ENCORE Feasibility Study Call I

Closing time and date: 1200 GMT   16/05/2016

Summary

The ENCORE Network+ is an EPSRC funded project which aims to explore the opportunities presented by developments in complexity science to improve the resilience and performance of complex engineering systems such as cities, energy and digital systems, space launch and recover systems and jet engines. Details about the project can be found at http://encore.sites.sheffield.ac.uk.

ENCORE is now calling for method-oriented and/or blue skies feasibility studies within the scope of the network, as detailed below. ENCORE will award a number of feasibility studies to individuals or groups on the basis of the applications received by the closing date of this call.

Scope

The scope of the feasibility studies should be framed within the thematic areas of the ENCORE Network+. These can be found in the Appendix A.

Funding available

A total of up to £40,000 is available and we expect to fund between 4 and 8 feasibility studies. The projects are expected to start not later than 4th July 2016 and have a maximum duration of 6 months. The applicants are encouraged to explore the possibility of matching funds.

Eligibility

Applications are open to individuals and groups with affiliation to a University in the UK.

How to apply

Applicants are invited to submit a 2 page proposal, and a submission form with their details. Please send completed submission forms and proposals in PDF format by email to encore@sheffield.ac.uk no later than **12:00 GMT on 16th May 2016**.

Guidance on writing application

Maximum length for the proposal, including references and pictures, is 2 pages, minimum font size 11.

The proposal should include

- A clear statement of the Thematic Area(s) being addressed;
- A problem statement;
- Evidence how the proposed project fits into the Thematic Area(s) being addressed;
- A statement of the methods to be used and how the skills of the proposer(s) fit to these;
- Clearly defined project outcomes (measurable);
- Details of how the feasibility study results could be exploited through further research proposals

Assessment

The proposals will be assessed by the Management Team and Steering Committee of the Encore Network+.

Proposal assessment will include:

- match to network remit;
- engagement of early career academics;
- realistic objectives within the constraints of funding and time;
- multidisciplinary and innovative science;
- industrial support;
- value in enhancing research activity;
- alternative funding sources.

Alternative funding source refers both to the availability of matching funds towards the feasibility study itself and to the availability of funding towards the exploitation of the feasibility study results.

Key dates

Activity	Date
Call conditions announced	17/03/2016
Closing date for applications	16/05/2016 1200 GMT

Funding decision	06/06/2016
Latest project start date	04/07/2016

Contacts

For general enquiries, and for anything concerning this call, please email encore@sheffield.ac.uk

For enquires about the themes and the scopes of the ENCORE network, please contact:

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APPENDIX A

ENCORE THEMATIC AREAS

The six Thematic Areas that are being addressed in this feasibility study call are outlined below.

1. **Resilience in network and process dynamics**: A key problem for engineers is defining the relationship between how a CES is designed, the behaviour that this design produces in normal use, and how this behaviour alters when the system is subjected to multiple, overlapping shocks and stresses and also in the context of dynamics such as growth and adaptation. Reductionist assumptions on the nature of uncertainty and its propagation through the system can lead to incorrect expectations. An example is that the form of a city may be represented by a static transport network that exhibits a characteristic pattern of mobility, but we lack understanding of how this network interacts with associated energy, ICT and user networks operationally and under conditions of nodal or sub-system failure. This issue is compounded when considering multiple overlapping uncertainties.

2. **Understanding the constraints and design to benefit from these**: High-order CES such as cities or national infrastructure exhibit constraints that are often not considered in the models used to predict their behaviour. Processes such as aggregation and self organisation create temporal and relational constraints. We need to understand how such developmental constraints relate to design and performance in order to benefit, rather than suffer, from such characteristics (Thompson 1917; Kauffman 1993; Goodwin 2001). This is also linked to the CES being constrained to exist in a low-dimensional medium: space-time. Consider a real world energy network is a high-dimensional abstract structure projected onto two spatial dimensions and allowed to evolve in time. A transport network is also high-dimensional in its connectivity, but the structure of this connectivity is constrained by the physical infrastructure that it inhabits (Havlin 2011). Increasingly we are beginning to better understand the role of spatial and temporal constraints in the behaviour and configuration of complex engineering systems. We need systems of systems tools to express these higher dimensional characteristics in order to explore and understand their inherent risks and resilience. In the same way, we are beginning to understand developmental constraints in the growth and morphology of cities (Batty 2009) through exploiting understanding of the behaviour of complex systems (May 1976; Feigenbaum 1980), but we are still mainly focused on the physical properties of cities.

3. **Leveraging natural world examples of complex systems**: Significant opportunities to improve resilience and performance lie in the potential to extend this understanding into the underpinning engineering systems and social structures. Our aim is to extract the design principles that define beneficial attributes and behaviours in naturally complex systems and use this to inform the design of socio-technical systems. As an example Advanced Energy

eco-systems, often referred to as Smart Grid 3.0, will require the properties of self-organisation, self-repair, robustness and adaptation characteristic of naturally complex systems (Carvallo, Cooper 2011).

4. **Managing uncertainty in Complex Engineering Systems**: A challenge for engineers exists in their ability to alter and control the behaviour of existing CES to have predictable performance under uncertainty. Whether this is reconfiguring an energy system to accept a dynamic mix of generation types or updating software in communication networks, the implementation of minor changes can have cascading multi-scale impacts upon systemic behaviour and performance (Newman 2011). Over time multiple changes are a record or description of the emergence in such systems. We need effective tools to deal with uncertainty when the identification of all statistical properties of a system is not possible due to its complexity. The risk associated with the emergence and propagation of uncertainties through complex systems renders the understanding of the degrees of redundancy or resilience of a network false. New techniques are required to understanding the transitional characteristics to develop our ability to predict such failures (Scheffer 2009).

5. **Understanding risks in coupled sociotechnical systems**: Research is beginning to link models of CES to models of decision making (Vespignani 2012) to provide a more comprehensive understanding of both the impacts of CES design and management on societies and the potential for societies to be affect of their surrounding infrastructure. For example, water and power networks are key to the resilience of societies, but each is vulnerable to risk and uncertainty on a number of levels. Exploring the mathematical approaches to such coupling of human and engineering systems is a ‘blue skies’ topic. Applications of particular interest will include understanding uncertainty that should feed through to improved decision making for infrastructure projects.

6. **Understanding the bi-directional impact of human behaviour on CES**: Modelling within CES tends to focus on the ways in which the technical components of systems interact. These systems do not operate in a vacuum as they are developed to serve societal needs. Understanding the ways in which systems impact employee/user behaviour, and the ways in which employee/user behaviour impacts systems is crucial in order to identify dynamic issues that affect CES resilience. Similarly, understanding the impact of systems on individuals, communities and society, as well as the impact of individual, community or societal preferences, responses and expectations, will inform the understanding of the effectiveness of CES. Currently, assumptions about the impact of employee public behaviour on the resilience and effectiveness of CES tends to be built upon anecdote or assumptions. Recent research into emergency response, and critical national infrastructure employee willingness or ability to report to work during extreme events, demonstrates that these assumptions are often inaccurate (Rogers & Pearce, 2013). Additionally, cyber-security research into employee behaviour demonstrates an innate ability to find workarounds when the system fails to meet the needs of the user (Sasse, 2014). Research opportunities might include the generation of an empirical evidence base related to the

impact of CES on human behaviour and the impact of human behaviour on CES in order to improve and adapt our current understanding of the resilience of CES.

Outwith the thematic areas above we would like to **encourage innovative approaches to understanding complex systems.**

Experimental tools allowing the investigation of emergent behaviour, evolutionary approaches to selectively pick resilient solutions and convergent algorithms to pull complex systems back to optimal behaviour when disturbed are all methods within the scope of our mission. It is even conceivable that learning algorithms can adapt to new environmental constraints and increase system performance beyond that designed in at the outset, ie we give the machine the ability to learn new behaviours but allow the freedom for the machine to decide what it learns.

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