

# **The Dependability Interdisciplinary Research Collaboration (DIRC)**

Mid Term Review

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**Panel Report**

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## **1. Introduction**

In 1987 the then Chairman of the SERC, Sir William Mitchell, presented a case for increased investment in academia to promote inter-institutional and interdisciplinary working – especially to facilitate the shared use of expensive equipment. In 1988 the government launched the Interdisciplinary Research Centres (IRCs), with additional funding to the science base. In 1994 an independent panel chaired by Sir John Meurig Thomas evaluated the IRC programme, and strongly endorsed the value of the IRC concept. Interdisciplinary Research Collaborations were launched in 1999 as the successor to the IR Centres. The Dependability IRC (DIRC) was one of the five IRCs launched at this time.

The aim of EPSRC in forming the IT-Centric IRCs in 2000 was to recognise the potential of IT to facilitate inter-institutional working, plus its increasing importance as a component in a wide range of interdisciplinary activities. There were to be three fundamental aspects of the IRCs:

- The new “IT-centric” activities should engage with a broad range of research groups from different disciplines, institutions and organisations;
- The IRC should agree to a mid-term science review to provide guidance for the project leaders;
- There should have been a strong involvement of users (from industry, commerce, government and elsewhere) in creating and developing the vision for the IRCs.

DIRC is a collaboration of five universities: Newcastle, Lancaster, City, Edinburgh and York, which involves sociologists, psychologists, statisticians and computer scientists. It aims to address the dependability of computer-based systems. Dependability is a deliberately broad term to encompass many facets including reliability, security and availability. The term "computer-based systems" highlights the involvement of human participants. DIRC bases its programme on five broad themes: Diversity, Risk, Timeliness, Structure and Responsibility. From these it derives activities on which to carry out research. The current project activities (PAs) are:

- Human Interaction in Real-Time Systems
- Organisational Culture and Trust
- Deployment and Evolution
- Decision Support for Dependability
- Open-Source Software (Completed)
- Security and Privacy in Computer-based Systems
- Ubiquitous Computing in the Home
- Collaboration in dependable software
- Dependable, Service-centric Grid Computing

During the latter part of the project the team plan to move from the longer term PAs to shorter Targeted Activities (TAs) to increase the focus given to completing work on the themes. This will mean restructuring work currently being carried out on the PAs.

## 2. Basis for the review

Originally envisaged as part of the conditions for funding, the mid-term review provided the opportunity for a substantial review of the activities and achievements to date and was designed to provide advice and guidance to IRC Directors and Steering Committees over the remaining period of the awards. The outcome of the reviews will also provide EPSRC Council with evidence to evaluate the IRC concept (for example on the added value in promoting interdisciplinarity and breaking down “silos” within universities), the ability to identify good practice (in terms of new ways of working), and the opportunity to publicise collectively what has been achieved. The IRCs were provided with funding for six years, subject to a satisfactory mid-term science review. It should be stressed, however, that the mid-term review was seen as a “quality” review of the activities to date against the original objectives and future plans, and not a financial review. The intention of the review was not to alter the funding of the IRCs.

The criteria for the review were based at two levels: firstly, there were high level generic criteria that might enable “read across” between the IRCs, including those that allow general messages about the IRC concept as a business model and how this is progressing; secondly, for each IRC, the extent to which the original objectives are being met, the extent to which any difficulties associated with the IRC concept have arisen and been addressed professionally and financially, and plans for the future, including the remainder of the IRC grant, and beyond. All five IT-centric IRCs were assessed at the same time against the same criteria.

Below are the generic high-level criteria that were used for all the reviews. It was recognised that each of the IRC is different, with different characteristics and styles of management, and can therefore be expected to have a different “footprint” against these high-level objectives.

- **Research Excellence or Quality** of science (knowledge) delivered against milestones and any mid-term aims and objectives, including recognition of the interdisciplinary team as leading players in the field;
- **New opportunities for science** enabled by the IRC approach, including the extent to which it had influenced culture changes within the team, the wider research community, and within the universities themselves;
- **International recognition** of the IRC and its research, and its level of engagement with the wider international community;
- **Level of Collaboration** with users, especially industry, and participation in a meaningful way in genuine collaborative research and management of the IRC;
- **Sustainability** and re-use of the infrastructure provided through the IRC, including the development of students and research associates;
- **Dissemination and other indications of exploitation** where, and in what ways, the project has disseminated research outcomes, and IPR;

- **New ways of working** including interdisciplinary research, types of collaboration and technology transfer, and management of interdisciplinary and geographically distributed teams.
- **Good management** procedures and practices, including the adoption of risk management approaches, and flexible financial arrangements within the IRC team.
- **Plans for the future** covering both the remainder of the research grant and longer-term plans beyond the life of the IRC award.

### **3. Findings against generic criteria**

#### *3.1 Research Quality*

A thorough review of the research was carried out by the Steering Committee, which was set up as a senior review team, wholly independent from the programme. The research review by the Steering Committee benefited from their existing, in-depth knowledge of the work being undertaken.

The findings of the review were presented to the mid-term review by Prof. Martyn Thomas, chair of the Steering Committee, and a member of the review panel. The review panel concluded that the research being carried out was world-class and was redefining the international scientific landscape for dependable systems research. They felt that there was very strong interdisciplinary work at the heart of the scientific achievement and that there was great promise for the remaining three years of the EPSRC grant. The review panel felt that none of this would have been possible without the scale, flexibility and duration of the IRC funding.

In DIRC, two strands of the computer science community (formalists and statisticians) that had traditionally maintained separate views on dependability were now working together to great mutual benefit; the review panel were also extremely impressed by the difference that the social scientists and psychologists have brought to dependability research. One reason for these achievements is that social scientists and psychologists have methods for evaluating empirically, and thus formally, assumptions about human interaction with technology that computer scientists have tended to assume without proper evidence. The methodology that has been imported will have a lasting impact on computer science. The review concluded that the interdisciplinary aspect of the collaboration has exceeded expectations.

For the mid-term review, it had not proved possible to ensure that every published output had been captured and categorised into journals, refereed conferences, conferences, etc. For the final report of the IRC's activities it would be important to identify the top (e.g. six) publications with the highest impact. DIRC were recommended to capture the raw data over the remainder of the project, to prepare for later reviews. The review panel recommend that the EPSRC revisit the project three years after the end in order to answer questions such as: What happened to the people? What was started as a result of the 6 years of EPSRC funding? What impact was there?

In conclusion, the existence of the word "DIRCish" within the dependable computing science community says a lot about what has been achieved by the team; it would be

even more of an achievement if the word started cropping up in the wider science community.

### *3.2 New Opportunities for Science*

The main opportunities for new science spring from DIRC's achievements in creating true interdisciplinary research involving computer scientists, social scientists and psychologists. Continuing on this theme, a link could be made with another IRC (Advanced Knowledge Technologies [AKT]). DIRC and AKT work in complementary areas and as such could carry out research that would underpin the cyberstructure of modern society.

The DIRC team has learnt to recognise, embrace and respect the very different value sets of their constituent disciplines. This in itself is a scientific result that needs to be recognised and published. The review showed that multidisciplinary working is a much more complex issue than is generally recognised, and that the different scientific disciplines have surprisingly different professional values and attitudes; the review team wondered whether the ESRC could be asked to commission a survey or research into the best methods to be employed to help projects succeed. A measure of the success and dissemination of the programme would be if future researchers in each area (i.e. computer and social science) spontaneously thought "I need input from a computer scientist/social scientist rather than someone in my area".

The DIRC team are creating a new research agenda for dependability. The present boundaries are not those that will remain in the long term, this will more likely be much larger area i.e. coming together with other IRCs, etc.

### *3.3 International recognition*

DIRC was seen as working "ahead of the wave" and as a result it may be difficult for other researchers to appreciate what has been achieved. The review panel felt that the esteem indicators were strong and indicated significant interest amongst the international community; the team need to promote this interest into take up of their ideas. There is plenty of evidence that the international community recognise DIRC and there are many leading researchers that appreciate what they are doing. Having said that, appreciation within the UK is not necessarily as strong and the team have found that their work does not necessarily fit into existing journals. DIRC were strongly discouraged from setting up their own journal; the review panel thought that it would be a much better use of time, and better for future community integration, for the team to concentrate on integrating DIRC's methods and encouraging their take up, rather than concentrating on producing a journal. Intertwined with this debate, the review panel agreed with the DIRC Director that the web site is very important, so this should be considered a significant part of future dissemination. It should be good looking, have plenty of information and the team could also use glossies for publicity to companies, etc. On the issue of raising awareness the team were encouraged to invite one or two leading UK researchers to their workshops to help integrate DIRC's results into wider UK research; to continue to participate in important conferences, and to continue their "visiting scientists programme", which has helped to raise their profile internationally. The involvement of team members within the UK Government's *Foresight* activities was also seen as an important way of building their reputation within the UK.

### *3.4 Level of collaboration*

There is good interaction within the PAs in terms of academic collaboration. The Industrial Advisory Board (IAB) was seen as a valuable resource for advice and links into industrial collaborators. The review panel felt that in order to achieve their goals it was important for DIRC to do more in this area for the remaining half of the project. There need to be more targets and milestones and a quick turn off mechanism to use when negotiations towards a possible collaboration aren't getting anywhere.

### *3.5 Sustainability*

At the research review, ten out of the eleven technical presentations were by new generation i.e. students and postdocs. The presentations were all very well done and the review panel welcomed the input of the younger team members. There will continue to be an influx of younger researchers up to the end of the project as EPSRC studentships will be awarded until the end of the grant funding i.e. several students will continue beyond the life time of the grant. There was concern amongst the panel that, as the grant nears the end of the funding period, collaborators might be concerned about starting a collaboration that won't necessarily continue. There could be a case for a much larger international institute, which would not be within the scope of EPSRC funding; the project partners could consider approaching Europe, etc. A measure of success in achieving long-term sustainability would be to what extent the leading researchers can step back and allow the younger generation to take up and build upon their research ideas. There is the potential for a generation gap to form between the RAs and the "grey beards", although the panel were reassured that this has already been recognised as something to be addressed by the DIRC Executive Board. The team should work hard to ensure that there is a continuum through the levels of experience, thus ensuring a constant and stable flow of researchers i.e. younger people should be brought into the decision making/ideas processes and given appropriate responsibilities as their level of experience increases. It is also important that researchers trained within DIRC move on to work at different universities, and into industry, and spread their knowledge and skills in this area. The team have done well to bring the younger people on and should keep remembering to develop them and "hand the baton over" as appropriate.

The panel expressed concern about possible "re-entry scenarios" for the team members as DIRC funding came to an end. There could be a feeling of jealousy within the wider computer science research community and possibly non-integration issues could make the acquisition of grants difficult. The panel felt that the responsibility was on DIRC to make sure that there is enough mentoring for junior staff to ensure that as the project comes to an end they can compete in responsive mode and to ensure that they are integrated back into the community.

### *3.6 Dissemination*

One of the main publication outputs is expected to be a series of books based around the research themes, as outlined in the original DIRC proposal. In addition to these books, there will be the usual research publications in journals and conferences, as well as posters, talks, etc. There will also be a range of DIRC methods and supporting tools. The tools will be at the prototype level rather than be developed as products within the DIRC timescales. An area of risk for the team is whether the developed tools will be taken up and used by the academic and industrial communities. To mitigate this risk, the team are advised to get the tools out into the

world and encourage their use as soon as possible. The team are knowledgeable and experienced about scientific dissemination; one particular issue for the team to manage is the perceived problem with publishing in mainstream journals. To counter this they need to be proactive and may like to consider activities such as workshops, special issues of mainstream journals, and virtual publishing on the DIRC website. The writing of case studies could help to raise interest in general. Domain focused, rather than subject focused journals (e.g. The Journal of Childcare) are inevitably interdisciplinary and could help increase user interactions. A proactive process of dissemination and engagement with the community needs to be set up so that in 3 years time, when the earmarked EPSRC funding for DIRC comes to an end the community believes that it has been useful for them and that the “DIRCish” ideas get carried out into the broader community.

### *3.7 New ways of working*

The team have used their skills in a number of different sectors; thus far, most progress appears to have been made within Healthcare. Rather than focusing on the hardware or software the team have taken a holistic approach to the whole system, including the human operator and have shown that, in some cases, adding computer support for diagnosticians can make diagnoses *less* accurate. The focus has only been possible because the team have computer scientists and social scientists working together. DIRC has had to overcome a variety of difficulties in achieving real interdisciplinarity; this includes changing the time scales at which different sciences like to engage in a problem. For example, it is common in the social sciences for the same issue to be studied over months or years, rather than in the area of computer science where a practitioner might expect to spend a few days or weeks fixing a problem. There has been a valuable combination of empirical and computing science, leading to greater changes in the way in which computer science is done rather than the way in which sociology studies are completed, although there were signs that the computer scientists may have a significant impact on social science methods over the second half of the project.

The review panel felt that establishment of the Steering Committee as more “hands off” from the management of DIRC had enabled them to act as more independent arbiters; this had proved useful and focussed the minds of the team. In addition they felt that the matrix approach of having both cross cutting research themes and project activities within DIRC had worked well.

### *3.8 Management*

The team operates an Executive Board, consisting of the project director and other PIs. The membership of this board has proved stable, which was helpful for dealing with issues as they arose. The matrix structure means that people work together as one team rather than in individual institutions on particular projects, and hence it is important to have this top level strategy board.

In the initial period the Steering Committee has been very independent, thus giving focus to the team’s ideas; over time this can be expected to change as members get closer to the project to help ensure the sustainability of the research, thus it will be inappropriate for the Steering Committee to carry out an official review of the science towards the end of the project. An important factor in the success of the relationship between DIRC and the Steering Committee has been that the project team have been

frank and open with the Steering Committee, ensuring that the best science is carried out within the approved envelope of funding.

Several aspects of risk to the project have been identified and are being actively managed. One of the identified risks is that typically as research projects come to an end they tend to underspend, especially on staff as people move on to other positions. To mitigate this risk, the team have got off to a flying start and are currently overspending against the staff profile. This will be managed down towards the end of the IRC to fit within the funding available. Another identified risk is that the themed books might not be produced, although the reviewers were heartened to see draft chapters of one book and to hear that the contents list of another had just been prepared. Now that half the project has been completed the team are refocusing their efforts, in order that the work can be written up into the books. The review panel were pleased to see this approach and would welcome the same management technique being applied to the DIRC methods, to ensure that these also come to fruition and can be taken up by the community. They reminded the team to consider what they actually want the outputs of the project to be and that, as they cannot do everything, they should consider developing a prioritised list of key outputs. If it were considered better for the DIRC tools and methods to develop over a longer period of time, the team might choose a strategy that leads to better tools being published in year 8, for example.

There was some concern amongst the review panel members about what happens as the project nears completion, especially in terms of staff being assigned to different roles, such as one of the PIs being asked to assume a departmental headship within the last couple of years. If such things do happen it is clear that the PI would no longer be able to offer so much input and, in such a case, the project director should seriously consider using his power to move activity away from that particular institution. The review panel enquired about the extent to which the authority which the project director could wield was being fully utilised. Within one large project it is possible to move resources around to ensure that the most suitable persons are carrying out the most exciting research as the programme develops. To some extent this laudable aim is not aided by the universities themselves, who are predominantly interested in their individual research income. Also as the research changes it can be difficult to move resources around as it is often necessary to honour contracts to RAs, etc. If there is a case where a university is underspending its allocation, for whatever reason, it would be better to move those funds into another area so that further research can be carried out rather than the resources remain unused. With such a large amount of public money invested in the IRC it is necessary to work carefully to ensure that every penny is well spent on the best research.

Within the DIRC team there is concern about the time which PIs can contribute to this project, because of other institutional pressures; a carrot and stick approach could be taken by the project director in negotiations with the university to release as much time as possible for the PIs in return for shares of the funding. A generic lesson learnt from running this IRC is that it is much better to have one central pot that can be distributed dynamically rather than earmarked individual grants to the constituent partner universities.

### *3.9 Plans for the future*

The DIRC team plan to increase and strengthen their links with the Health sector. They already have links into several regional authorities, which have led to links in neighbouring authorities. Other application areas that could be exploited are defence, and involvement in the *Foresight* “Cybertrust” project.

The most important activity to be undertaken is for the team to get the DIRC methods out into the community. Therefore they should consider how best to achieve this goal, and also the balance to be drawn between these promotion and validation activities and undertaking new science. The review panel expected that new science should be carried out but that this should be carefully balanced against validation, etc. activities as the project progresses. The review panel were adamant that they did not want the activities of DIRC to cease at the end of year 6 and so encouraged the team to look to alternative sources of funding, via a balanced portfolio of e.g. industrial support, EU funding, etc. Another idea included continuing and expanding the ideas via some sort of network; for example, a possible network might be joint with the Advanced Knowledge Technologies (AKT) IRC. The DIRC team need to consider developing a forward management plan for years 7, 8 and 9 (i.e. beyond the period of the EPSRC award).

#### **4. Comments against high level criteria (not captured elsewhere).**

##### *4.1 Review the IRCs as a potential funding mechanism for future large projects.*

The review panel commended EPSRC for foresight in funding interdisciplinary work. The six year funding window set aside for the IRCs was seen as absolutely necessary for the collaborations; owing to the nature of interdisciplinary work, it is necessary for there to be a learning period, where researchers learn to understand and respect the skills, values and intricacies of the other subjects, as well as planning the work that can be done together. This means that researchers are being asked to take a period of time where they are likely to have a very low publication output, whilst learning new skills that can then be applied to a new area of research. Six years provides enough time to offset this risk, and means that leading researchers are prepared to get involved in projects even though there is a major learning curve.

##### *4.2 Consider the ‘added value’ generated from the approach and interdisciplinarity of the IRCs.*

Dependability of computer-based systems is now seen as being best addressed by looking at the whole computer system, including the human aspects of the system such as the operator. This type of research would have proved difficult to carry out before the formation of this IRC.

##### *4.3 Comment and provide recommendations for the benefit of the IRCs to the IRC and EPSRC, especially in relation to the interfaces between the IRCs, users and EPSRC.*

The decision to form an independent and senior Steering Committee meant that it was able to provide robust advice to the project team. This has helped to ensure that the very best research was carried out in a focused manner and has been seen as a significant benefit by the project director.

##### *4.4 Identify aspects of ‘good practice’, rather than ‘best practice’, for the IRCs.*

Senior visiting fellows have proved an excellent way to involve a wider group of leading researchers, both scientifically and in terms of value for money. Many continue to be involved in the project after their return to their home institution. The

Steering Committee and industrial advisory board have also provided valuable advice. Several activities have been run with “Operational Research like” teams (where a team drawn from several disciplines comes together to address a well defined problem on constrained timescales) which the researchers believe fosters the strong interdisciplinary nature of the work. The team have also found that it is important to work as an integrated team, rather than cross cutting sub-sets based on status, such as permanent staff, RAs, students. By working as one team, everyone is aware of what is happening within the large project.

## **5. Conclusions and recommendations**

The balance between the medical domain work and the other areas is good; it is neither too strong, nor too weak. The same is true for the balance between interdisciplinary and inter-site activity. The team has taken the view that, since it is an IRC, interdisciplinarity should always predominate and inter-site aspects should be adjusted to make sure that the collaboration remains effective as a team and focused.

The balance has to date been focused on research rather than dissemination, although an impressive number of papers have already been published. However, it is now time to think about delivering tangible outcomes by the end of the project.

EPSRC should work together with the IRCs to re-publicise the outcomes of the IRCs, based on these mid-term reviews, by the end of the year,

DIRC was encouraged to seek additional support for assistance with outreach activities or, if such support was not available, measure how important this activity was relative to the other activities in the project and redistribute funds accordingly.

The Steering Committee has provided a very useful, independent function to ensuring that the team examines all research priority and other questions closely, to ensure that the correct decisions have been made. Now that the work is well under way there may be greater scope for the Steering Committee to act as advocates for the project, assisting in areas such as sustainability/dissemination/generating interest of the results within the wider community.

Due to the nature of the distributed collaboration, team members have found that their travel has been greater than expected, therefore the team is encouraged to use whatever technical and efficiency solutions that they can find to reduce this overhead on their time. Additionally it should be possible to reduce the pressure on the travel budget by carefully planning the best ways to reduce the cost of travel and accommodation, such as hiring halls of residence for meetings, etc.

The legal/economic aspects of this work are interesting but the review team advises that they should not be allowed to divert the team from their planned goals and objectives for the next three years. A workshop could be held in this area and the team should carefully manage this to ensure that they are not raising expectations by bringing such experts into the collaboration. To do so could lead to a defocusing of the activities over the remaining period of the award.

DIRC is unique amongst this round of IRCs in that it did not propose to develop a specific product, but rather to advance scientific understanding across a broad front;

the success of DIRC will therefore be measured by the pervasiveness of the “DIRC methods” through the community and the way in which the community, external to the DIRC partners, speak of and use the outputs.

The team should work hard to finalise agreements with various industrial partners and should strive to recruit as many partners as possible, taking a very pragmatic view to their recruitment i.e. a quick no is better than a very long drawn out negotiation that has only a low possibility of turning into a collaboration.

DIRC should consider carefully its plans for the time beyond the EPSRC funding. For example, it might be appropriate to attempt to set up some sort of EU dependability institute.

The panel was concerned that because DIRC was so far ahead of the rest of the dependability community and doing something completely different, they had experienced difficulties in getting their work published in existing prestigious journals – so much so that there had been mention of starting a new journal. This route would be disastrous as it would create an artificial division in the dependability community; both the Steering Committee and the mid-term review panel strongly urged the team not to follow this route. Rather it is more important for DIRC to raise awareness of their achievements and activities within the UK community, as they have done on the international stage. This would help to ensure that the UK community can become aware of the methods that will develop and appreciate the way in which formal methods, statistics, psychology and social sciences have come together to solve problems in a holistic manner, rather than concentrating on e.g. making sure that programs are bug free. The team should actively seek to alleviate this problem by (for example) inviting colleagues from the UK community to their workshops, and giving seminars, etc. at universities outside the collaboration. Other institutions are more likely to welcome this approach if there is something arising from interaction with DIRC that can add to their own research.

It is important for the team to address this issue because in three years or less they will want to bid to funding agencies for further research, which could easily prove problematic if the rest of the community does not understand or appreciate what they have done. There is still a large amount of research going on in dependability in the UK outside of the IRC. It is important that the interdisciplinary approach fostered by DIRC is diffused into that wider community.

The panel requested that the web-site be updated and regularly maintained to ensure that the most accurate and informative material was presented, to best represent the IRC’s goals and achievements.

The DIRC team was encouraged to proactively manage their relationship with the officers responsible for Dependability in the European Commission’s Framework Programme 6, and to invite them to workshops, to talk about views of dependability and therefore to be educated in the “DIRCish methods”.

The panel felt that it was appropriate to consider what the establishment of an IRC had achieved over other forms of support, such as an equivalent managed programme or responsive mode. They concluded that managed programmes could never achieve

the level of coordination that an IRC does. However, this comes with an overhead of the time of the project director and lead researchers, which tends to be greater than that of a managed programme, because of all the coordination activities which must be carried out. The IRC requires a longer-term commitment by individuals than a managed programme in order to allow researchers to really explore the new area and spend a period of time learning in order that more effective progress can be made in an interdisciplinary area. Responsive mode enables the best researchers to bid for funding as and when they wish to, but can lead to fragmentation and the lack of coherence within research areas. IRCs act as a magnet for the best people in particular areas and so the issue in comparing the two is not in terms of quality but rather in terms of making things happen and getting the best groups working together; this can most easily be achieved via the IRC mechanism. The management of the IRC is crucial to ensuring that the large and flexible allocation of funds is used in the manner in which it was intended to be used, i.e. flexibly so that the most exciting and appropriate research can be done. Entities such as industrial advisory boards are rarely, if ever, created for managed programmes or to direct responsive mode. By founding such boards, opinion and expertise are brought in to assist in focusing the research into the most appropriate areas for potential take up and wider use. It was felt that it would be more difficult to attract persons of high international standing to serve on such boards and advisory committees without the presence of the IRC label.

The review panel noted the inevitability of the Steering Committee “going native” as the IRC developed. This was natural and advantageous, as it allowed members to become more firmly aligned to the interests and activities of the IRC, but also meant that the Steering Committee should not review the science for EPSRC at the end of the 6 year period.

The review panel was impressed with the organisation and success to date; achieving true interdisciplinary working had not been a trivial task. The team was informed that they have exceeded expectations so far and that it is clear that really exciting results will happen in the next three years, so expectations for next three years are now even higher!

DIRC has made an impressive start. Now that it is past the half way point, the team was advised to keep up the quality, momentum and outputs, as they also looked to the future beyond EPSRC core support.