach, problems cannot be properly tackled even if people were equipped with excellent knowledge and tools.

Systems Thinking is really helpful when faced with complex problems in the real world. At the start I was confused with the terminology and questioning Systems Thinking fundamentals. However I gradually gradually I have noticed that my thinking style has changed. I was able then to recognise the full power and greatness of Systems Thinking. This process takes a while, and teaching in Systems helped me on this transformational path.

Another key point, that I learnt from the EngD in Systems course, is the concept of Process. Ever increasing complexity forces us to seek cutting-edge knowledge, tools and techniques.

From another side, knowledge should be driven by real world problems, and there is no other way around – we cannot create some theories as an answer first and then 'make up' some imaginary problems. The concept of Process helps to spot those real world problems and then to use Systems Thinking to address them. This means that being practical, in effect, expands the boundary of knowledge.

Apart from the learning and training aspects, the EngD in Systems gave me an opportunity to meet and work together with many Research Engineers - brilliant people with diverse backgrounds. Moreover, academic and administrative staff at the Centre are really excellent and very supportive, which makes the four year journey much easier than I had anticipated.

All in all, the EngD years are an important part in my life. It affected me significantly on many aspects and I really appreciated and enjoyed it. It is a piece of precious memory!

Awards

Research Engineers' design highly commended at the Integrated Habitats Design Competition Awards

Research Engineers Phil Hampshire (Cohort 3) and Celia Way (Cohort 1), were part of an interdisciplinary team of engineers, environmental consultants and landscape architects from Buro Happold and Grant Associates to gain a highly commended award in the 2010 Integrated Habitats Design Competition. The focus of the competition was to promote and encourage trans-disciplinary working and design, to integrate systems that work with nature, to adapt to climate change and enhance biodiversity.

Phil outlined the design philosophy of their entry: "When designing 'Happy Habitats' we set out with the intention of putting both nature and society at its very heart. From the outset we tried to create an urban community, in which people can live, work and play alongside thriving natural systems. The design philosophy was to integrate greenery and habitats into the built environment in a way that provides mutual benefits for all concerned. We wanted to create a place where people can see, feel and understand the advantages of this new paradigm of design - a design, which integrates and enhances the environment by protecting and creating natural habitats, that grow and flourish rather than destroying them through the development process. The aspirational end result was to create a happier place for everyone and everything."

The Happy Habitats design applied knowledge and skills developed through EngD in Systems research to integrate green roofs and sustainable urban drainage systems into the site in imaginative and inspiring ways. The design was focused on increasing both long term and short term economic, social and ecological capital, through providing durable and adaptive spaces. This included utilising roof area as a space to generate energy, grow food and provide amenity space.

The team's design was exhibited at the Building Centre in September 2010. More information can be found on the design at http://ihdc.org.uk/.

Research Grant in Systems - 'Transforming Energy Demand through Digital Innovation'

Dr Chris Preist and Dr Mike Yearworth have been awarded an EPSRC grant (£350k) under 'Transforming Energy Demand through Digital Innovation' programme, to assess how digital technology could transform the newspaper industry over the next 10 years and the resulting impact on climate and energy use that such transformations may bring.

The SYMPACT project, will partner with Guardian News and Media and the University of Surrey Centre for Environmental Strategy to build models of different future scenarios as to how the news industry might look as a result of digital technology innovations. The modelling approach will integrate life-cycle assessment techniques into systems approaches, allowing the combination of quantitative energy and emissions analyses with more speculative models of technological and behavioural change, such as models of the shift from paper to online news reading or the uptake of electronic reader devices.

News & Events 2009-2010

The First Annual Research Conference for the Engineering Doctorate in Systems

On 17 May 2010 the IDC in Systems held its First Annual Research Conference: a whole day event celebrating the work of the 50+ Research Engineers registered on the EngD in Systems programme either at the University of Bristol or the University of Bath.

Prof Patrick Godfrey launched the event with a welcoming talk. This was followed by final year REs giving oral presentations of their work. All other cohorts (1st, 2nd, 3rd year REs) displayed posters during a specially organised lunchtime session.

The work presented was equally split between three large themes: sustainability and renewable energy; defence aerospace and security; and product/process design and development.

During the event the annual Frazer-Nash prize for the best publication was awarded to Paul Gibbons, a 3rd year RE working with Gatwick Airport.

The Conference featured two plenary talks. Dr Mike Yearworth, Reader in Systems, presented “Systems Research in Engineering: Principles, Methodologies and Examples”, where he gave an overview of underpinning principles of Systems research, and analysed examples of the unique stakeholder needs-driven Systems approach, developed at Bristol. Prof Chris France, Director of the Centre for Environmental Strategy, University of Surrey and a strong supporter of the ‘EngD movement’, followed with a talk about the specific requirements for an EngD thesis.

This will now be an annual event, a key forum for research in Systems across the Centre, and an additional mechanism by which the research progress of the Doctoral students is reported and reviewed.

News & Events 2009-2010

Blockley Series of Lectures

The Systems Centre is delighted to introduce this year a new series of lectures in recognition of Prof David Blockley's fundamental contribution in establishing the Systems movement within the University of Bristol.

The Blockley Lectures will feature prominent speakers from the UK and abroad working in the field of Systems, with topics ranging across different disciplines - engineering, management science, education, environment.

The Blockley Lecture Series was opened on 2 December with the first lecture, A Tale of Two Systems, by David Blockley:
"…In the tale of Two Cities, Dickens wrote 'It was the best of times…..It was the worst of times……'. In the tale of Two Systems, at its best engineering is incredibly successful - witness big bridges, electrical machines, jet engines, the transistor, wireless computing and the Internet and much more. At its rare worst, people are killed and our environment damaged – bridges collapse, industrial plant explodes, vehicles crash, oil spills and the environment, and indeed the climate, is changed.

I will trace the story of how I came to see the gaps (indeed the gulfs) between what we know, what we do and why things go wrong. I will describe why I think these gaps play a crucial role in why engineering is seriously undervalued by many.

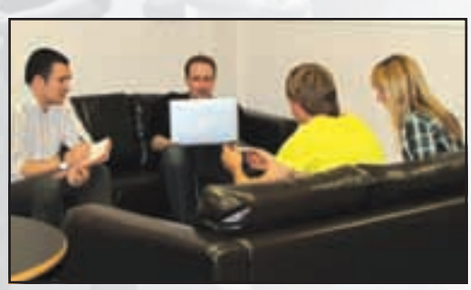
I will describe the central importance of Systems Thinking in attempting to a) narrow the gaps, b) point out that engineering has a relevance way beyond its own specialisms and c) argue that we must have a conversation with a much wider audience than we have in the past.

I will argue that the role of Systems Thinking is to integrate the language of uncertainty and complexity and its expression in risk. Risk has a bad press usually associated only with harm. But risk is also about opportunity – we need to be ready to take advantage of good unintended and unforeseen consequences too. In summary I will argue that managing risk is a tale of two systems - the 'hard' embedded in the 'soft'".

The new look Systems Centre opened its doors on Monday 11 October 2010

In March 2010, Research Engineers Phil Hampshire and Matt Montgomery designed and facilitated a workshop in which almost 20 REs and Systems Centre staff took part. The aim of the day was to gather data to inform a restructuring of the Knowledge Exchance Suite (KES) – 'home' of the Systems Centre. The main focus was on better use of the available space, to create an environment dedicated to supporting REs' self study and peer-to-peer learning, and to enhance facilities for networking and engagement with Systems Centre stakeholders.

A stakeholder needs-driven Systems Thinking approach was used to generate a comprehensive overview of the existing limited space and to suggest feasible solutions for improvement. The outcome was a feasibility report, and architect firm White Design was commissioned to generate a design. It took just five weeks to complete phase 1 of the refurbishment project. Since the opening of the Centre the previously underused KES has seen over 20 Research Engineers working in the newly created 'research lab'; the Centre hosted the End of 2nd Year progress review conference (with 60 delegates); and REs have been using the space highly effectively, and daily, to work in groups, to share ideas and to discuss ongoing research and challenges.



Our Associates

The Systems Centre brings together academics from across various disciplines in Engineering, Science, Management and Education

Academic involvement is key to the Centre's efforts to

- develop new areas of academic research in the area of Systems
- build a repository of interdisciplinary expertise which may be employed to address the complex challenges faced by industry in the 21st Century
- undertake industry sponsored research through the EngD and Masters in Systems degree programmes, and otherwise.

We would like to thank all EngD in Systems supervisors for their contributions and continued support.

University of Bristol		University of Bath
Dr A. Achim	Dr K. Eder	Prof A. Graves
Prof A. Champneys	Prof K. Potter	Dr A. Heath
Dr A. Richards	Dr M. Tierney	Prof A. Plummer
Prof C. Allen	Dr M. Yearworth	Prof C. Mitchell
Dr C. Preist	Prof N. Lieven	Dr C. Williams
Dr D. Agrafiotis	Dr O. Kasyutich	Dr J. Swart
Prof D. Cliff	Prof P. Godfrey	Prof P. Keogh
Dr D. Han	Prof P. Mellor	Prof P. Maropoulos
Prof D. Smith	Dr P. Warr	Dr P. Shepherd
Dr G. Hilton	Prof S. Burgess	Prof P. Walker
Dr J. Burn	Dr S. Cornell	Dr S. Cayzer
Prof J. Davis	Prof S. Heslop	Prof S. Culley
Dr J. MacDonald	Prof T. Martin	Dr S. Meeran
Dr J. May	Dr T. Tryfonas	
Dr J. Rossiter	Dr R. Vaidyanathan	
Dr H. Saidani-Scott		

The Systems Centre is honoured to have 18 Visiting Professors and Fellows, who contribute significantly to our teaching programmes, research and strategic development of the Centre.

Prof D. Oxenham	A. Terry	P. Best
Prof G. Hutchinson	C. White	P. Cooper
Prof H. Sillitto	E. Langman	R. Beasley
Prof P. Brook	G. Rosenberg	S. Barrett
Prof P. Head	L. Farrow	
Prof R. Vidgen	M. Sandbrook	
Prof D. Hitchins	N. Allan	

Systems Centre
University of Bristol

Merchant Venturers Building
Woodland Road, Bristol BS8 1UB

email: systems-eng@bristol.ac.uk

www.bristol.ac.uk/eng-systems-centre/