Government Office for Science

Introduction to Systems thinking

GORS

Government Operational Research Service

GSE Government Science & Engineering

Report of GSE and GORS seminar

Civil Service Live

Tuesday, 3 July 2012

Government Office for Science

Contents

Introduction

Many policy problems are complex and interconnected, where even grasping the nature of the situation may be challenging, let alone designing policy interventions that achieve what you intend them to. From regulation of financial markets to addressing climate change in a global context, the Government faces a broad range of complex challenges that will need not just a wide range of science and engineering expertise to tackle them but also a systems approach to shape effective policy interventions.

On 3 July 2012, the Government Office for Science organised a seminar at Civil Service Live to provide an introduction to systems thinking in the Civil Service. The expert speakers drawn from the Government Science and Engineering (GSE) community and Government Operational Research Service (GORS) explained the key concepts within systems thinking and demonstrated some of the different approaches applicable in a Civil Service context.

What is systems thinking?

Systems thinking is a way of exploring and developing effective action by looking at connected wholes rather than separate parts. Systems thinking is a powerful approach to support evidence based decision making and is essential to successful delivery of complex projects where there are many stakeholders and many possible solutions.

Box 1 – Key concepts in systems thinking

Within systems thinking there are four key concepts:

1. Context and belief systems. People do not have a consistent view of a system. 'Soft' systems approaches can be used to understand these different perspectives, enabling solutions to be developed that meet a diverse range of stakeholders needs and wishes.

2. Parts, wholes and layers. All systems are similar. For example they have an environment, sub-systems and interactions. Understanding of basic systems theory helps ensure that solutions are viable and that systems (including social systems) can meet their performance and effectiveness requirements.

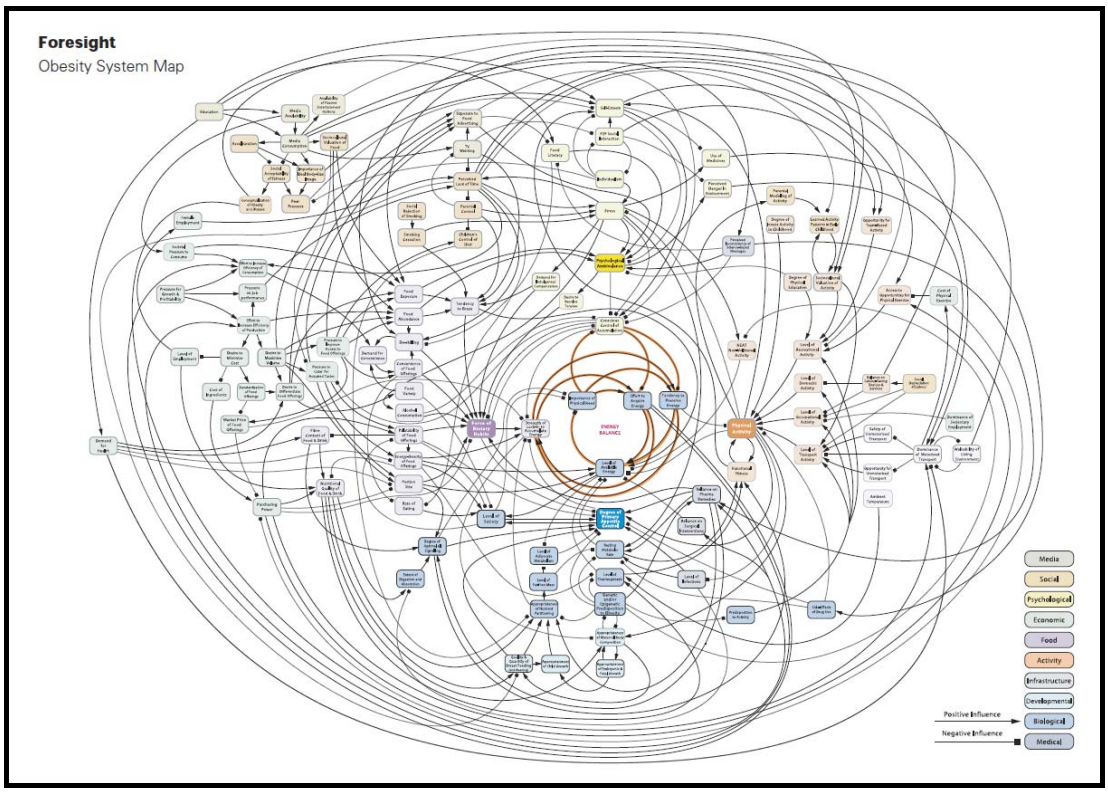
3. Connections and loops. Understanding how different systems interact is one of the most powerful tools to solve some of the most intractable situations faced by government. System dynamics has been used to describe complex situations and evaluate alternative policy and technical solutions.

4. Processes – and how change happened. The systems approach is core to realising complex systems. It has been used to get humans on the moon, win the Battle of Britain and transform major corporations.

Presentations

Dr Claire Craig, Director of Government Office for Science introduced the session by highlighting the importance of systems thinking for the Civil Service. The Foresight project on obesity illustrates a complex challenge, where different government departments have an interest or responsibility for different aspects of the system.

Figure 1 – Foresight obesity map



http://www.bis.gov.uk/assets/foresight/docs/obesity/12.pdf

Professor David Oxenham, Chief Systems Engineer, Defence Science and Technology Laboratory (Dstl), outlined some basic ideas related to frameworks for systems thinking and discussed how a systems approach can be applied in

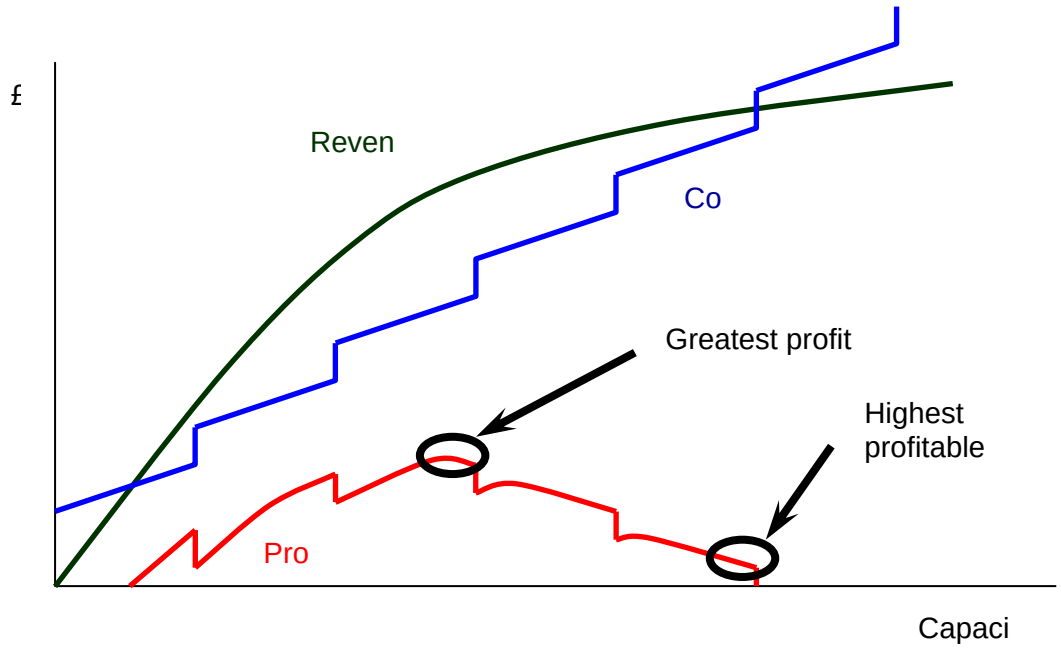
- decision making
- creating fit-for-purpose solutions to complex problems
- developing policy options

Professor Oxenham highlighted several case studies that illustrate styles of thinking that might help get better outcomes when dealing with complex interacting issues. He also highlighted some of the challenges inherent in working in a complex area that cause projects to fail as well as the tools for addressing these challenges.

Duncan Kemp, former Chief Systems Engineer at Department for Transport, discussed systems thinking in a policy context. He discussed three specific examples of using systems thinking to help inform the rail reform programme.

- Using Checkland's soft systems methodology understanding different perspectives on the purpose of the railway
- Using system dynamics to understand the interactions between different rolling stock markets
- Using the systems approach to understand all of the changes needed to deliver the desired benefits

Figure 2 Optimum capacity for the rail network - different perspectives



Panel Discussion

Dr David Cope, Head of Operational Research in Defra, explained that systems thinking is a central element of what makes a good Operational Researcher. The way that he and his GORS colleagues approach complex ('wicked') problems, build and test hypotheses and generate models of the world rely on a good understanding of the system, the interactions in that system and the emergent properties of that system. Whilst not every Operational Researcher is an expert in this field, they tend to have a strong 'systems' framework to their approach.

There are great opportunities in applying systems thinking in government today, where society is ever more interconnected, where there are non-linear relationships between intervention and impact. No single discipline has a monopoly on grasping these opportunities, and a coordinated approach across analytical disciplines will add value to government.

The panel took questions from the audience on working with decision makers to define purpose and optimum outcomes, communicating about systems and some of the practical tools that can be used to represent systems. Systems thinking approaches complement the detailed knowledge that scientists, engineers and others working in specific sectors may have of a specific component of the systems.

The case studies illustrated how systems thinking can not only help with understanding processes. It is primarily focused on outcomes and results and, when done well, can facilitate collaborative working, development of a shared understanding of the nature of the challenge and a transparent evidence base for all to interpret.

Figure 3 – Speakers: Dr David Cope, Professor David Oxenham and Mr Duncan Kemp (left to right)

Appendices

Glossary

System	an integrated or interdependent set of elements forming a complex whole
System dynamics	how different systems interact and change over time or in response to different interventions; can be used to describe complex situations and evaluate alternative policy and technical solutions.
Operational Research	the application of scientific methods to management problems. Also known as 'management science', operational research aims to provide a rational basis for decision-making by understanding and structuring complex situations. This often involves building mathematical models to predict system behaviour and thereby assist the planning of changes to the system.

Recommended resources

Government Science and Engineering (GSE) http://www.bis.gov.uk/go-science/science-in-government/science-engineering-profession/gse

Government Operational Research Service (GORS) www.operational-research.gov.uk/

Operational Research Society http://www.learnaboutor.co.uk/

International Council on Systems Engineering www.incoseonline.org.uk/

Royal Academy of Engineering - Principles of engineering systems for the 21st century
http://www.raeng.org.uk/news/publications/list/reports/Creating_Systems_that_work.pdf/

Peter Checkland - Systems Thinking, Systems Practice, Wiley [rev 1999 ed] and Soft Systems in Action, Wiley (with Jim Scholes) [rev 1999 ed]

Robert M Pirsig - Zen and the art of motorcycle maintenance, William Morrow & Company [1974]

Bristol University Systems Centre: http://www.bristol.ac.uk/eng-systems-centre/
(various resources related to systems thinking and videos of visiting speakers and academics speaking on a systems theme)

Open University Learning space on systems thinking and practice:
http://openlearn.open.ac.uk/mod/oucontent/view.php?id=399236&direct=1

Background on our professions

Government Science and Engineering (GSE)

Government Science & Engineering (GSE) was established in June 2008 and aims to increase recognition of the profession's contribution to policy as well as build a strong and vibrant community with robust links between the different analytical streams and policy makers. GSE is a self-nominating community which has over 3,200 members from more than 30 different Government organisations. It is open to all civil servants with science and/or engineering qualification or background or who work in a related area.

Government Operational Research Service (GORS)

The Government Operational Research Service (GORS) is a cross-government analytical profession with a history that can trace its roots back to the Second World War. The 450 GORS members across government come from a variety of backgrounds, including maths, physical and natural science, engineering, computer science, and some even have Operational Research degrees. OR is a multidisciplinary discipline itself, and draws on this by applying over 100 different techniques and approaches to help solve applied policy and operational problems in government.

Speaker biographies

Dr Claire Craig, Director of the Government Office for Science

Claire has joined the Civil Service twice. In between, she worked for the strategy consultancy McKinsey & Co and at the Confederation of British Industry. She also helped launch a Millennium Funded hands-on science centre and leisure destination in her home town of Bristol.

She was awarded a CBE for her leadership of Foresight, a programme of science-based strategic futures projects reporting to the Government's Chief Scientific Advisor and various Ministers. She then moved to the Prime Minister's Delivery Unit and has subsequently worked in strategy and policy in the Ministry of Defence, Cabinet Office, Office of Fair Trading and Department for Business, Innovation and Skills.

Claire has a lifelong interest in science and in learning, having been involved with several educational institutions as a Governor or Fellow. These include a teaching University and a Cambridge College. Her first degree was in physics and she did a short stint of post-Doctoral work in geophysics at the University of Texas at Austin.

Professor David Oxenham[1], Chief Systems Engineer, Defence Science and Technology Laboratory

David Oxenham is Chief Systems Engineer and a Senior Fellow of the MOD's Defence Science and Technology Laboratory based at Porton Down in Wiltshire. His interests and activities are wide ranging with a common thread related to developing and applying a systems approach to complex problems in defence and security bringing together analysis, technology, military concepts and industrial capabilities.

David joined the Ministry of Defence (MOD) as a scientist in 1980 after completing a PhD in Low Temperature Physics at Birmingham University. His career has spanned research, trials, project support, operational analysis and programme management.

David chairs an international Defence Research Collaboration Panel on "systems engineering for defence modernisation" and a cross-Government professional leadership group in Systems Engineering. He is a member of two National Defence Industrial Council (NDIC) Working Groups; sits on Systems Engineering Advisory Boards for Imperial College and Bristol, Loughborough and Cranfield Universities. He is a member of the Peer Review College for the UK's Engineering and Physical Sciences Research Council.

He holds two visiting professor appointments:

Bristol University: Royal Academy of Engineering VP for Sustainable Systems

Imperial College, London: Royal Academy of Engineering VP for Integrated Systems Design

Duncan Kemp[2], former Chief Systems Engineer, Department for Transport

Duncan is an experienced systems engineer and programme manager with over twenty years experience across multiple sectors, embedding pragmatic systems engineering processes to deliver improved project performance, at reduced risk and costs.

Duncan has recently rejoined MoD as the **Engineering Development and Skills team leader** and was lead systems engineer for the Department for Transport until March this year. Duncan is a member of the International Council for Systems Engineering (INCOSE).

Dr David Cope, Head of Profession for Operational Research in Defra.

David has worked in central government for seven years in a variety of roles from analytical advice to policy development to operational performance improvement. Before this, his previous career was as an ecologist, collecting, analysing and modelling data with the aim of better understanding and predicting trends in the size of populations of animals of conservation interest.

David is currently the Head of Knowledge, Transparency and Resilience in Defra, as well as being Head of Profession for Operational Research.

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What next?

Are you a systems thinker[3]?

- Do you enjoy the challenge of difficult and complex issues?
- Are you flexible, adapting your thinking to changing situations
- Do you prefer to let results speak for themselves rather than seeking personal recognition?
- Are you self-assured, confident and trust your own perception of a situation?
- Can you offer an opinion even in the face of uncertainty or incomplete evidence?
- Can you strike a balance between being open to alternative views and challenging them?

Sign up for an action learning set

To express an interest in joining a cross government action learning set on systems thinking, please email: mailto:GSE@bis.gov.uk

[3] Adapted from Dstl systems thinker development guide: http://www.bristol.ac.uk/eng-systems-centre/allpdf/idc-conference-2012/simon-swales.pdf.)

This publication is also available on our website at http://www.bis.gov.uk/go-science

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