

Project Acronym: e-Uptake

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e-Uptake Final Report

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Executive Summary

The aim of the e-Uptake project was to identify and study inhibitors and enablers of adoption of e-Infrastructure services and to devise and, where possible, implement practical interventions to foster adoption of e-Research methods and e-Infrastructure services. In order to achieve this aim, we gathered evidence through more than 100 interviews with researchers and intermediaries such as members of research computing services. We also continued an ongoing data collection on training requirements and gathered data on training provision. Together, the findings provide the most comprehensive overview of the factors influencing adoption that has been collected to date.

Because the wealth of information cannot easily or usefully be distilled into a single report, we have opted to present them mainly through an online database of findings that stakeholders can use to find the information they are interested in and to conduct their own analysis according to their own needs. The use of hyperlinks and keywords allows more complex relationships to be expressed than can be done in a linear textual format.

Based on this corpus of evidence, we developed a number of interventions in the area of training, outreach and education. Our analysis of gaps in provision of such activities has identified a need to embed them more strongly in institutions and existing knowledge transfer arrangements. Also, there is a need to provide more seamless engagement that follows on from initial interest to the support of activity planning and decision making, as well as the acquisition of skills. The training, outreach and education activities developed by e-Uptake correspond to these stages of uptake.

The JISC e-Research Roadshows are a spin-off activity from the e-Uptake project; they aim to raise interest among researchers through a series of tailored presentations at institutions around the country. The *Research in a Connected World* brochure contains a coordinated collection of articles that allow researchers to deepen their understanding of the principles of e-Research and distributed computing. A series of training events and a UK Summer School as well as online training material to support the acquisition of technical skills have also been developed with support from this project. For example, we provided a sequence of three training events specifically aimed at Arts and Humanities as well as Social Science researchers. In order to address the issue of researchers being asked to commit large amounts of time to gain the necessary skills, the first part provided a normal introduction to data integration using OGSA-DAI and was followed by an online event to deepen understanding. The final part took the form of a hands-on workshop where researchers were invited to discuss their specific data integration problems with the OGSA-DAI team. Other activities included the development of a tutorial on social simulation and the development of online training material for the Arts and Humanities.

Based on the corpus of material produced and our analysis of it, we are in a position to draw conclusions and make recommendations that we hope will be taken up by stakeholders such as funders, institutions and service providers to improve the provision for the needs of researchers adopting e-Research practices. In particular:

- Investments must be made to foster a pervasive and consistent support infrastructure both at the local institutional level and nationally. This provision needs to be funded long-term and with realistic career prospects for staff involved.
- Education, outreach, training and support activities need to be better integrated to provide an appropriate level of support at all stages of adoption and tailored to specific audiences. An appropriate training infrastructure needs to be available on demand.
- There is a need for an ongoing community engagement strand that can continue to feed information into the work of service providers and other stakeholders to ensure that pathways to adoption are created that maximise the benefits that e-Infrastructures services bring to the community.
- There is a need for much closer collaboration between technology developers, service providers and researchers in order to ensure that tools and services meet the needs of research communities.

1. Background

The academic research community is entering a period in which a new kind of digital infrastructure – comprising distributed, networked, interoperable computing and data resources – is becoming widely available. Commonly known as cyberinfrastructure in the US and e-Infrastructure in the UK and Europe, it is expected to lead to new forms of research (sometimes referred to as e-Research), not least by enabling and promoting large-scale and interdisciplinary collaborations that, over time, will become accepted, essential components of research practice across all disciplines. In the UK, the Research Councils and JISC have funded a number of services that provide resources to researchers that build on technologies and capabilities developed by the e-Science Programme. These services provide generic compute and data resources (e.g., through the National Grid Service), more specialised research services (e.g., through the National Centre for Text Mining), support for collaboration in research (e.g., through the Access Grid Support Centre), advisory and support services (e.g., the Digital Curation Centre or the UK Access Grid Support Centre) as well as basic infrastructural services for identity management (through the UK Access Management Federation and the UK e-Science Certification Authority).

Together, these services provide the building blocks of e-Infrastructures that enable new ways of doing research – e-Research – that have the potential to lead to a significant change in research productivity and the ability to tackle research questions previously beyond reach. In order for the e-Research community to realise the full potential of e-Infrastructures for research, issues about the uptake and embedding of these socio-technical configurations in day-to-day working practices need to be addressed, and opportunities for widening the uptake need to be understood and exploited. The UK's JISC has recognised this and has funded three Community Engagement projects (Voss *et al.* 2007, see outputs). The eIUS project focuses on uncovering and documenting existing usage of e-Infrastructures that may inspire further uptake. More information can be found on the eIUS website at www.eius.ac.uk. The ENGAGE initiative aims to uncover examples of e-Research projects that can benefit from a short-term injection of effort that helps them to overcome concrete obstacles they face.

The Widening Uptake of e-Infrastructure Services (e-Uptake) project complements the other two projects by studying the inhibitors researchers face in taking up e-Infrastructures and by documenting and leveraging possible enablers that may help to overcome them. Its aims therefore are of a more strategic nature, informing the decision making by a range of stakeholders such as services providers, institutions, funders and the researchers. In the following section we will discuss the concrete aims and objectives of the project in detail.

2. Aims and Objectives

In order to capitalise on the opportunities that e-Research offers, pathways for the diffusion and uptake of e-Research approaches and e-Infrastructures must first be understood and then be made as smooth and well supported as possible. This involves the identification of factors that either inhibit or enable their uptake and the translation of the knowledge gained into practical advice and action that would lead to these factors being mitigated. This was the core aim of the e-Uptake project. This empirical part of the project set out to collect evidence from researchers using e-Infrastructure services on the one side and from intermediaries such as university research computing services and e-Science centres on the other. This combined evidence was complemented by a review of the existing literature to provide a comprehensive account of the state of adoption, the inhibitors and enablers of uptake, and recommendations based on this understanding.

The aims of the training workpackage in e-Uptake were to develop an understanding of the requirement for e-Research training and education in the UK and to pilot examples based on this requirements gathering. Our experiences with running such events, together with the outcomes of the training requirements and provision surveys, have led us to reconsider these aims. One of the reasons for this was that it became clear that the level of uptake within the Arts and Humanities disciplines and the Social Sciences is relatively low and that at any point in time only relatively few researchers are in a position to benefit from traditional training events. Instead, what is needed at present is early outreach and education as well as the delivery of specific interventions to help projects move from one stage of uptake to the next, e.g., from project formulation to technology

selection (*cf.* Voss *et al.* 2008, see outputs). The early intervention part of this in particular requires interventions that *scale*, both across domains and as the adoption of e-Research approaches increases. Consequently, we shifted our focus from small-scale traditional training events to the production of re-usable outreach and education material and larger events such as roadshows and summer schools.

Another main aim of the training workpackage was to develop a UK one-stop-shop for information about events, digital library contents and support contacts. Here, the collaboration with the ENGAGE project led to the decision to focus on the back-end and federation functionality while using the ENGAGE portal as the delivery mechanisms through which researchers would access the content.

3. Methodology

This section describes the methodological approach taken in the empirical work of the project as well as the approach for developing practical interventions and the UK one-stop-shop.

3.1. Conceptual Background

As the starting point for its study of the adoption and diffusion of e-Research approaches and supporting e-Infrastructure, the project took a conceptual perspective rooted in studies of science, technology and innovation. In Voss *et al.* (2007, see outputs), we outlined this perspective, which is perhaps best summarised as *mutual shaping* (Williams and Edge, 1996): technological development and social processes influence one another. This perspective is in opposition to technological determinist views that claim that technological development follows its own internal logic and 'impacts on' society. At the same time, it also takes issue with views at the opposite end of the spectrum that argue that technologies are entirely 'socially constructed' phenomena and so neglect to acknowledge how technical realities may constrain the choices available to social actors. Mutual shaping stresses the interplay of both technological impact on the one hand and social processes of adoption, adaptation and shaping of the direction of technological developments on the other.

An important consequence of this view of mutual shaping is to see the decisions that different actors make in their wider social and organisational contexts as being equally important as technological factors. Our investigation of factors inhibiting or enabling the uptake of e-Research approaches and e-Infrastructures therefore had to cover aspects such as organisational arrangements, career paths, training, funding, research policy, etc. While it is important to realise the role of the organisational and wider social context in the study of any technology, it takes on a specific significance when we consider the development of infrastructural technologies such as e-Infrastructures for research (Edwards *et al.* 2007). Processes of infrastructural development are contingent on a large number of social and technical factors but while there is much uncertainty at any point in time, there are also "shared patterns, processes, and emergent lessons that hold widely true across the comparative history and social study of infrastructure" (*ibid.*, p.1).

Edwards *et al.* suggest that "effective infrastructures are rarely 'built' in an entirely top-down, orderly, and blueprint-like way" (*ibid.*, p.2) and that use of technologies, and in particular infrastructural ones, is often deeply embedded in a complex web of socio-material relations. Consequently, we also had to go beyond the separate consideration of individual factors and instead try and uncover the complex interactions of different social and technical arrangements, ranging over of technology supply, technology configurations, service provision, uptake, appropriation and usage.

3.2. Empirical Approach

To achieve the aims of the project we had to look beyond isolated, contingent or random problems that people encountered in employing e-Infrastructure services. Rather, we sought to identify recurring, widespread barriers that could be overcome by a set of targeted interventions that the project itself has been able to pilot or to make recommendations that might be followed up by e-Infrastructure stakeholders. Furthermore, the study had to reflect the diversity of the target population (research active members of the UK academic community), their different interests and possible uses of the services (from the Access Grid Support Centre to the National Grid Service) and the number of potential factors influencing uptake (from individual practices to organisational factors and wider

research policy). It was important for us to sample not just the views of early adopters but also those of people who had not yet engaged with e-Infrastructure services in order to understand the factors underlying this. In addition, we needed to contrast the information gathered from academic end users with the views held by service providers and technology providers as well as intermediaries such as application developers, e-Science centres and academic hosting institutions.

The first step in our research was to review the existing literature on uptake of e-Infrastructure services in research and to analyse existing data collected as part of previous and ongoing activities of the project partners. This work resulted in a list of barriers identified in the literature as well as an initial list of enablers and candidate interventions to address these barriers. These findings were organised through a typology covering and further detailing the various dimensions identified above. Based on the understanding gained through the literature review, we developed a two-stage fieldwork approach that focused on researchers in the first stage and on research computing services and other intermediaries in the second.

The most significant projects identified were the Study of Users' Priorities for e-Infrastructure for Research study (SUPER: Newhouse et al., 2007), the AHRC e-Science Scoping Survey (Anderson, 2007), the Log Analysis of Digital Resources in the Arts and Humanities study (LAIRAH: Warwick et al., 2006), the Accelerating Transition to Virtual Research Organization in Social Science study (AVROSS: Barjak et al., 2007), the Dealing With Data report (Lyon, 2007) and the Scoping e-Infrastructure Usage report (Mascord et al., 2007).

For the first group of respondents – the researchers – we developed a questionnaire eliciting basic information about their background and research activities, their involvement in e-Research projects, their experience in using advanced ICTs, their use of JISC-funded and other services and their use of support and training mechanisms. The questionnaire is included in Appendix B of the Community Engagement Report (Deliverable D1.2). This was complemented by telephone or, where feasible, face-to-face interviews. These were based on the answers provided in the questionnaire and took the form of semi-structured open conversations with the aim of eliciting more contextual information about researchers' use of ICTs. A proforma was developed to guide the interview process. This is included in Appendix C of the Community Engagement Report (Deliverable D1.2).

The second round of interviews focused on members of staff within research computing services in research institutions as well as other intermediaries such as staff at e-Science centres. Here, the approach taken was to conduct interviews guided by a proforma comprising questions about service provision at the research institutions studied. This proforma is included in Appendix D of the Community Engagement Report (Deliverable D1.2).

3.3. *Development of Interventions*

As training was already identified in the JISC call as a major area where interventions would be required, we also ran a training survey as a continuation of surveys that the National e-Science Centre's Training, Outreach and Education Team (TOE) has been conducting for a number of years to elicit information about training provision and requirements. This longitudinal collection of data was used as a basis for an analysis of the changing requirements for training and education. The changing nature of these requirements gives some indication of the rate of maturation of the field as a whole. An analysis of this data highlighted a number of requirements that had not been anticipated at the start of the project. In particular, a clear need was identified for introductions to the basic concepts of distributed systems and e-Research. This highlights a move in researchers' perceptions of e-Infrastructures as they become aware of the needs for not just gaining basic skills to manipulate the infrastructure but come to an understanding that they will need to modify their approach to research to encapsulate "computational thinking" in parallel with making use of the infrastructure. This change in approach can be partially characterised by the growing inclusion of simulations within the research process in addition to the normal model of hypothesis generation and testing.

Another aspect is that the demand for Arts & Humanities and Social Science hands-on courses turned out to be less well developed than was anticipated at the beginning of the project. This may reflect the lack of mature applications in this area. Greater demand may appear as more applications for these

communities become widely available on national infrastructures and as the circle of researchers actively engaging with e-Research widens beyond the early adopters.

Consequently, we had to rethink the originally proposed approach of running a series of training events. Instead, we decided to pursue a broader strategy to influence the development of training provision in the UK and internationally. Figure 1 is an attempt to show the inter-relations between the activities of the e-Uptake project and the context in which they operate. The three deliverables of training sustainability, training requirements, and training gap analysis sit between training interventions and the community. They provide a mechanism by which intelligence was gathered to shape the interventions developed in the e-Uptake project. In addition they are designed to provide the context for helping to shape policy in this arena based on objective studies of a broad sweep of requirements across domains.

Growing out of the evidence gathered, we developed a group of interventions such as the UK one-stop-shop, training and education materials, training events, e-Research roadshows, etc., some of which were predictable at the beginning of the project, some of which have developed in response to community requests (cf. sections 4.6 and 4.7). The interventions place emphasis on the development of training material and larger-scale events with a wider educational rather than skills-oriented character, as the former have a longer life-span and therefore promise greater potential impact.

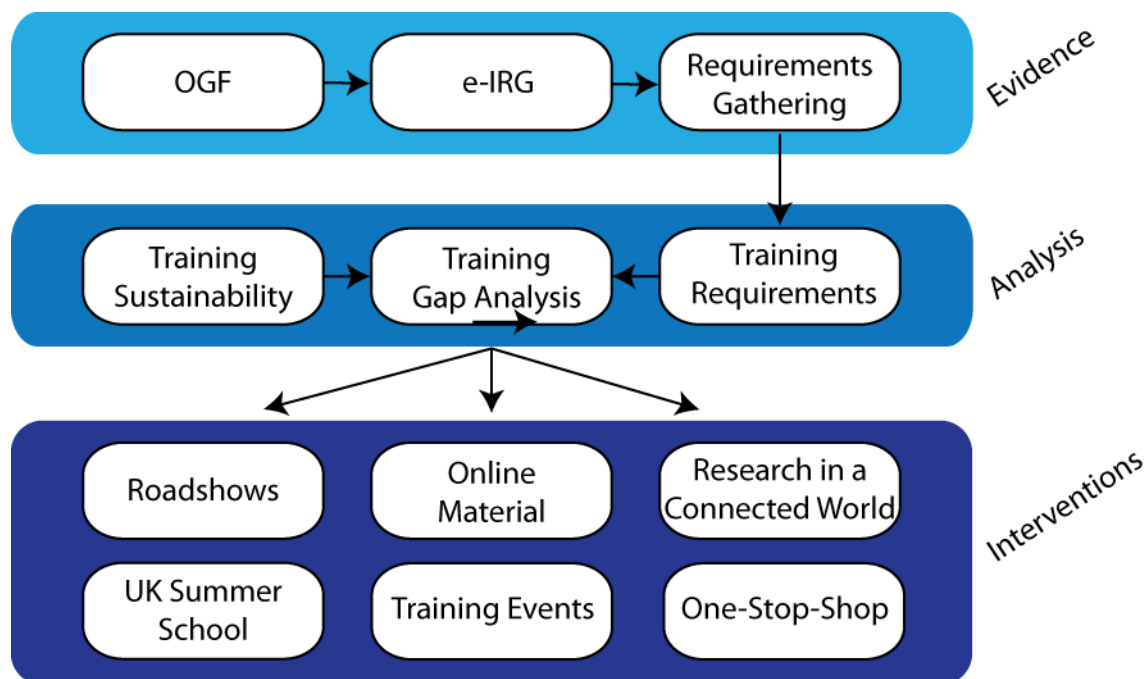


Figure 1: Interventions in context

3.4. Conceptual Framework for the UK One-Stop-Shop

As discussed above, the collaboration with the ENGAGE project and the decision to integrate the UK one-stop-shop into its portal changed our approach to its development. Rather than focusing on the development of user-facing functionality, we focused our efforts on understanding the process of information federation between different parties involved in e-Infrastructure usage and provision. Our main aim was to develop sustainable ways of providing information about events, training material and support contacts. We have placed the digital library at the centre of these processes, as a 'one-stop-warehouse' of information. This does not mean that it is the only source of information but rather that it acts as a broker for information from diverse sources, described with appropriate metadata and available through standard mechanisms such as the Open Access Initiative Protocol for Metadata Harvesting (OAI-PMH) or Atom feeds.

4. Implementation

This section describes the practical approach that was taken to collect data for the study, to process and to analyse it into usable outputs, and to develop interventions on this basis.

4.1. Stage 1: Researchers

The identification of suitable respondents was a major issue we faced. We knew that lack of knowledge of and experience with e-Research and e-Infrastructures would limit the value of responses from people chosen randomly from the research community, so we needed to define a sample of early adopters or people we could reasonably expect to be familiar at least with the principles of the use of advanced ICTs in research. Candidate respondents were identified using a combination of web searches, existing databases such as the UK research councils' web-based databases of grants, and web mining. We found that it was relatively easy to compile long lists of candidates but that filtering them using our selection criteria (active in research and using at least one of the JISC-funded services) involved a large amount of manual work to compile the required information from publicly available data.

We therefore decided that it was practically impossible to define a suitably representative sample *a priori* and that an iterative approach was needed that would monitor the coverage achieved along a number of dimensions as the interview process progressed. In addition to primary stratification by research disciplines, we were also aware that other dimensions would be relevant because they influence the kinds of barriers that researchers face and the way they react to them. For example, researchers at different stages of their careers may have different interests, attitudes towards technological innovation, skills as well as investments in standard methods and tools. Consequently, we were aiming to ensure that our sample included respondents of different levels of seniority.

Before the main study began, a pilot study of four interviews took place, where the online questionnaire and the interview schedule were tested in the field. There seemed to be no problem with the tools themselves. However, the initial approach email needed to be more personalised, in order to better engage the candidate interviewees. The design of the questionnaire and the interview schedule were substantially informed by earlier work conducted in collaboration with the eIUS project, involving 13 face-to-face pilot interviews and by two detailed meetings with Jan Rae, of the Open University's Institute for Educational Technology, who acted as an external advisor on survey design.

We conducted a total of 53 interviews with 55 individual researchers, yielding more than 25 hours of recorded audio. Before the interview, respondents were asked to fill in the short questionnaire so that the interviewers would have some baseline information to guide the interview process and in order to monitor our coverage. An analysis of this data is presented in deliverable D1.2, the Community Engagement report.

4.2. Stage 2: Intermediaries

Respondents for the second phase of the fieldwork were recruited from research computing groups at research institutions as well as from groups of other intermediaries, e.g., from e-Science centres. The main emphasis was on representatives from universities with a large research volume and above average success rate in securing Research Council grants. To ensure a degree of representativeness, we chose institutions from three groups. Firstly, we included institutions traditionally found at the top end of research league tables, then institutions that are outperforming their peers and, finally, some small, specialist institutions that had strengths in particular research areas or were particularly active in e-Research. Figure 2 illustrates how we use the THES 2007/08 ranking and HESA funding data to select institutions. From each institution, we tried to recruit two respondents, one with a strategic management role and one with a role that would bring them into direct contact with researchers in their everyday work.

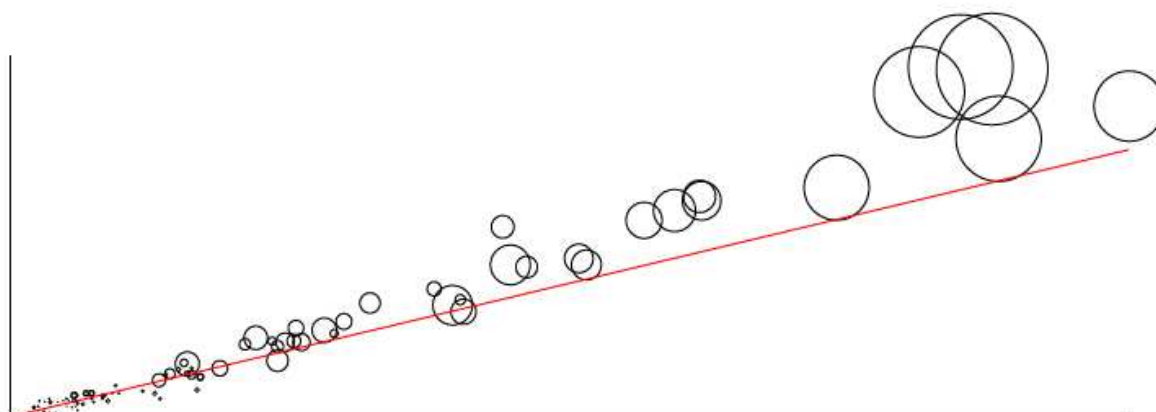


Figure 2: UK universities by THES 2007/08 ranking (number of applications on the x-axis and number of awards on the y-axis) and HEFC funding (2006/07, bubble size). The red line represents the mean success rate of around 24%.

4.3. Method of Analysis for Phase I and Phase II Fieldwork

The interviews were fully transcribed by a commercial transcription service and quality assured by the project team. The data from both phases of fieldwork was initially coded using free coding (i.e., without a pre-existing coding schema) and the lists of codes generated were factored into the typology developed from the initial literature review. As the coding scheme contains in excess of 150 detailed codes, it was organised hierarchically to facilitate navigation.

From the fieldwork data, we extracted instances of inhibitors and enablers as described by the respondents. Each has a short descriptive title, a longer description and is supported by at least one more specific example and a quote from the interview. In addition, inhibitors and enablers were linked to the typology and further classified as being general, discipline specific, institution specific or service specific.

A review of traditional Qualitative Data Analysis packages (Voss *et al.*, 2008, see outputs) showed that these tools did not support some of the functionality required by the project, such as the integration of survey and questionnaire data or collaborative use across organisational boundaries. We therefore decided to develop our own approach to represent the data. We initially used an XML schema developed by ESDS (Cummings, 2006; Milosavljevic, Grover and Corti, 2007) and developed a web-based interface for browsing and searching anonymised extracts of our fieldwork data on the basis of the questionnaire data and our typology. However, considerations such as the effort required to mature this approach and to achieve sustainability led us to adopt a more pragmatic approach in the end. We are currently using the Connexions system at Rice University as an alternative platform (www.cnx.org) for representing the data. We also intend to make this database available within the ENGAGE portal to allow future researchers, as well as other stakeholders such as service providers and JISC programme managers, to mine the information produced.

4.4. Training Surveys

For the training requirements report (D2.1.1), we collected data from respondents at various e-Science events and through an online survey. Together with earlier iterations of this survey, we now have data from 455 respondents, collected between 2004 and 2008. This longitudinal collection of data allowed us not only to make statements about training requirements at any particular time but also to begin tracking the development of requirements over time.

A second component of this work explored the bigger picture, detailing general requirements identified by trainers and educators in EU and international contexts. We drew conclusions from work carried out by the e-Infrastructure Reflection Group (e-IRG) Education and Training Task Force (ETTF) and the Open Grid Forum (OGF) Education and Training Community Group (ET-CG). At the same time,

the project has had a significant impact on the work of these groups and has contributed to their reports.

Data for the training sustainability report (D2.1.2) was collected using a training provision survey that was distributed to institutions providing training or education. The survey results were discussed at a workshop in December 2007 and the draft document went out for further input by the community. Through a combined analysis of the training requirements and the provision survey, we developed a gap analysis that highlights requirements for the ongoing development of training, education and outreach activities (D2.1.3). The questionnaires used in the training requirements and training provision surveys can also be found in the respective deliverables.

4.5. Interventions: Workshops

Throughout the project, we have run workshops and meetings to solicit input from the community on a range of specific issues, to help to evaluate our activities in the project as well as to ensure that key stakeholders were involved in and able to provide input to our work. In particular, some of the events listed below were the outcome of meetings between the project and OMII-UK, NGS and the ESRC-funded e-Infrastructure for the Social Sciences project.

- The International Workshop on Virtual Research Environments and Collaborative Work Environments, held at the e-Science Institute in May 2007 aimed to explore the overlap between the VRE and CWE communities and to foster collaborations between them. This event was followed up by a workshop at the ECSCW conference in Limerick in September 2007.
- A Birds of a Feather session at the UK e-Science All Hands Meeting in Nottingham in September 2007 brought together a range of participants involved in training, outreach and education activities.
- The ICEAGE Forum meeting at the International Summer School on Grid Computing in Mariefred, Sweden in July 2007 provided further input to the development of an understanding of training requirements.
- We organised sessions of the Education and Training Community Group as well as the Arts, Humanities and Social Science Community Group within OGF. The project was represented at OGF21 – OGF25.
- Workshop for e-Science Educators: this workshop, held at the e-Science Institute in December 2007 served to provide feedback on the draft training provision report and further input for its development.
- Workshop on Grid-Enabled Datasets in Art, Humanities and Social Sciences: this workshop held at the e-Science Institute in December 2007 brought together researchers working on grid enabling datasets and served to provide an overview of activities in this field. The training event on OGSA-DAI was a direct output of this workshop (see below).
- Workshop on Fostering e-Infrastructures: from user-designer relations to community engagement: this workshop, held at the e-Science Institute in May 2008, focused on user-designer relations, requirements work, support for communities, training and education requirements and models of access to resources.
- Workshop on Profiling UK e-Research: Mapping Communities and Measuring Impacts (All Hands Meeting, Edinburgh, September 2008). The main objective of this workshop was to bring together members of the e-Research, innovation studies and science policy communities to explore the challenge of measuring the impact of research innovations and its implications for science policy. Presentations available on the All Hands website at <http://www.allhands.org.uk/2008/programme/index.html>
- A workshop on e-Research Community Engagement (Oxford, May 2009) looked at evidence-based interventions to widen uptake. It brought together researchers involved in community engagement activities, end-user driven development as well as social shaping research.

- Project members were involved in setting up two community engagement workshops organised jointly with the VRE programme. Under the title “Leaping Hurdles: Planning IT Provision for Researchers”, the two programmes demonstrated their outputs and their relevance to the wider HEI community. The e-Uptake findings were used as discussion points in breakout groups, which were aimed at identifying specific actions that can help to widen uptake. The events were well-attended and drew audiences from beyond the e-Science community, with many representatives from information services at UK institutions being present. The events were also attended by some of our respondents, who were specifically invited.

4.6. Interventions: Training Material and Events

OGSA-DAI for the Arts, Humanities and Social Sciences

We organised three related OGSA-DAI training events aimed at Arts & Humanities and Social Science application developers. The first event was a traditional face-to-face training event¹, which was followed up by a web-based training event covering a wider set of topics² (e.g., using OGSA-DAI on the NGS) and allowing attendees time to explore uses of OGSA-DAI in their own environments. Finally, a face-to-face event allowed attendees to meet up with the OGSA-DAI team to discuss their experiences and any development plans or issues faced³. The experience with this set of training events was mixed. On the one hand, attendance was disappointing and made the effort invested seem disproportionate. On the other hand, the final event proved to be very useful for the attendees, who had direct access to expertise and received ‘at elbow’ support for their development projects. The OGSA-DAI team also felt that the event was useful as the direct interaction with the application developers allowed the exploration of a number of application scenarios and helped to better understand some issues that came to light through this collaboration.

Overall, one might argue that while the effort invested was relatively large (with the OGSA-DAI team outnumbering the attendees), the event still provided useful insights into how future training events might be set up. The combination of traditional training with ‘at elbow’ support is now also being taken up in the context of the International Summer School on Grid Computing and similar concepts have been explored elsewhere, for example in the context of establishing EGEE sites.

Research in a Connected World

One of the main requirements established was for a resource that bridges the first contact with e-Infrastructures (dissemination and outreach) and further engagement, allowing researchers to develop enough understanding of requirements to utilise training effectively. This has partly been captured in the requirement articulated by the community for an introductory textbook on distributed computing. Through additional resourcing made available by JISC, we developed a training resource that we hope will form the basis for a future, more extensive, textbook. The contents of this resource were based on the curriculum designs created in international fora such as OGF and e-IRG. Individual sections were contributed by a number of subject experts, who generously volunteered to author content. To date we have received 19 contributions, which are currently being collaboratively edited by the project team and the contributing authors.

Taking advice from the Community Engagement programme steering committee, we decided to produce this training resource as a set of independently authored modules on the Connexions system developed and hosted at Rice University⁴. The system allows the modules to be bundled into collections and delivered as sets of web pages as well as in print format. The use of an open data format (CNXML) and federation mechanisms such as OAI-PMH and OpenSearch ensures that the

¹ <http://www.nesc.ac.uk/esi/events/871/>

² <http://www.nesc.ac.uk/esi/events/873/>

³ <http://www.nesc.ac.uk/esi/events/874/>

⁴ <http://cnx.org>

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content can be reused in different ways, integrated into the digital library and, through this, into the ENGAGE portal. It also ensures that the hosting arrangements can be changed in the future should this become necessary.

Distributed Systems Summer School

In connection with e-Uptake, the NGS has identified a UK Summer School based on the highly successful ISSGC series as an important high-profile event which can be used to reach a broad spectrum of advocates within organisations and communities. As our research has highlighted the need for closer integration between provision of training and support, and for improved local support, the summer school is aimed at developing the skills of those involved in providing support for research. Planning for this event is under way and e-Uptake is providing input on the development of the programme with the main effort for the event itself coming from the NGS and external contributors. The school will take place on 7th-11th September 2009 at Coseners House near Oxford⁵.

Video/Audio Presentations

The project contributed to the development of online learning materials, including video/audio presentations from events such as the ISSGC schools. Presentations from the 2008 ISSGC have been recorded and the resulting material is currently being transformed into online presentations that will be made available through the UK one-stop-shop. These presentations provide in-depth material on a range of background and specific subjects. To supplement these we created short (1-2 min) videos addressing specific activities (i.e., managing a certificate, security, submitting a job, etc.). Again, this requirement and the coverage planned emerged from the longitudinal effort to collect requirements from the community (established in earlier projects and now supported by e-Uptake), cf. section 4.4.

Video materials can be found in the digital library by searching on a number of criteria and returning a results page or a RSS feed. For example, the following search returns an RSS feed with a list of video presentations ordered by date:

http://library2.nesc.ed.ac.uk/fedora/sru?query=any~'*video'+relation~'lib%3a*'&maximumRecords=250&startRecord=1&sortKeys=date&recordSchema=rssiceage.

e-Roadshows

e-Uptake interacted with the e-Research Roadshows project⁶ (spun out from e-Uptake and funded by JISC), both in supporting the development of roadshows and in using these as opportunities for gathering further requirements as well as generating new online material. The roadshows target communities currently not using e-Research techniques or e-Infrastructures. Roadshows are usually hosted by a local organiser who recognises an opportunity to develop a community. Communities might be cross-disciplinary within an institution or geographic region, or they might be geographically spread, but come from a particular discipline. The objectives are to support researchers who wish to explore/adopt e-Research methods, to support researchers who wish to explore/adopt existing e-infrastructure services, to help IT services plan their support for this adoption by researchers and to increase the number of researchers using e-Research methods and e-Infrastructures.

CCPB Training Event

Together with the Collaborative Computational Project for Biomolecular Simulation (CCPB) and the NGS, we organised a training event⁷ at the e-Science Institute in November 2008, focusing on the execution of common biomolecular simulation codes on the NGS. It provided an introduction to running jobs on the NGS followed by a step-by-step guide to running AMBER, NAMD and GROMACS codes, both from the command line and through the NGS portal.

⁵ <http://www.iceage-eu.org/adsss09/index.cfm>

⁶ <http://www.jisc.ac.uk/whatwedo/programmes/einfrastructure/eresearchroadshows.aspx>

⁷ <http://www.ccpb.ac.uk/events/workshops/previous/NGS/>

Arts & Humanities Training Material

We have produced a case study based "beginners guide" to using a campus grid and the national grid service, based on case studies of arts and humanities research projects that have used grid technology to solve research questions. The guide is based around a series of questions about the concept of grid computing, the possibilities that it offers researchers, and the practical steps that were needed for researchers to harness the potential of the technology. These materials will be maintained on the AHeSSC website, and may form the basis of future training events.

Social Simulation Tutorial

A tutorial was given at the 5th International Conference on e-Social Science in Cologne in June 2009⁸. At this event, attendees learned how to build social simulation models using the RePast simulation system and to run these models on grid infrastructures in order to explore different policy scenarios using parameter sweeps. The training material⁹ produced for this event is available for future training events in the social sciences and will be utilised and maintained in the NeISS project, funded by JISC under the Information Environment programme. We will further exploit this material in the EC-funded EUAsiaGrid project, which will contribute to an extended version of the tutorial that will cover more of the functionality of the simulation models developed as part of the GENeSIS node of NCeSS.

4.7. UK One-Stop-Shop

The UK one-stop-shop was developed on the basis of the existing digital library run by NeSC. Existing functionality was extended and tailored to provide the specific functionality required for provision of UK event data, training material and support contacts. The digital library is compatible with JORUM and its entries are LOM and Dublin Core compliant. It is federated with a number of other libraries such as BELIEF and DILIGENT at the European level. As the emphasis shifted from the provision of a central delivery mechanism to federation of content, we worked on providing appropriate extended metadata fields to support federation as well as on developing simple APIs that websites such as the ENGAGE portal can consume. For example, the event data is available as an Atom feed with embedded xCal data.

We implemented a UK e-Science collection to provide easy access to UK e-Infrastructure training material. This currently includes training material produced by the NGS and other UK projects. The digital library search mechanism was integrated into the ENGAGE portal as a demonstration of how digital library content can be federated and made more widely available through integration into a wider range of community-relevant websites. Training material from the digital library is available through an OAI-PMH interface. Figure 3 shows the integration of both the event feed (on the right hand side) and of a search interface into the ENGAGE portal. The ENGAGE portal is the main consumer for these interfaces at the moment but they are generally available for other consumers wishing to make use of this information. In particular, we would envisage that this centrally provided mechanism would be of interest to institutional research computing services to integrate into their own provision of supporting material.

⁸ <http://www.ncess.ac.uk/conference-09/workshopsandtutorials/socialsimulations/>

⁹ <http://tinyurl.com/socsim>

Figure 3: UK One-Stop-Shop Integration in the ENGAGE Portal

4.8. Collaboration with Partners

As already mentioned, we developed close relationships between the three JISC Community Engagement projects. In order to maximise the impact of the Community Engagement Strand as a whole, to avoid duplication of effort and to minimise the burden on respondents taking part in these three studies, a common framework of understanding was agreed between the three projects.

This common framework of understanding has enabled us to develop a consenting process and, based on this, to share our interview data where the respondent gave the necessary consent. In addition, it has enabled us to explore ways in which further complementary activities could be developed between the three projects such as the development of the ENGAGE portal (at www.engage.ac.uk) as a common platform for delivery. The close collaboration with the other two projects has had implications for the work in e-Uptake in that we have devoted effort to avoiding duplication, thereby improving the outcomes for the community engagement strand as a whole.

In addition to this, we also collaborated with projects funded under the EPSRC Usability call, with the JISC VRE programme and with other partners through the e-Science Institute themes that the project partners were involved in. We also worked with the National Grid Service and provided input to the NGS User Survey, the results of which have recently been published (NGS 2008).

At an international level, we engaged with the Open Grid Forum through the Education and Training Community Group as well as the Humanities, Arts and Social Sciences Community Group. NCESS is also a partner in the EUAsiaGrid project, which aims to foster the uptake of e-Infrastructure services in the Asia-Pacific region. Furthermore, we had interactions with other partners working on uptake and community engagement, e.g., in the context of TeraGrid and Open Science Grid.

5. Quality Assurance and Evaluation

This section describes the quality assurance and evaluation processes implemented in the e-Uptake project. It is based on the project plan and additional work conducted within the evaluation workpackage of the project. Aspects of this work permeate the whole project, as different work

activities demand specific forms of quality assurance and evaluation. They are two closely related but distinct activities. While quality assurance is focused on the *quality* of individual outputs, evaluation is concerned with the *effectiveness* and *relevance* of the overall project and its activities. Both require the definition of appropriate criteria and of processes that aim to ensure these criteria are met.

As a consequence, quality assurance was an element in every activity carried out by the project and evaluation took the form of regular review in project meetings and through the steering committee. As it is likely to be much costlier to repair problems than to spot them and take appropriate action early on, the aim was always to improve the quality and relevance of work conducted in the project on an ongoing basis and to take action as soon as problems became apparent. Project members took responsibility for the production of quality work in the areas that they were active in and for the evaluation of the project's activities. Responsibility for workpackage activities and outputs rested with the workpackage leaders and responsibility for the project as a whole with the principal investigator, who exercised oversight and was the final arbiter in decision-making. In the following sections, we describe briefly the procedures put in place for quality assurance of various project outputs.

5.1. Empirical Data

In the preparation of the empirical data collection, care was taken to devise a research design and a research method that would serve the needs of the project and lead to outputs and outcomes that are relevant to stakeholders and of high quality. The research design is concerned with the logic of the research, what questions are asked and how they can be answered by the data collected. It was clear from the outset that the question to be asked was about the existence of factors influencing the uptake of e-Infrastructure services and the ways in which they are encountered, experienced and overcome by researchers. A quantitative assessment of the pervasiveness or importance of these factors was not part of the research design. Consequently, the research method employed placed an emphasis on the collection of accounts by researchers and intermediaries describing how they encountered issues in the uptake and usage of e-Infrastructure services.

The empirical data collected by the project consisted mainly of recordings of telephone interviews. The interviews themselves were semi-structured and guided by a proforma that was created to ensure that all areas under investigation were adequately covered. The resulting data and associated metadata such as consent information were stored in a repository accessible only to the project team. A commercial transcription service was used to transcribe each interview. In order to improve the quality of this initial transcription, a glossary of terms was produced and made available to the transcription service.

Transcriptions were subsequently checked by project staff to ensure they accurately reflected what was said in the interviews before being coded and analysed. The coding used was open and developed in response to the data as opposed to closed categories.

Throughout the interview process we reviewed the progress made and the coverage achieved, adjusting our selection of candidates where necessary in order to ensure effectiveness and relevance. The workshops conducted and the presentations given throughout the project also helped to further validate the approach.

5.2. Reports

The reports produced by the project were subjected to project internal review before being disseminated to the steering committee or the wider public. They were assessed according to the criteria set out below.

Completeness and Level of Analysis: Reports should incorporate the best information available to the project and, where it is not possible to consider all the data available in their production, this should be clearly indicated so that it is possible to plan future revisions. The level of analysis should be adequate for a research output that is ultimately intended to inform decision making by various stakeholders. Any statement made should be checked to assure that it sufficiently unpacks the facts that were found and places these facts in a relevant context so as to allow the reader to draw meaningful conclusions.

Language, Style, Grammar, Spelling and Format: Reports should be written in a way that makes them easy to read and comprehend by their intended target audience. This involves avoiding unnecessary jargon, introducing specialist terms, using a clear structure both at the document and the sentence level as well as checking grammar and spelling. In addition, reports should use a consistent format based on paragraph styles rather than direct formatting.

Provenance: Any information used should be clearly traceable to a source such as an existing report or article that is cited or to fieldwork data. Where fieldwork data is being drawn on, quotes should be used to demonstrate to the reader what data underpins a statement. These quotes should be chosen to contain enough context to allow a reader to see what is being said. While quotes should reflect accurately what was said, they should be restricted to relevant parts of speech. Ellipses and substitutions of words can be used but should be clearly flagged through use of square brackets.

Review Process: Each report should have two reviewers who will be responsible for providing independent feedback to the report authors. Of these, at least one should be from a partner institution that is not directly involved in the production of the report. Reviewers should use the information in this evaluation report as a guide and checklist for assessing the quality of reports.

Timeliness: Reports should be circulated for review early so that any issues can be addressed as soon as possible. Where reports are to be submitted to the steering committee or to be made public, they should be made available early enough to allow reviewers two weeks of time to produce feedback as well as to allow the authors two weeks of time to incorporate this feedback.

Effectiveness and Relevance: The material contained in reports should be relevant to the stakeholders identified in the project plan so that they can take appropriate action in response to issues uncovered. Given the scope of the project it is not possible to produce tailored reports for each stakeholder community but findings should be flagged as particularly relevant to stakeholders where this is possible.

5.3. Events

Training events and workshops were evaluated through questionnaires or feedback sessions. Questionnaires were either specific to the event or, where training was provided as part of a conference, part of the conference evaluation forms. The feedback collected was reviewed and factored into future training provision and workshop planning.

The training events on OGSA-DAI for the Arts, Humanities and Social Sciences are of particular interest as they represented an attempt to close the gap between traditional training events, online training and consultancy. Even though the number of attendees was low, the experience was very positive and attendees rated the concluding hands-on session with the OGSA-DAI team highly as it allowed them to make real progress on issues they were interested in or struggling with.

5.4. One-Stop-Shop

Through the development of the ENGAGE portal as a central delivery mechanism for the three community engagement projects, we were given the opportunity to coordinate the development of the One-Stop-Shop with the activities of the other projects. The framework of understanding between the projects and the regular meetings enabled us to work towards a common aim of providing a portal that would address the wider community of UK researchers while developing a federation infrastructure that enables other parties to utilise the same information for their purposes.

The regular review of achievements and defined courses of actions in the community engagement meetings and the collaboration with ENGAGE in particular have helped to ensure the quality and relevance of the One-Stop-Shop mechanisms by providing an understanding of the requirements as well as a practical instantiation and test of the mechanisms under development.

6. Outputs and Results

The main 'tangible' outputs of e-Uptake are the corpus of fieldwork data, the collection of findings distilled from these, the UK one-stop-shop and its public-facing functionality in the ENGAGE portal,

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the Research in a Connected World brochure and other training events as well as the various reports and academic papers the project produced. In the following sections, we describe some of these and provide pointers to others.

6.1. Corpus of Fieldwork Data and Database of Findings

The main output of the project is a corpus of detailed findings that provide evidence for the existence of inhibitors and enablers of e-Infrastructure services adoption. As the number of individual findings is quite large and as a resulting document would be in excess of 300 pages long, we decided that the best way to represent this material was through an online resource. In this way, the detail can be preserved while making the material more accessible through the extensive use of hyperlinks and through a search function.

After some initial investigations of this form of representing the data using custom built tools, we decided to adopt the Connexions service developed at Rice University, which provides support for authoring learning material and structuring it as a set of collections of re-usable modules. We found that the functionality provided by the service can model all the aspects of the data that we felt needed to be supported. The fact that the service supports OIA-PMH harvesting and OpenSearch means that we can integrate the data into other systems such as the ENGAGE portal or the UK One-Stop-Shop.

The screenshot displays the Connexions system interface. At the top, there is a navigation bar with 'Home', 'Content', 'About Us', 'Help', and 'MyCNX' tabs. Below this, a breadcrumb trail reads 'You are here: Home > Workgroups > JISC CE Projects'. The main content area is titled 'JISC CE Projects' and includes a description: 'A workgroup for the three JISC Community Engagement projects'. Below the description is a table of findings. The table has columns for 'Title', 'ID', 'Size', 'Modified', and 'State'. The findings listed include 'e-Research Community Engagement Findings', 'ENGAGE Development Summary: HiTheR', and several 'Inhibitor' entries such as 'Access Regulations for Data Sets', 'Access to Access Grid Nodes and Overheads in Arranging Meetings', 'Awareness of Services', 'Communication and Knowledge Transfer', 'Delays in Gaining Access', 'Institutional Context and Culture', 'Managing User-Designer Relations', 'Parallelisation of Code', 'Relationship between e-Science and HPC', 'Understanding of Distributed Systems by IT Services', and 'Validation of and Support for Code'. A sidebar on the right shows 'MY ACCOUNT' for AlexVoss with links to 'MyCNX Home', 'Profile & Account Settings', and 'My Favorites (edit)'. At the bottom of the page, there is a footer with the Rice University logo, a Creative Commons license, and a 'POWERED BY' logo.

Title	ID	Size	Modified	State
e-Research Community Engagement Findings	col10673		2009-03-26 04:31am	Checked Out
ENGAGE Development Summary: HiTheR	m20184	2.3 kB	2009-03-11 09:29am	Created
Inhibitor: Access Regulations for Data Sets	m20185		2009-03-26 03:11am	Published
Inhibitor: Access to Access Grid Nodes and Overheads in Arranging Meetings	m20185		2009-03-26 03:13am	Published
Inhibitor: Awareness of Services	m20963		2009-03-26 03:18am	Published
Inhibitor: Communication and Knowledge Transfer	m20965		2009-03-26 01:42am	Published
Inhibitor: Delays in Gaining Access	m20964	3.8 kB	2009-03-31 10:06am	Modified
Inhibitor: Institutional Context and Culture	m20967		2009-03-26 01:47am	Published
Inhibitor: Managing User-Designer Relations	m20971		2009-03-26 03:00am	Published
Inhibitor: Parallelisation of Code	m20981		2009-03-26 04:54am	Published
Inhibitor: Relationship between e-Science and HPC	m20968	4.8 kB	2009-03-31 10:17am	Modified
Inhibitor: Understanding of Distributed Systems by IT Services	m20941		2009-03-26 04:56am	Published
Inhibitor: Understanding of Distributed Computing Principles	m20940		2009-03-26 01:32am	Published
Inhibitor: Validation of and Support for Code	m20940	2.0 kB	2009-03-31 09:54am	Created

Figure 4: Findings in the Connexions System (editor view)

At the same time, the system allows the integration with material produced by the other two community engagement projects, ENGAGE and eIUS. For example, descriptions of inhibitors might link to use cases produced by eIUS or to the description of an ENGAGE project that has overcome the issues concerned. We hope that these projects will also adopt the Connexions service as a mechanism for managing and preserving their outputs, allowing full integration and cross-referencing. In addition to the web-based view, the system also supports the production of a compiled PDF version that can be downloaded or printed using an on-demand printing service.

The screenshot shows the Connexions system interface. At the top, there is a navigation bar with 'Home', 'Content', 'About Us', 'Help', and 'MyCNX'. A search bar is also present. Below the navigation bar, the breadcrumb trail reads: 'You are here: Home » Content » e-Research Community Engagement Findings » Inhibitor: Understanding of Distributed Computing Principles'.

On the left side, there are two panels: 'CONTENT ACTIONS' with options like 'Download PDF/ZIP...', 'Add to ...', 'E-mail the author', and 'Print this Web page'; and 'TABLE OF CONTENTS' with a tree view showing categories like 'Training, Education and Outreach' and 'User-Designer Relations and Requirements'.

The main content area displays the report details:

- INSIDE COLLECTION (REPORT): **e-Research Community Engagement Findings**
- Report by: Alex Voss
- Inhibitor: Understanding of Distributed Computing Principles**
- Module by: Alex Voss

 The report text states: 'Researchers are often not aware of the potential of distributed systems or of the issues involved in developing and using them. This means that they find it difficult to make sense of the e-Infrastructure services or to related them to their own work and come up with possible ways of using them. While training material exists that provides instructions for the use of advanced ICT systems, there is a lack of material that teaches the underlying principles of e-Research and helps researchers to engage creatively and critically with these technologies.'

Two examples are provided:

- EXAMPLE 1**: "...grid computing ... is an under utilised resource. I think there probably are barriers to people understanding how they could use it, what they could do with it, and seeing it as a true alternative to maybe poorly managed desktop processing or using under resourced local computers but I'd imagine that there's a, there's a lack of understanding of the technical context" (information services professional)
- EXAMPLE 2**: "They probably wouldn't understand the impact it would have the way access it and what they would do with it. But they'd probably believe that because they can do what they're doing now that it's okay. But it'd be similar to somebody who sits and writes out fifteen letters in Word to fifteen people that are all the same and types them all out. But the person next to them puts the names and addresses into an excel spreadsheet and merges a letter from word. You both get the same result but the one has done it in about a tenth of the time but the other person doesn't think there's anything wrong with what they've done. They've used their own skills they've done the job it works but if

Figure 5: Findings in the Connexions System (output view)

The openness of the system will help to ensure the sustainability of the outputs. We envisage that other projects will revise the material and add to it. The role-based access control in the system will enable collaborations and a distribution of responsibilities after the end of the current projects. The fact that the data can be exported in a well-defined, XML-based format means that the collection of material is not dependent on the existence of the Connexions service but can be imported into another instance of the software the service is based on or that it can be converted to other formats for import into different systems.

6.2. Deliverables

The project has produced the following deliverables, which capture and describe its outputs. They can be found on the ENGAGE portal at <http://engage.ac.uk/e-uptake/e-uptake-deliverables>:

D1.1 Typology Report: presents an overview of the types of findings the project has produced. This deliverable is meant to act as a short summary of the much more comprehensive deliverable D1.2, which lists findings in more detail.

D1.2 Community Engagement Report: provides an analysis of the empirical findings of the project. Due to the restrictions of a traditional report (linear structure and length), this is complemented by the database of findings.

D1.2.1 Review Workshop: the workshop in Oxford and the two wrap-up events in Edinburgh and London allowed us to review the findings and to see them in the context of work undertaken in other projects, especially those funded under the EPSRC Usability call and the JISC VRE programme.

D1.3 Impact Assessment: included in this final report, cf. section 9, outlines the impact that the project has had on factors influencing the uptake of e-Infrastructure services. It is important to note that this can only be a tentative assessment as the real impact will only become evident over time.

D2.1.1 Training Requirements Report: provides an analysis of the training requirements that were formulated on the basis of the longitudinal training requirements survey conducted.

D2.1.2 Training Sustainability Report: reviews e-Infrastructure Training and Education in the UK based on information gathered through workshops and a questionnaire.

D2.1.3 Support Gap Analysis: based on the training requirements and information on training provision, provides an analysis of the gaps that are evident.

D2.2 UK One-Stop-Shop: provides a collection of material (training material, events list and list of support contacts) as well as a federation mechanism to enable their flexible dissemination to different audiences. The primary consumer of this information is the ENGAGE portal.

D2.3 Workshops and Training Events: provided training and engagement opportunities for stakeholders. Cf. section 4.6 in this report.

D3.1 Evaluation Report: included in this final report, cf. section 5. Describes the mechanisms and activities utilised during the project to ensure delivery and quality of work.

6.3. Publications

The project has contributed to the following publications in workshops and international conferences as well as international journals. The following list can also be found online¹⁰:

Voss, A. and Procter, R. (2009). Virtual Research Environments in Scholarly Work and Communications. In Wusteman, J. and Eden, B. (eds). Special issue on Virtual research environments: issues and opportunities for librarians next generation OPACs. *Library HiTech* 27(2), pp. 174-190.

Voss, A., Asgari-Targhi, M., Procter, R., Halfpenny, P., Fragkouli, E., Anderson, S., Hughes, L., Fergusson, D., Vander Meer, E., Atkinson, M. (2009). Adoption of e-Infrastructure Services: findings, issues and opportunities. Proceedings of the 5th *International Conference on e-Social Science*, Cologne, June.

Halfpenny, P., Procter, R., Lin, Yuwei and Voss, A. (2009). Developing the UK e-Social Science Research Programme. In Jankowski, N. (Ed.) *e-Research, Transformation in Scholarly Practice*, Routledge.

Vander Meer, E., Fergusson, D. and Atkinson, M. (2009). Development of Curricula for e-Science: Challenges and Opportunities. *International Technology, Education and Development Conference*, Valencia, Spain, March.

Chue Hong, N.P. and Voss, A. Why good software sometimes dies – and how to save it. Workshop on Project Management and User Engagement. *Proceedings of the IEEE International Conference on e-Science*, Indianapolis, December 2008.

Fergusson, D., Romano, D., Vander Meer, E. and Atkinson, M. (2008). Distributed Computing Education, Part 1: A Special Case? *IEEE Distributed Systems Online*, Vol. 9, No. 6. June.

Fergusson, D., Hopkins, R., Romano, D., Vander Meer, E., Atkinson, M. (2008). Distributed Computing Education, Part 2: International Summer Schools. *IEEE Distributed Systems Online*, Vol. 9, No. 7, pp. 2, July.

Fergusson, D., Jandric, P., Hopkins, R., Vander Meer, E., and Atkinson, M. (2008). Distributed Computing Education, Part 3: The Winter School Online Experience. *IEEE Distributed Systems Online*, Vol. 9, No. 9, September.

Fergusson, D., Barbera, R., Giorgio, E., Fargetta, M., Sipos, G., Romano, D., Atkinson, M., Vander Meer, E. (2008). Distributed Computing Education, Part 4: Training Infrastructure. *IEEE Distributed Systems Online*, Vol. 9, No. 10, October.

¹⁰ <http://engage.ac.uk/e-uptake/e-uptake-publications>

Low, B., Cassidy, K., Fergusson, D., Atkinson, M., Vander Meer, E. and McGeever, M. (2008). Distributed Computing Education, Part 5: Coming to Terms with Intellectual Property Rights. *IEEE Distributed Systems Online*, Vol. 9., No 12, December.

Atkinson, M., Fergusson, D., and Vander Meer, E. (2009) Curricula Development for e-Science: Meeting the Challenges. *Computing Now Online*, from IEEE Intelligent Systems, March.

Atkinson, M., Vander Meer, E., Fergusson, D., Davenhall, C. and Mehammed, H. (2009) Strategies and Policies to Support and Advance Education in e-Science. *Computing Now Online*, from IEEE Intelligent Systems, May.

Voss, A., Asgari-Targhi, M., Halfpenny, P., Poschen, M., Procter, R., Anderson, S., Dunn, S., Fragkouli, E., Hughes, L., Atkinson, M., Fergusson, D. and Mineter, M. (2008). Fostering e-Infrastructures: from user-designer relations to community engagement. *e-Science Project Management Symposium*, Oxford University, April.

Voss, A., Asgari-Targhi, M., Procter, R., Halfpenny, P., Dunn, S., Fragkouli, E., Anderson, S., Hughes, L., Fergusson, D., and Atkinson, M. (2008). The JISC e-Infrastructure Community Engagement Projects. *Proceedings of the eResearch Australia Conference*, Melbourne, September.

Voss, A., Asgari-Targhi, M., Procter, R., Halfpenny, P., Dunn, S., Fragkouli, E., Anderson, S., Hughes, L., Fergusson, D., and Atkinson, M. (2008). Paths to Wider Adoption of e-Infrastructure Services. *Oxford e-Research Conference*, Oxford, UK, September.

Voss, A., Procter, R., Halfpenny, P., Asgari-Targhi, M. and Poschen, M. (2008). Steps Towards Mapping e-Research and Measuring Impact. *Proceedings of the UK e-Science All Hands Meeting*, Edinburgh, September.

Voss, A., Asgari-Targhi, M., Procter, R., Halfpenny, P., Dunn, S., Fragkouli, E., Anderson, S., Hughes, L., Mineter, M., Fergusson, D. and Atkinson, M. (2008). Widening Uptake of e-Infrastructure Services. *Proceedings of the 4th International Conference on e-Social Science*, Manchester, UK, June.

Voss, A., Mascord, M., Argüello Castelleiro, M., Asgari-Targhi, M., Procter, R., Fraser, M., Jirotko, M., Halfpenny, P., Fergusson, D., Atkinson, M., Dunn, S., Blanke, T., Hughes, L. and Anderson, S. (2007). e-Infrastructure Development and Community Engagement. *Proceedings of the 3rd International Conference on e-Social Science*. Ann Arbor, October.

The OGF "IPR for e-Science and Education" information document has been revised after a second consultation with University of Edinburgh lawyer, Mags McGeever, and has been submitted to the OGF editorial process for publication later in 2009.

6.4. Other Dissemination Activities

- Alex Voss presented on a panel on *Breaking the Barriers to Broad Adoption of e-Science* at the Microsoft e-Science Conference in Chapel Hill, NC in October 2007 and e-Uptake presented a poster on Fostering Wider Adoption of e-Research.
- Rob Procter and Alex Voss participated in a workshop organised by Malcolm Atkinson at NeSC in March 2008 to discuss the Century of Information Research Strategy document. e-Uptake provided further input to this through the co-Investigators within the UK e-Science Directors Forum.
- e-Uptake organised a session on *Barriers to the Take-up of Technologies* at the JISC Innovation Forum at Keele University in July 2008. The session was very well attended, a record can be found at <http://tinyurl.com/5sjbs6>

- Hardisty, A., Chue Hong, N., Procter, R., Hughes, L., Voss, A. and Fraser, M. (2008). *e-Infrastructure: tool for 'grand challenges' or tool for everybody?* BoF session at the UK e-Science All Hands Meeting, September. Summarised in UK e-Science Technical Report UKeS-2009-01 (http://www.nesc.ac.uk/technical_papers/UKeS-2009-01.pdf)
- e-Uptake also contributed a short article to the September 2008 edition of the OMII Newsletter.
- The e-Uptake Digital Library was showcased at booths at All Hands 2008 and EGEE'08.
- e-Uptake participated in the NGS User Forum and Innovation Forum events.
- e-Uptake provided input to the ongoing development of the ENGAGE portal and have contributed to the design of a flyer for the JISC community engagement projects.
- Alex Voss participated in the European Commission's Consultation Meeting for the 7th Call of FP7 in December 2008.
- We have participated in meetings with JISC Innovation Programme Managers and are following up this engagement through a mailing list and further meetings as well as through the Oxford Workshop.
- Rob Procter presented at the JISC Conference on 24th March in a session on 'What researchers want from IT'. <http://events.jiscinvolve.org/session-what-do-researchers-want-from-ict/>
- e-Uptake contributed to the Changing e-Science Landscape event on 16th-17th April at the National e-Science Centre. This event was organised by Sarah Fulford, in preparation for the review of the e-Science programme.

7. Outcomes

The e-Uptake project collected evidence from the community about inhibitors and enablers of uptake and has developed a number of interventions to foster adoption of e-Infrastructure services. The empirical material, as well as its analysis, was made available in the form of a collection of findings and a number of deliverables that describe the state of adoption, the typology of issues as well as recommendations for different stakeholder groups. The UK one-stop-shop was developed and integrated with the ENGAGE portal as the main delivery mechanism. A number of specific training events were organised but the main emphasis was on strengthening early education and outreach mechanisms through roadshows and the development of the Research in a Connected World brochure. Workshops and meetings organised through the project have helped to ensure engagement with different communities and other projects with a similar purpose.

While the outcome of these activities on researchers' practice and on the uptake of e-Infrastructure services can only be judged over a longer timespan, we can say with confidence that the project has established a sound foundation for community engagement that can be taken forward by stakeholders and the wider e-Science community. The material outputs such as the reports, the training and education material and the UK one-stop-shop will continue to underpin the process of fostering sustainable communities of practice. The evidence gathered and represented in the form of the deliverables will feed into strategic decision making at a number of levels (cf. section 10).

The e-Uptake project has developed and demonstrated a methodology for community engagement that can provide a sound basis for further activities through funded programmes or through activities by stakeholders such as service providers, e-Science centres or institutions. We have documented the process in a number of academic papers as well as in our reports and the experience gained in the project will serve as a reference point in future activities.

8. Conclusions, Implications and Recommendations

Our research has highlighted a broad range of applications of e-Infrastructure services and e-Research methods. As might be expected, the patterns of adoption differ between different kinds of institutions as well as between disciplines. While our research design does not provide quantitative evidence of the level of uptake and the importance of issues uncovered, it provides evidence of the

existence of inhibitors and enablers as well as the in-depth understanding that is essential if interventions that may be subsequently devised to tackle them are to be effective. We can also point to some repeating patterns that occur throughout our fieldwork.

As e-Infrastructure services mature technically and as e-Research methods gain wider acceptance, it is important to build the supporting 'human infrastructure' at institutions as well as at a national level to ensure that researchers are supported at every step. Only through consistent and pervasive support infrastructures will we be able to make e-Research practices widely adopted and produce the improvement of research outputs that we are ultimately aiming for. In our deliverables, we have drawn conclusions on the basis of the evidence and experiences gathered in the project and have formulated a number of recommendations to various stakeholders, which are below.

One theme that comes out strongly from the fieldwork is that of integration of outreach, education and training activities. Training needs to be clearly structured and their design needs to be informed by an understanding of the needs of their target audiences. At the moment, many researchers attending training courses are confronted with command-line tools that they are unlikely to adopt. Instead, the training for end users should focus on distributed computing principles and the use of adequate application environments, portals or desktop tools.

An important pre-condition for the wider availability of training is the provision of a training infrastructure that is available when courses are run and that is indistinguishable from the production infrastructure for all practical purposes. Such an infrastructure does not need to be permanently installed but can be provided on demand through virtualisation and cloud computing mechanisms. While the hardware resources can be provided on demand, there is a need for a continuous provision of a human resource to keep training material and the training environment up-to-date and to provide an important outreach and liaison function. A more detailed discussion of the implications of our research for the provision of training can be found in the Training Gap Analysis report (Deliverable D2.1.3).

Deliverable 1.2 documents a large number of issues raised by our respondents. It is clear from the evidence we have collected that there is a continuing need to promote innovations in the technologies that underpin e-Research. Equally, those issues which we have categorised as social issues provide clear evidence of the need to improve the 'human infrastructures' which ensure that the research community has the capacity to exploit these technical innovations. The overarching conclusion we draw from these social issues is the need to establish support structures for e-Research practices that span the local provision of IT and local support for research, the institutional provisions that provide economies of scale and the national provision that helps to align arrangements throughout the HE sector. It is necessary to foster a human infrastructure that integrates across organisational boundaries and hence is tuned to the capabilities of the technical infrastructure.

Problems have been caused by an undue emphasis on technological achievements at the cost of understanding the real circumstances of use and the impact of arrangements on the research process. To a certain degree, this may be rooted in the fact that many of those involved in developing the technical infrastructure are themselves computer science researchers, who are evaluated by their production of papers and grant income rather than the production of technologies that are fit for general usage. It is therefore necessary to further the professionalization of research computing support and to provide long-term investment in it to establish the career paths that will allow staff to make the decision to follow this route rather than a research oriented career path.

There is a clear need for more practical knowledge about methods for studying working practices to be embedded in the education of technologists entering the field of e-Research. The combination of technological skills, an ability to conduct workplace studies and engage with application researchers is a key enabler for the development of hybrid skills that enable effective boundary spanning. Again, the development of these hybrid skills can only happen on a wider scale if there are clear career paths that build on roles that require them.

e-Infrastructures for Research often provide relatively advanced functionality but it is important to recognise also that relatively simple services that are broadly applicable could have a similar impact. Issues of data management have been flagged up in previous studies (e.g., Newhouse *et al.*, 2007) and feature strongly in the responses we gathered. The problems encountered range from a lack of

storage capacity to performance issues and problems with a lack of skills in effectively managing large amounts of data. We would recommend that funders, service providers and institutions consider the day-to-day data management needs of researchers in addition to their current efforts directed at the long-term preservation of research data.

It is likely that the emergence of a pervasive set of new practices across disciplines will take some time. The fostering of a sustainable, fit-for-purpose human infrastructure and, in particular, the emergence of sufficient numbers of boundary spanners who can act as facilitators will depend on the emergence of clear career paths for individuals interested in pursuing this path. As a consequence, we would recommend that funders as well as HEIs make a clear commitment to the role of research computing departments and their staffing.

9. Impact Assessment

The impact of the e-Uptake project will inevitably take time to materialise and maximising the impact remains, in very real ways, an ongoing concern for the lead project partner.

We expect impacts of the following kinds:

- Helping JISC, e-Infrastructure service providers and HEI research support services to identify barriers and problems experienced by their user communities and to develop ways of addressing them.

We have already had the opportunity to provide input into strategic planning by the NGS through a number of interactions over the course of the project. Most recently, we have contributed to the collection of requirements for the third phase of the NGS with a view to informing its strategy for getting institutions involved more strongly and to widen uptake to new user communities. In particular, we have had an expression of interest from Sarah Fulford from the EPSRC to provide input to the International Review of the UK e-Science programme. Our work has also influenced the formulation of the Century of Information Research strategy document.

Under the auspices of the lead project partner¹¹, we plan to conduct a series of meetings with JISC programme managers, e-Infrastructure service providers and to host at least one workshop to which HEI research support services will be invited to disseminate the project findings and to discuss strategies for responding to them. We will be liaising with Matthew Dovey and Judy Redfearn about holding further meetings with JISC programme managers.

- The corpus of findings will be made available within the ENGAGE portal to allow future researchers as well as other stakeholders such as service providers and JISC programme managers to mine the information produced. In conjunction with the events discussed above, the availability of this data will enable further analysis and increase the ability of stakeholders to respond to the needs of researchers in different research domains.
- The e-Uptake project has supported the first (and currently) only systematic analysis of the research community's requirements for training and education in the field of e-Infrastructures. Many approaches to developing the capacity of the research communities both in the UK and internationally are based on suppositions about the ability of the research community to absorb and adapt to e-Infrastructure. Often there is no hard evidence of the preparedness of the research community to acquire the necessary skills to absorb these techniques or the ability of existing educational structures to support this adoption. The e-Uptake project has provided clear and reliable evidence to support the development of policy in the area of e-Infrastructure education.
- The training and outreach events and their supporting materials (available through the One-Stop-Shop) that have been piloted by the project partners will serve as a template and resource base for future events.

¹¹ The NCeSS Hub will terminate on 30th September. Its research activities will be continued under the auspices of the Manchester eResearch Centre (MeRC), research director, Rob Procter. Alex Voss will also continue to be involved through his Advanced Research Fellowship at the University of St Andrews.

- The *Research in a Connected World* brochure will begin the process of filling the gap in early stage educational material identified by the e-Infrastructure education community at workshops run by e-Uptake and other projects. We have identified significant interest in the community to continue to develop this resource further towards the ultimate goal of having a textbook available.
- The UK one-stop-shop mechanisms for feeding event information, training material and support information into the portal will be maintained and will continue to work as they do at the end of the project. They will continue to provide a scalable mechanism for the effective dissemination of information to the wider community.
- The project has developed a methodology for community engagement that can provide a basis for further activities through funded programmes or through activities by stakeholders such as service providers, e-Science centres or institutions. We have documented the process in a number of academic papers as well as in our reports and we would hope that the experience gained can serve as a reference point in future activities.

10. Sustainability

Operationalising these findings and recommendations will require further coordinated effort by a range of stakeholders. Together with the other two JISC Community Engagement projects, e-Uptake has produced valuable outputs for the wider community that we believe should be sustained, exploited and expanded. This can be done at three different levels of increasing value but also at increasing costs.

The first would maintain the outputs themselves in a static form so that they can continue to be consumed by stakeholders after the end of the projects. We have chosen the ENGAGE portal as the main dissemination platform for the project outputs as this is most likely to be available in the longer-term future. Also, because it combines input from all three projects, it has significant value for the community. The UK one-stop-shop mechanisms for feeding event information, training material and support information into the portal will be maintained and will continue to work as they do at the end of the project. Our database of findings has been created on the Connexions system and we are continuing to populate it with material from our study. In order to ensure the sustainability of our data irrespective of the fate of this system, we have created mirroring mechanisms that we will also use as a basis for a mechanism feeding the database of findings into the ENGAGE portal. Finally, other project outputs such as the various reports produced can also be found on the portal.

This first level of sustainability only captures and maintains a static representation of the state of community engagement at the end of the Community Engagement strand without further funding. It sustains the material outputs but not the network of researchers who have been working closely together over the past two years. We believe that this network, which is expanding to include staff members from e-Infrastructure service providers (most importantly the NGS), is even more important than the material outputs.

The second level of sustainability would ensure that the social relations established can be maintained and that the analysis of the project outputs can continue to add value to what has already been achieved. As all three projects have interviewed members of the e-Research community, a corpus of interview material has been assembled from which added value can be extracted, especially by comparing and contrasting material from e-Uptake, ENGAGE and eIUS. We have not been able to do this as part of the current funded projects but believe that this would be of immense value to the community. We have had a number of meetings between members of the three projects to explore ways of funding such continued activities and we are working towards putting forward a proposal for funding by early Autumn 2009.

The third level of sustainability relates to the wider role of community engagement as the e-Science community moves into a new phase after the e-Science review later in 2009. We believe that activities such as the current Community Engagement strand are essential to the continued success of the whole while e-Research endeavour. The importance of community engagement is being increasingly recognised internationally. For example, the NSF is funding a programme of work under its Virtual

Organizations as Sociotechnical Systems (VOSS) call¹², for which it has made available significant amounts of funding. Likewise, the European Commission will be including a strand on Virtual Research Communities in its latest call under the FP7 programme. The outline of this strand contains a number of elements that are consonant with the aims of the e-Uptake project.

In the UK, JISC has once more led the field in recognising the importance of the human, social element of e-Infrastructures and has funded projects that have raised the bar for community engagement activities. In our view, it is essential that momentum is maintained and more deeply embedded in institutional contexts as well as in the organisational practices of service providers such as the NGS and of intermediaries such as e-Science centres. We believe that while the current funded activities provide value to the community and will have a significant impact, research must continue in order to capture the continuing evolution of e-Infrastructures and e-Research methods. There is a danger that the evidence gathered by the projects ages and becomes less and less useful or even misleading as it no longer describes contemporary realities. Therefore, we would call on funders to consider including similar calls for community engagement activities in their future programmes. The arrangements currently in place for sustaining the outputs of the JISC Community Engagement strand will ensure that future activities will not have to start from scratch but have a solid foundation to build on.

11. References

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¹² http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503256