EPSRC Centres for Doctoral Training - 2013 exercise
In 2009 EPSRC made a major investment in Centres for Doctoral Training (CDTs). Following a mid-term review on CDTs in 2011, which required the Centres to demonstrate progress and impact in their areas, Council agreed that a balance should be maintained between Centres and Doctoral Training Grants (DTGs). Therefore, we will maintain our level of expenditure for Centres.

Planning has begun for a CDT call which is likely to be issued in early 2013. We will identify priority areas as part of the call, and new and existing centres will apply against the priorities.

We have started engaging with key stakeholders on priority areas, which has involved a workshop and dialogue with Strategic Partner universities and companies. We will also be discussing priority areas with Strategic Advisory Teams. Comments on priority areas have been sought from Universities and EPSRC Strategic partners.

More details on the process will be made available in autumn 2012.

EPSRC ICT Theme
In addition to the engagement activities mentioned above, the ICT Theme has begun engagement with the ICT community on priority areas for the CDT 2013 exercise.

Centres for Doctoral Training typically support around 50 students over the lifetime of the grant, thus the ICT Theme is seeking to define priority areas at a breadth which requires this level of support. At this stage of engagement, we wish to consider all priority areas with links to the ICT Theme. This means that areas can be 1) predominantly in the ICT Theme remit 2) be led by other ESPRC Themes but have a significant ICT element or 3) require ICT trained graduates though the area itself is not within the ICT Theme’s remit.

In May 2012, the ICT Strategic Advisory Team (SAT) met to provide some initial thinking on priorities. We wish to share the identified areas with you and seek your views on these, as well as exposing skills gaps that may not be covered. This forms part of our wider engagement and will help inform the development of the CDT priority areas.
ICT CDT 2013 Engagement Form

Each of the following sections describes an area identified during our initial discussions under which several topics have been highlighted as belonging to it. For each of these areas we ask that you answer the following questions:

- Studentships within a Centre should share a common thread. How would you describe the thread for this area?
- Why would this benefit from a cohort approach to training?
- What topics should belong to this area but are currently not captured?
- What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist?

At the end of the form, the final section provides space to highlight areas not already covered. You are not required to complete all sections of this form, just those that you find relevant. However, if you provide comments to a particular section, all questions within it must be completed.

We welcome you to engage widely with your colleagues and to share this information beyond your own department, university or company. However, **we will only accept responses from those originally contacted, or their nominated representative. We ask that you collate any responses into the form below and record all those who have contributed to its completion.**

<table>
<thead>
<tr>
<th>Initial Contact:</th>
<th>Professor Michael Luck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affiliation:</td>
<td>King’s College London, Department of Informatics</td>
</tr>
<tr>
<td>Email address:</td>
<td><a href="mailto:michael.luck@kcl.ac.uk">michael.luck@kcl.ac.uk</a></td>
</tr>
<tr>
<td>Nominated</td>
<td></td>
</tr>
<tr>
<td>Representative:</td>
<td></td>
</tr>
<tr>
<td>Affiliation:</td>
<td></td>
</tr>
<tr>
<td>Email address:</td>
<td></td>
</tr>
</tbody>
</table>

Please provide the name and affiliation of any additional contributors:

- Steffen Zschaler, Department of Informatics, King’s College London
- Kaspar Althoefer, Department of Informatics, King’s College London
- Thirishantha Nanayakkara, Department of Informatics, King’s College London
- Peter McBurney, Department of Informatics, King’s College London
- Christian Urban, Department of Informatics, King’s College London
- Katarzyna Musial, Department of Informatics, King’s College London
- Laurence Tratt, Department of Informatics, King’s College London
- Kevin Lano, Department of Informatics, King’s College London
- Peter Sollich, Department of Mathematics, King’s College London

Please return to Christina Turner ([Christina.Turner@epsrc.ac.uk](mailto:Christina.Turner@epsrc.ac.uk)) by **09:00 Monday 9th July**. Forms will not be accepted after this date.
Big Data

ICT Systems; Intelligent Systems; Optimisation; Managing Big Data; ‘Towards an Intelligent Information Infrastructure’; One or more science or social science application areas; Statistical data analysis

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

Common denominator of all projects is the data science with such areas as data capture, storage, integration, management, curation, analysis and visualisation. Methods and tools for: processing of large-scale data, knowledge discovery in data, eliciting semantics, predictive modelling, visualisation, and adaptive mechanisms for changing data.

2) Why would this benefit from a cohort approach to training? (1000 character limit)

Correctly capturing and managing big data and its semantics requires many perspectives: research methods from social sciences to elicit and reason about tacit theories, techniques and concepts from statistics and computer science to provide a formal foundation for acceptable translations between theories and to perform analyses, software engineering expertise to build efficient and robust systems for managing big data, and HCI and psychology to design effective interfaces. This cannot be achieved by a single PhD project, yet these must be linked in training researchers to make connections and communicate in all these domains. It requires a cohort training approach across different disciplines. The skills required are multi-disciplinary, and students will enter this area from different backgrounds. Creating and educating a cohort means that students can each bring something and learn from one another, as well as from lecturers.

3) What topics should belong to this area but are currently not captured? (350 character limit)

a) Data modelling  
b) Predictive analytics  
c) Adaptation and learning mechanisms for handling changing data  
d) Data visualisation  
e) Ethnographics of data usage

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)

There is limited research on how big data is produced and consumed and how this affects its understandability and analysability. We are also still far from understanding how we can benefit from the implicit semantics for data analysis or transformation. Data-intensive science helps to integrate and unify experimental, theoretical and computational approaches to science but also requires new methods to tackle challenges arising from the vast amount of structured and non-structured data and their changing nature. There is currently enormous unmet demand for people (both in research and commercial worlds) with knowledge in the areas of statistical analysis, predictive modelling, and large-scale data processing [1], [2], [3].

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Quantum ICT

Quantum ICT; Quantum photonics; Quantum Technologies

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Core/Enabling Technology for ICT
Parallel systems; III-IV; Optical wireless Communications; Mixed signal microelectronics design; Radio frequency and Microwave; Electronic systems; Programming languages

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

A common thread is building reliable software and systems, which requires detailed knowledge in many interlocking topics---for example, reliable hardware, verification, software engineering, DSLs, security and software analysis.

Additionally, cyber-security, particularly graduates having both technology skills

2) Why would this benefit from a cohort approach to training? (1000 character limit)

In order to build a toolchain for reliable software and systems many components need to build on top of each other, and many approaches have to interlock (like reliable hardware, verification of components etc). It is clear that the required expertise cannot be obtained by a single PhD student; cross-fertilisation between `theory' and `practice' is also vital for producing actual software and systems.

The skills required are multi-disciplinary, and postgraduates will enter this profession from different disciplinary backgrounds. Creating and educating a cohort means that students can each bring something to the table and learn from one another, as well as from the lecturers. The same principle already applies in other multi-disciplinary training, such as in MBA programs.

3) What topics should belong to this area but are currently not captured? (350 character limit)

Software engineering, software analysis, reliable software development, programming languages / DSLs, game theory and social choice theory, norms and trust, multi-agent systems, social network analysis, complex adaptive systems, political theory

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)

Groups who work on whole or parts of toolchains for reliable software only emerged recently. In Australia and Germany two groups work on verified operating systems. In the US and France two groups work on verified compilers. There is nothing comparable in the UK.

Cyber-security, particularly graduates having both technology skills and awareness of policy issues. Evidence for gaps: Conversations with people having cyber defence and policy responsibilities in Government (eg, GCHQ, the Foreign Office) and in large private-sector organizations, such as banks.
High Performance Embedded Systems
Safety Critical Systems; Verification and Programme languages; Real-time systems; Software Verification; Parallel Systems.

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
ICT for Manufacturing

III-V Technologies; Cloud/Crowd Services; Radio frequency and Microwave; Optical wireless communications; Robotics; Photonics and Communications Systems; Optimisation; Simulation; ICT Manufacturing; Photonic Systems

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Robots within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

Given funding for robotic systems that can be companions for humans (Robo companion flagship in Europe, 2012 DARPA robots to collaborate with humans in disaster response, and Japanese robotics exoskeletons for the elderly and patients with neuro-motor disease), investment in human-robot interaction and human-robot co-existence is needed in UK.

2) Why would this benefit from a cohort approach to training? (1000 character limit)

A cohort approach is best suited because human-robot interaction has its own broad philosophical and scientific questions about how humans behave when they work in partnership with others with diverse capabilities, how they would depend on machine intelligence, what machine intelligence should achieve to win a reasonable respect from humans in a team, how robots should handle the delicacy of human body, imprecise memory, and uncertainty of human cognition, and what ethical constraints should be imposed on human-robot interaction. Therefore, this requires a highly-multi-disciplinary cohort that brings together diverse expertise from artificial intelligence, human motor control, human behavioural psychology, mechanics, control, languages, software, embedded processing, and concurrent programming.

3) What topics should belong to this area but are currently not captured? (350 character limit)

Implanted sensors for healthcare monitoring, wearable robotic jackets for rehabilitation, workout, and motor empowerment, adaptive automated environments in surgery, human-robot teams in disaster response, search and rescue, defence, etc.

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)

Existing gaps in human-robot interaction have been made clear by the DARPA challenge on humanoids in disaster response focussing on robots to utilize human tools, from hand tools to vehicles, advancing technologies of supervised autonomy, mounted mobility, dismounted mobility, dexterity, strength, and platform endurance. Supervised autonomy will allow robot control by non-experts, to lower operator workload, and allow effective operation despite low fidelity. European efforts focus on technology that integrates perception, cognition, emotion, and action with a contextual awareness of self, others, and the environment. Therefore, a CDT for human-robot interaction will be well poised to address embodied cognition, learning through interaction with humans, computational challenges of orchestration of intelligence, agent based systems, advanced perception, vision, olfaction, and audition, advanced human-robot
Medical ICT
Systems Biology; Bio-photonics; Medical ICT

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Core Analytics

Applied Maths e.g. Statistics; Computational Science; Optimisation; Maths and Software Sciences; Risk / Rare Events / Maths and Stats; Artificial Intelligence.

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

This can be seen as fitting with, or as part of, Big Data!

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Utility Computing (?)

Ethics; Future connected cities (plus communities inc. rural areas); Managing Big Data; Cloud/Crowd Services; IT as a utility; Smart cities; Infrastructure e.g. ICT/transport etc; Artificial Intelligence; Digital Economy – business models; Smart Grids; Pervasive and Mobile Systems; Safety/Dependability inc. supply chain logistics and shock analysis; Organisational information (e.g. knowledge capture).

1) Studentships within a Centre should share a common thread. How would you describe the thread for this area? (350 character limit)

2) Why would this benefit from a cohort approach to training? (1000 character limit)

3) What topics should belong to this area but are currently not captured? (350 character limit)

4) What skills gap do you feel this area will address? What evidence do you have that such a gap does or does not exist? (1000 character limit)
Additional Information
During the ICT SAT meeting it was highlighted that the following areas had not been captured but should be considered.

- Design
- Creative Industries
- Infrastructure at a high level (Roads, ICT, water etc.)
- Grand Challenges
- Agile Computing
- Core Skills Base – comms/CS/EEng in general

You may include comments on these areas within your answers to the following questions.

1) Are there other areas you would highlight as priorities?
   a. What skills gap would this cover, not currently covered by the areas above?
   b. How would you describe the common thread for this area?
   c. Why would this benefit from a cohort approach to training? (2000 character limit)

An important area for ICT is inference and Bayesian learning. This would include inference about networks, and could be broadened to include the study of dynamical processes on networks. In this context there are links to communications networks, so this is relevant to ICT. Also relevant are applications in bioinformatics and biomedical inference, including Bayesian survival analysis. There is an accepted shortage of statistically trained people.
2) Are there areas where there is a need to guarantee student numbers but a cohort approach is not an appropriate training model?
   a. What evidence do you have that such a guarantee is required?
   b. Why would a cohort approach not be appropriate? (2000 character limit)