JISC Final Report

Project Information			
Project Identifier			
Project Title	Building Research and Innovation Networks (Brain)		
Project Hashtag			
Start Date	1st April 2009	**End Date**	31st March 2011
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Partner Institutions	University of Leeds		
Project Web URL	project-brain.org		
Programme Name	*VRE3*		
Programme Manager	Chris Brown		

Document Information			
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Project Role(s)	Project Director, Project Manager, Process Work Lead, Leeds Partner Lead		
Date	30/03/2011	**Filename**	Brain Project Final Report.doc
URL			
Access	This report is for general dissemination		

Document History		
Version	**Date**	**Comments**
1.0	30/03/2011	

Table of Contents

1 ACKNOWLEDGEMENTS 3

2 PROJECT SUMMARY 3

3 MAIN BODY OF REPORT 4

3.1 PROJECT OUTPUTS AND OUTCOMES 4
3.2 HOW DID YOU GO ABOUT ACHIEVING YOUR OUTPUTS / OUTCOMES? 6
3.3 WHAT DID YOU LEARN? 12
3.4 IMMEDIATE IMPACT 17
3.5 FUTURE IMPACT 19

4 CONCLUSIONS 20

4.1 CONCLUSIONS - SPECIFIC AREAS 20
4.2 GENERAL CONCLUSIONS FOR THE COMMUNITY AND THE JISC 21

5 RECOMMENDATIONS 22

5.1 RECOMMENDATIONS - SPECIFIC AREAS 22
5.2 GENERAL RECOMMENDATIONS FOR THE COMMUNITY AND THE JISC 23

6 IMPLICATIONS FOR THE FUTURE 23

6.1 IMPLICATIONS OF THE WORK FOR OTHERS 23
6.2 FURTHER DEVELOPMENT TO BUILD ON THE WORK OF THE PROJECT 24
6.3 PROJECT SUSTAINABILITY 26
6.4 PROJECT CONTACT AND MANAGEMENT OF OUTPUTS 26

7 REFERENCES 26

8 APPENDICES 26

1 Acknowledgements

The project wishes to acknowledge the funding from the JISC, under the VRE3 programme, which made the project possible, as well as the other support that the JISC provided and particularly the help of Programme Managers, Frederique van Till and Chris Brown. All members of the project team played vital roles in the delivery of the project and acknowledgement is made of the work of Ajdin Brandic, Dimoklis Despotakis, Vania Dimitrova, Derek Griffiths, Peter Haine, Jim Hensman, Stella Kleanthous and John Tutchings. A project of this kind was dependent on the involvement of a very large number of people who gave freely of their valuable time and were essential to the success of all aspects of the project. Because of space, it has been necessary to restrict those mentioned, but many other individuals and groups made substantial contributions to the work of the project. Acknowledgement is made and thanks given for the contribution of the whole research and research support community at the University as well as staff in other roles and the considerable number of businesses and other organisations who helped the project in many different ways.

The project would like to acknowledge the contribution and help of the following individuals and groups:

Mark Abrams, Prof. Ruth Aylett (Heriot-Watt University), Tina Bass, David Bennett, James Bennett, Matthew Blackett, Prof. Mike Blundell, Christine Broughan, Colin Bruce, David Burden (Daden), Laurie Burrow (Converteam), Sharon Cartwright, Jacqueline Cawston, Sue Charlesworth, Elizabeth Cheese, Mark Childs, Leyna Cowie, Paul Dimmer, Prof. Helmut Dispert (Kiel University of Applied Sciences, Germany), Jo Dobson, Marion Doyen, Stephen Downes (National Research Council of Canada), Ian Dunwell, Prof. Erik Duval (Katholieke Universiteit Leuven, Belgium), Rossana Espinoza-Ramos (Warwick University), Lorna Everall, Paul Fairburn, Simon Fielden, Prof. Janet Finlay (Leeds Metropolitan University), Selina Fletcher, Prof. Neil Forbes, Prof. Sara de Freitas, Ross Gardler (OSS-Watch), Prof. Mark Gaterell, Keith Goodall, Leslie Gourlay, Rachel Granger, Tony Gutteridge, John Halloran, Christine Hamilton, Tom Hamilton, Prof. Phil Harris, Suzanne Hilton, Tim Horne, Jane Howard (Emerge Network), Pete Hudson, Jane Hytch (Imagineer), Augustine Ifelebuegu, Laura James (Cambridge University), Virginia King, Les Kirkup (University of Technology, Sydney, Australia), Moya Kneafsey, Paula Kramer, John Latham, Kathi Leahy (Imagineer), Richard Leary (WMHive), Catherine Louch, Tim Luft, Prof. Joe Luca (Edith Cowan University, Australia), Gideon Maas, Prof. Malcolm Macintosh, Louise Marjoram, Prof. Ian Marshall, Brian McCaul (Institute of Knowledge Transfer/University of Leeds), Tony McNally (Climate Change Solutions), Helen Mitchell, Michael Morgan (University of Monash, Australia), Sue Moron-Garcia, Prof. David Morris, Mike Musson (WMHive), Carmel de Nahlik, Michael Odetayo, Panos Petridis, Prof. Mike Phillips (Plymouth University), Prof. Keith Popplewell, Amanda Reece, Carley Rimmer, Mark Rushforth, Peter Samuels, Mark Schneider, Fiona Secondino, Dina Shah, Vaughn Shilton, James Shuttleworth, George Siemens (Athabasca University, Canada), Prof. Peter Sloep (Open University of the Netherlands), Tom Smith (University of York), Elise Smithson, Nicole Steils, Petar Stojik, Gemma Sutton, Alan Taylor, Andrew Tonks, Prof. Mike Tovey, Nigel Trodd, Ian Upton, Gerry Urwin, Ross Varney, Vicki Watson, Etienne Wenger, Prof. Sarah Whatley, Scott Wilson (CETIS), Joss Winn (University of Lincoln), Pete Woodbridge, Prof. Andree Woodcock, David Wortley, Dave Wright

2 Project Summary

The Brain project aimed to facilitate the building of communities of research and innovation based at Coventry University and to create a sustainable VRE framework embedded in the Institution that could support this. Preliminary work done as part of a previous JISC project had identified this as key to developing the research potential of the University and harnessing its collective intelligence. The University has a particular orientation towards Applied Research, working with partners from business and community. The lessons from the project were thus seen as potentially valuable to the JISC and HE communities, for which this direction was being seen as increasingly important.

The project had three main interlinked components:

- Finding out what people did in the area of research and innovation and what they needed to improve this.
- Analysing how University research-related processes worked and how they could be improved.
- Helping to fulfil user requirements - particularly by facilitating building communities and developing and integrating supporting tools and services.

During the course of the project, following a major consultation and review, the University restructured its research strategy around eight key "Grand Challenge" themes. This presented a major opportunity as well as challenge to the project. The project was involved with this initiative at a deep level and was part of formulating strategic plans for each of the Challenges, as well as continuing to develop and implement work within them. This engendered a high level of engagement with researchers and research which provided unique insights for the project and help to embed its work within the Institution.

The project and the tools and services it has developed have met with a very favourable response, attracting unsolicited comments such as, “this is an incredibly good facility”, and “it has huge commercial potential”. However, the progress of the project has also revealed the unexploited potential that still remains and indicated that we have only scratched the surface of what is possible. Most valuable perhaps has been the knowledge gained generally about researchers and the research process which will be of undoubted value to the JISC and HE community.

3 Main Body of Report

3.1 Project Outputs and Outcomes

Output / Outcome Type *(e.g. report, publication, software, knowledge built)*	**Brief Description and URLs (where applicable)**
Project Website - Information Content/Software	The main website linking to the services provided is at: project-brain.org. This website is also intended to be part of the global network of researchers helping collaboratively develop some of the broader themes of the project, for instance collective intelligence and methodologies to share practice – such as the use of pattern languages. It includes short video interviews recorded for the site with leading thinkers such as George Siemens and Etienne Wenger. An outline of the work of the project using a pattern-based format can be found starting at the *About* page: project-brain.org/about/. Implementation information for the site software can be found at: http://code.google.com/p/projectbrain/downloads/list
User Requirements Analysis - Report	Based on over 150 interviews, focus group sessions and other activities. See Section 3.2.1, Section 3.3.1 and Appendix D and E.
Research Process Analysis – Report	Based on work with a strategy focus group and research support staff as well as researchers. See Section 3.2.2, Section 3.3.2 and Appendix A.
Tools and Services – Software	A number of tools and services to support collaborative working were developed. See Section 3.2.3 (i) and (ii) for descriptions of this work. Software developed is released under the MIT Open Source License and can be found in: http://code.google.com/p/brainapp/downloads/list http://code.google.com/p/brainapp-web/downloads/list for stand alone and online versions, respectively. The online version of the tools developed can be accessed at: project-brain.org/connectapp/.
Expertise Maps – Report	One important use of the above tools and services was to map

	the expertise of the University in various areas and using various organisational criteria. Section 3.2.3 (iii) describes this work. Examples can be accessed at: http://project-brain.org/files/2011/04/Brain-Digital-Media-Research-Mapping.pdf http://project-brain.org/files/2011/04/Brain-Sustainable-Agriculture-Research-Mapping.pdf
Tools and Services for business and community engagement - Software	A central aim of the project was to help link research to business and the community. Adaptations of some of the tools developed as well as mashups were used for this. Section 3.2.3 (iv), describes some of this work.
Online Research Network (CircuitNet) - Software	The major underlying aim of the project was to help develop and sustain communities. Section 3.2.4 (i) outlines this and the online services implemented to support this aim. CircuitNet can be accessed at circuitnet.project-brain.org. Implementation information can be found at: http://code.google.com/p/circuitnet/downloads/list
Immersive Research Spaces - Software/ System	The project aimed to investigate new types of space and environments to facilitate collaborative thinking and working. Section 3.2.4 (ii) describes an example of this.
Project 1st Six Monthly Report – Report	Accessible at: http://project-brain.org/files/2011/04/Brain-Project-1st-6-Monthly-Report.doc
Project Annual Report – Report	Accessible at: http://project-brain.org/files/2011/04/Brain-Project-Annual.doc
'Connecting Knowledge, People, Communities and Systems' – Presentation	Presentation at OSS-Watch Bar Camp, April 2009, Oxford. Accessible at: http://project-brain.org/files/2011/04/Brain-Presentation-BarCamp-Oxford.ppt
Building Technology Enhanced Learning solutions for Communities of Practice – Workshop/Presentation	University of Leeds partners organised workshop – ECTEL 2009, September 2009
'Brain Project' – Presentation	Video at Dissemination/Meeting VRE/VRERI Event, February 2010. Accessible at: http://vimeo.com/9855264
'Brain Project' – Publication/Presentation	Poster for Dissemination Event: Virtual Research Environments: the next steps - Knowledge Exchange Workshop (JISC/SURF etc.), Rotterdam, June 2010. Accessible at: http://project-brain.org/files/2011/04/Brain-Poster-Rotterdam-Knowledge-Exchange-Workshop.ppt
'Brain Project' – Publication/Presentation	Slide-show for Dissemination Event: ED-Media 2010, June 2010
'Tools to Find Connections Between Researchers' – Publication/Presentation	Paper for Dissemination Event: ECTEL 2010 Workshop Proceedings, http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-675/paper6.pdf
'Facilitating Interdisciplinary Research – Requirements and Realities' – Publication/Presentation	Paper for Dissemination Event: ED-Media 2011 Conference (Forthcoming)
'Between Physical & Virtual' – Event/Report	Brain Focus Area Event, November 2009, Report – project-brain.org/events/pandv/report-betweenpv/
'Innovative Future' – Event/Report	Brain Focus Area Event, December 2009, Report - project-brain.org/events/innovative-future-event/
'Zero Waste' – Event/Report	Brain Focus Area Event, October 2010, Report - project-brain.org/events/zero-waste-and-how-to-achieve-it/report-zero-waste-and-how-to-achieve-it/
Process Review Focus Group – Meeting/Presentation	Special stakeholder event to provide feedback on research process analysis work – February 2010
Project Launch Event – Event	Official Brain Launch Event with General and Technical presentations and focus group meeting – March 2010

Project Dissemination Presentations – Presentations	Approximately 20 presentations and demonstrations to research groups, business support staff, management groups, Open Days etc.
Project Evaluation Event – Event/Presentation	Evaluation event including use of immersive discussion system, for internal and external researchers - March 2011
Project Evaluation Focus Groups – Meetings	5 events for different focus groups to give feedback on the project (September 2010 – March 2011)
Research Community – Knowledge built	Embedded in the different participants and groups involved in the project (researchers and research groups, the different focus group members and the project team itself) - is a far greater understanding compared to when the project started of the issues involved in creating collaborative communities together with at least some appreciation of the concepts, processes and solutions required. Although hopefully a significant start has been made, perhaps the biggest contribution of the project is creating an impetus and direction which it is hoped the Institution will follow in the future and which it is hoped will also be able to help the JISC and HE Communities.

3.2 How did you go about achieving your outputs / outcomes?

3.2.1 WHAT THE PROJECT DID – FINDING USER REQUIREMENTS

An extensive requirements analysis, which was continued over the course of the project, was undertaken. Over 150 interviews and other sessions and activities were carried out and many generic use cases based on actual examples of usage to drive and benchmark the project were put together based on this work. Section 3.2.5 (ii) discusses the methodology used for interviews and other activities. An outline of some typical use cases, included:

- A University meeting with another institution is taking place to discuss possible future collaboration. What work has been done with them in the past and what are potentially the best research areas to explore?
- A business needs to know how to calculate the surface area of a complex object. This doesn't correspond easily with Institutional disciplinary divisions. Who would know at the University?
- A funding call on Energy and Communities involves subject areas ranging from environmental science, civil engineering and computer simulation through to psychology, sociology and economics. Who should be involved - including external partners, and what facilities would support the preparation of a proposal and the continuing collaborative research activities of the project itself?

Results from the requirements analysis work are discussed in Section 3.3.1.

3.2.2 WHAT THE PROJECT DID – ANALYSING RESEARCH-RELATED PROCESSES

Research processes were considered in a wide context initially and then ones that were particularly relevant to the project's work identified and concentrated on, with particular emphasis on information related areas. As an example Appendix A, Illustration 1 shows the principal information sources that are required by research project processes. Key issues addressed included:

- What is the information support provided for research processes?
- What are the key data needs and how are they met?
- What systems are used and how reliable are they?

Information about research related processes was obtained partly through the general user requirements work but also through interviews with specific stakeholders. Preliminary analysis based

on this was then fed back to special Focus Groups organised for this purpose, which allowed suitable models to be derived and refined.

The main conclusions from this area of the work are described in Section 3.3.2.

3.2.3 WHAT THE PROJECT DID – DEVELOPING TOOLS AND SERVICES

This section describes a selection of the tools and services developed by the project to meet requirements that were identified, together with examples of how these were used in practice.

i. Who Knows What? – Tools to Find Expertise

A key requirement identified in discussions with researchers, business development staff and others was to find relevant expertise relating to a particular topic when putting together a project proposal, writing an academic paper etc. Appendix B, Illustration 2 shows the output from the use of a tool constructed for this purpose. To implement this, a range of different data sources - including user profiles from a CV database, information about bids and projects, public relations information about expertise and other sources were brought together for the first time at the University. Additional features implemented included searching by logical combinations of keywords and the inclusion of synonyms. Later enhancements to the system allowed information from other sources, for instance about companies, to be included.

ii. Who Connects to Whom? - Tools to Find Connections

A related requirement was one to find connections between researchers which could be used to identify potential partnerships or collaborative relationships. In work with users it was clear that there was a requirement to go beyond simple matches on the basis of common authorship of academic papers and similar connections and to find more oblique, even serendipitous connections. The example shown in Appendix B, Illustration 3 demonstrates some of the aspects of the tool which aimed to reflect this requirement. In the example shown, the tool has also picked up a variety of other researchers and associated research areas outside the main field work of the researcher in question (which relates to wireless sensor networks and computer analysis of medical images).

In some cases these connections are quite unexpected but nevertheless relevant, including mathematicians through the analytical techniques used, specialists in visual representation through the visualisation techniques used, and specialists in different types of image analysis from disciplines as diverse as automotive engineering, metallurgy, and Geographical Information Systems. Particularly interesting, as in this example, is where connections which bridge the sciences and the arts can be made. As with the Expertise Search Tool, later enhancements included adding external information - from companies and other universities, for instance. Particularly significant in later developments were features to allow the system to scale to allow much larger sources of information covering many academic institutions and companies to be included. This required techniques for ranking and filtering connections and these developments are an active and continuing area of work for the project.

iii. Finding New Opportunities - Mapping Expertise

The University's reorganisation of research to focus on a number of Grand Challenges provided an ideal opportunity for the project to use the tools it had developed. Visualisation facilities, in this case using the Open Source VUE system, were linked to the tools described earlier to allow expertise maps as shown in Appendix B, Illustration 4 to be created, which were used to assist in determining strategic research plans. Also illustrated is an example of the use of a number of knowledge and semantic analysis techniques that were developed to use these mappings to identify gaps in the market and new opportunities. In the example shown, mappings from two different areas, which included expertise from another University, were used to help put together a proposal which was successful in obtaining Research Council funding.

This work is being extended to include wider skills and competencies, allowing the system to include University personnel other than researchers, such as professional services staff. This work also has

direct relevance to businesses, who usually do not define their expertise in academic terms, and the project has been working with industrial partners particularly to develop this.

iv. Supporting Links with Business and the Community

A key aspect of the project was its orientation towards business and community engagement with research. The project has thus worked extensively with a number of business networks as well as individual companies and other organisations. Appendix B, Illustration 5 shows an ongoing project development to connect the web version of one of the research expertise tools described earlier with a major business network, WMHive - formerly the Advantage West Midlands (RDA) ICT cluster network, which has information on over 5000 businesses involved in ICT and other technology areas. This has major potential benefits for both research and industry through opportunities for joint projects and other collaborative work, provision of learning and training, student mentoring and placement and extending the system to support wider academic – business innovation networks both nationally and internationally. The system could also form a gateway to other services, for instance ones supporting virtual businesses and collaborative design, such as those developed by the EU projects, Synergy and ID-Space, and this has been looked at with the developers and providers of these services.

The second example in Appendix B - Illustration 5 shows the use of a mashup of information linking research with the relevant businesses and business clusters, using Google maps to display information geographically.

3.2.4 WHAT THE PROJECT DID – BUILDING AND SUPPORTING PHYSICAL AND VIRTUAL COMMUNITIES

i. Physical Events and Social Networks

The central theme of the project was facilitating communities of different kinds. A significant amount of its work was therefore directed towards helping to build and support communities and networks, adopting a very flexible approach to suit the specific requirements of those involved. An example which illustrates the role that a project like Brain can play relates to an initiative around the theme of waste. The project used some of the tools it had developed to bring together researchers from a number of different faculties in response to an opportunity that had arisen in this area. Appendix C, Illustration 6, shows an event at the University on this theme which attracted 70 people and was able to bring together key stakeholders from business and the community, such as the local council leads on environmental issues from all three major parties, for detailed discussions with researchers at the University on the steps to develop and fund projects in this area. An active group now exists in this area and has met several times.

Also shown is an online system implemented by the project, CircuitNet (Coventry Innovation and Research Community Network), used to provide flexible networking support for discussions and collaborative working around particular themes or initiatives such as this. The project has organised a number of events and activities around different themes and made a detailed analysis of the factors that lead to successful physical and virtual meetings. The project found that many researchers and research groups already had networking systems that they used or had preferences for. In many cases simple e-mail groups proved to be adequate for what was required. The project therefore did not seek to impose its developments on researchers, but interfaced to their systems where possible to provide complementary facilities as required.

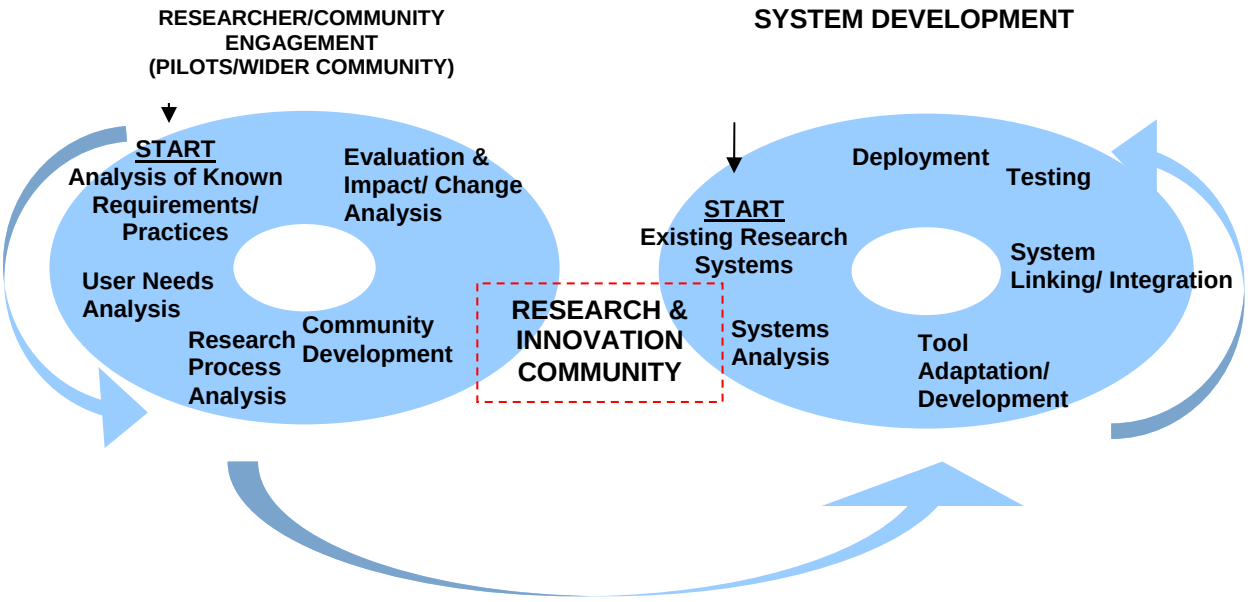
ii. New Systems to Support Collective Thinking

The project has initiated innovative and cutting edge developments and worked as part of research networks, such as the Research Council SPIRES network, to explore wider aspects of relevant issues in different areas. One development of this type has been to explore the use of immersive 3-D spaces to facilitate collective brainstorming, discussion and thinking. A system shown in Appendix C, Illustration 7 was developed working with an innovative company, Get Real Solutions, and has been used to help visualise and develop concepts and interact collectively with knowledge. This system uses some of the tools mentioned earlier as web services, illustrating the potential of flexible, interoperable developments. This was used as part of events, including a major evaluation event,

involving researchers from Coventry and other universities as well as businesses, some of whom were physically present and some who participated online. The illustration also shows a variant of this system used for crowd sourcing public opinion and facilitating user feedback, implemented for a company, Imagineer Productions, who are involved in a major initiative for the 2012 Olympics and have been working with the project.

3.2.5 PROJECT METHODOLOGY

i. General and Evaluation



The diagram above, reproduced from the original project submission, shows the model which the project used throughout the term of the project and proved very successful for its needs. The basis of the methodology was the interlinking of the requirements analysis and community development cycle with system development and deployment, using Agile and RAD techniques to provide very short cycles of user feedback and incremental development.

This presupposed a process of continuous evaluation and careful consideration had to be given to the methodology for this. The work of the current project had built on work from a previous small JISC project [see References: JISC DINCoP Project Report, 2007], which had carried out a preliminary analysis of user research requirements at the University and had looked - using examples from business, government, research and other areas - at what factors contributed towards successful Communities of Practice. This had concluded that successful communities were in fact in practice communities of communities where flexible interactions took place within and between larger and smaller groups - going down to individual level, so that at each of these levels significant benefits were obtained by those involved.

This often meant that the "Community" was often seen by participants not as the wider whole, but primarily as the specific area within which most of their activities occurred. This observation and analysis was incorporated into both the overall and evaluation methodology for the project. Thus even though development of communities and systems supporting them and the evaluation of these did include general criteria, the main mode of operation of the project was to concentrate on particular areas, groups, businesses and even individuals and carry out developments and the evaluation of these very specifically, developing and supporting higher level connections and activities based on what emerged from this work, rather than trying to impose this beforehand.

This led as well to the project adopting a very "hands on" approach, working closely with researchers and groups over a period of time and participating in their activities as appropriate to be able to understand the issues from the "inside". In some cases, project team members had research

experience themselves or were already involved in the areas of work under consideration, which helped to facilitate the close stakeholder engagement the project was seeking.

ii. User Requirements Gathering

The project used a variety of techniques to gather user information, including interviews, focus groups and various other group activities, surveys and questionnaires. What method was employed depended on what type of requirement was being considered and on the wider context. In the later stages of the project particularly, much of this aspect of the work took place as part of other activities, such as demonstrations and dissemination events, as well as activities organised by others. The primary means of gathering information especially in the initial stages was by face-to-face interviews, normally taking 1 – 2 hours. Where appropriate, measures were taken to try to reflect a cross-section of users involved in any particular area. At a simple level this could be by providing a spread across obvious groups, such as undergraduates, graduate students, academics, and business developers. Again, research and innovation in different subject areas had very different demands and this was reflected both in the pilot areas chosen and in the selection of cases to analyse. Care was also taken to provide a wider context. The main focus of research at the University was on Applied Research. However, there were groups working in other areas of research and it was important to include some of these in the analysis. For instance, the University had a major mathematics research group working in the field of continuum mechanics and electromagnetism and members of this group were interviewed for the project.

The underlying approach adopted when interviewing users was that of Appreciative Enquiry, thus highlighting the positive and what had worked well and been effective. Nevertheless, it has also been necessary to identify the issues, problems and barriers that exist, considering the challenges but also importantly the opportunities that these presented. Interviews and discussions focused around the following general questions:

- What research/innovation work are you/have you been involved in?
- What types of activities and processes has this required and involved?
- What examples of shareable practice can you relate?
- What tools and services have you used?
- What's missing - what improvements or refinements to these, or new facilities, do you feel are required?
- What issues/problems/barriers have you encountered?

The project has been very interested in different approaches to user analysis and has discussed this issue with a number of other projects and researchers. For instance, the approach taken by the JISC Academic Social Networking project, based at Cambridge University was considered particularly interesting and two members of the project team spent a day visiting members of that team looking at their approach. Based on an extensive exercise with groups of users, that project has derived three personas which provided archetypes for different types of users. These were used to design the user interface for the system being developed. A number of the techniques used in this work corresponded to the approach Brain was using even to some level of detail and the project was able to apply some of the results to its own work.

iii. Technical

As envisaged in its original plan, the technical methodology of the project was pragmatic and very "bottom-up", starting from existing systems and attempting to link these and support interoperability, rather than trying to reinvent wheels. Adherence to standards was an important principle for the project together with a strong focus on service oriented approaches. This was, however, not always easy, and had to be tempered with realism as necessary. For instance, the project did a significant amount of work relating to using OpenSocial, the open API for social networking applications, using Apache Shindig as a container, for example. However, even though some of this work contributed towards the systems developed, it became clear that few useful open source applications that could be used with this existed and other approaches would mainly have to be used in practice.

Again the project strongly supported the concept of the Personalised Research Environment, analogous to that of the Personalised Learning Environment, and Scott Wilson's (See References: Scott Wilson, 2009) work in this area was one of the important influences on the project. Some work was done using the Wookie framework, which is one means of implementing this approach. Although the PRE aim and the use of frameworks such as this are still believed to be key approaches for the future, in practical terms it is felt these technologies have not reached the maturity and take-up to be viable in production environments.

Where no suitable service or application existed for some purpose, the project carried out some development, but again concentrated on the re-use of existing resources and adopted a modular and component-based design approach that the role could be adapted flexibly for other purposes. For instance, ConnectApp, a tool that was developed to find connections between researchers, was also then adapted to find connections between companies and between companies and researchers.

3.2.6 AIMS AND OBJECTIVES - CHANGING PERSPECTIVES

The initial aims and objectives of the project were to develop a VRE as part of a Community of Practice, particularly to facilitate working across disciplines and to support Business and Community Engagement. Also important in its aims was to increase awareness, both at the Institution and in the wider HE Community, of the benefits as well as the issues relating to this approach. The project maintained this as its fundamental driver throughout its course. However, in line with some of the considerations discussed in the Methodology section above, it became increasingly clear that generic objectives and outcomes had to be translated into specific ones relevant to individual research groups and researchers for this to become meaningful.

Therefore even the concept of a VRE was rarely broached directly in the work of the project. However, hopefully in a significant number of cases, those involved with the project understood from their point of view what a VRE was or could be. This tied in with one of the precepts of the project, that the traditional concept of a VRE as an entity – manifested for instance as a single portal, was not necessarily obsolete but had to be seen in the context of other more devolved approaches in a Web 2.0 world.

3.2.7 HOW THE PROJECT WORKED

The main components of the project's work: User Requirements Analysis, Process Analysis, Service and System Development, Community Development, Service Deployment, together with Evaluation and Dissemination, were connected together in the form shown by the methodology diagram in Section 3.2.5. Four thematic areas, Serious Games & Creative Industries, the Environment, Health & Health Technology and Entrepreneurship and Enterprise, had been chosen to provide a focus for the scope of the project, although it was intended to widen this out as far as possible within the constraints of project resources. Although not necessarily following a strict sequence for these themes, the initial work of the project concentrated on each in turn, looking at specific requirements within these areas and then following this through to analyse process, develop services etc.

Initially especially, the project aimed to develop strong relationships with individual research groups, rather than necessarily trying to cover a wider range more superficially. Thus for instance in the area of Serious Games, the project participated in the associated Research Group consistently for the whole of the period of the project. This meant that the project became a standard agenda item on meetings of the Group, for instance, and because of the close relationship that had been built up, engaging researchers and evaluating the impact of the project were made easier. With some groups of researchers this helped to make the project part of the research solution, rather than something providing just a networking or technical facility. In some cases this even led to some misunderstanding about the role of the project and we were called in to help in specific areas of expertise which were quite outside our area of competence. However, this then provided an opportunity to look at requirements in a deeper way and integrate our work more closely with specific research areas.

Developing this close relationship over time also applied to work with businesses and business networks and helped to create a situation where the project was seen as aligning closely with the

requirements of these bodies and therefore involved at a deep level with finding the desired solutions. For example, one business working with us included the project in a bid to the Heritage Lottery fund without us initially knowing! Again the project was involved with and actively participated in a leading network in the Creative Industries area. This meant finding the time for perhaps 20 meetings over the course of the project, but allowed us to discuss with both the network as a whole as well as many individual businesses about the project and allowed the project to get involved in a number of initiatives and research collaborations. Building up these close relationships over time meant that some business and businesses networks would discuss problems with us without necessarily pre-supposing what kind of help they were expecting. Work done by one of the project team as part of a large initiative providing technical and other help to businesses showed the importance of this because it demonstrated that many requests from businesses were very loosely and imprecisely formulated, making it difficult to identify relevant researchers. Therefore one of the processes that the project had to consider, together with the tools and services to facilitate this, was how to enhance and augment this initial information so that it could be adequately dealt with and building up close ongoing relationships with businesses and other organisations helped greatly in this.

As the project proceeded, more of the work already undertaken could be reused so that new developments and pilots could build on earlier work. At about the midway stage of the project, a reorganisation of University research, mentioned earlier, began to take place. Until then, research had been organised around a number of Applied Research Groups, Applied Research Centres and Institutes. Although these were still kept in place, the organisation of research as a whole was focused on 8 Grand Challenges, and the project was given the opportunity to take part in facilitating this. Even though this went beyond what had been originally envisaged in terms of the scope of the project, by this stage sufficient progress of the project as a whole had taken place so that this was viable, although still very challenging. This provided a different type of opportunity because the project was able to interact with much larger numbers of researchers and look at requirements and solutions to different types of problem. For instance key issues and questions that arose were related to finding new internal and external partnerships and looking at possible funding and market opportunities.

This area of work perhaps benefited the project more than any other because of the degree of engagement it led to. Up to a certain degree, as is common with many projects, engagement with users up till then had been project driven and initiated. However now users were actively seeking out the project both with problems and requirements but also with new ideas of what they wanted the project to do. This was most useful because rather than having to rely on questionnaires or interviews initiated by ourselves to ascertain requirements, the project obtained a real feel for what people wanted. This engagement also was very helpful in evaluating the work of the project because users volunteered information about what they thought of particular aspects of the projects work and also were motivated to spend time providing feedback on changes and enhancements. For example, two Research Assistants who were part of a major research group in Sustainable Agriculture, spent a considerable amount of time and effort providing very detailed feedback on the work of the project as it related to the work of the group.

Although care had to be taken to maintain the timescales and commitments in the Project Plan, the project could in its later stages be more closely driven directly by user demands and feedback. It was asked to contribute to a number of high-level strategic initiatives and implement solutions and run pilots in many more areas than its resources allowed. Although the project was still best known for the results of what it was doing as we had intended, it also became a talking point in its own right which both helped to raise its profile and encouraged further feedback and engagement.

3.3 What did you learn?

3.3.1 WHAT USERS WANTED - REQUIREMENTS ANALYSIS

Extensive ongoing work with users, using some of the techniques mentioned earlier, helped to establish a detailed picture of user requirements and issues. A summary table based on the user needs work of the main functional areas in which users currently used or required tools and services is shown in the Appendix D. In relation to facilities that were asked for, a number of underlying themes were identified as particularly important, including:

- The support and facilitation of connection and community.
    - "How do I find the person I want to talk to?" and "How do I discuss a good idea I've had?", were recurring themes.
- Ease of use and integration with existing work practices.
    - Recurring issues included having to re-enter identical or similar information multiple times and non user-friendly interfaces. Because of the importance of user interface considerations, a set of criteria to guide work in this area was drawn up and is shown in Appendix E.
    - A handful of applications (e.g., Microsoft Word, Outlook) accounted for nearly all usage and new services or applications needed to integrate easily with these.
- Support for key workflows and tasks
    - Many researchers expressed the view that the biggest problems they faced in carrying out their research were not related to the research itself but concerned some of the organisational and management tasks required. Examples included: Preparing a funding proposal; Obtaining ethics approval for research activities; Making financial arrangements for external project partners and financially tracking collaborative projects.

3.3.2 RESEARCH PROCESSES AND INFORMATION

Important findings about research related information were:

- There was often no universal agreement about master sources of critical data elements. Even when master sources were agreed, processes for ensuring they were up to date and accurate were inadequate.
- Different data sets often did not include consistent common key fields that could be used to connect the information together.

Data quality was thus a problem with detrimental efficiency and cost consequences for the Institution. In relation to the work of the Brain project, these issues were apparent in relation to requirements it had identified to answer questions such as: Who knows what?; Who is available to work on opportunities?; What work can we re-use, or use as a model?; Where are the documents/ publications relating to a project?

A number of the most often requested requirements also demonstrated the issues involved with connecting different pieces of information and associated systems. For instance, frequently requested in one form or another was the need to only have to create or update a particular piece of information once, even if it was subsequently used in many places - as one user expressed it, *"The frustrating thing is being asked for the same information several times in different forms".* This requirement was expressed in relation to maintaining profile information on websites and social networks, supplying information about research supervisory experience and setting personal preferences of many kinds, among others. What was needed was aptly described by one user as "*a big spreadsheet with lots of columns where you put in or change information under any category just once*". Looking at this in any detail revealed that even if the information required by some application was identical to another's, a range of problems usually existed relating to interfaces, formats etc.

When considering the workflow of typical projects, common structures and patterns were apparent. A basic outline structure is shown below, which does not attempt to cover the range of possibilities actually encountered.

Initiation – (e.g., Following from previous work; Initial idea or concept; Funding opportunity; External business requirement; Consortium or partner invitation etc.)
Setting up – (e.g., Concept development; Funding search; Consortium and partnership building; Bid preparation etc.)
Main activity - (e.g., Ethics approval; Literature review; Requirements definition; Main research or innovation process; Testing; Evaluation; Publishing, Financial Management, etc.)
Completion and follow up – (e.g., Dissemination; Product development and launch; Organisational embedding etc., Reporting, Financial completion)

Of course actual activities carried out and their sequence were dependent on the particular case and the organisational and other context and each activity could itself be subdivided into options and sub-sequences. Despite this complexity however, it was possible to see commonalities and to make generalisations which in principle could have been used to provide common solutions to the benefit of users and to improve efficiency. This tied in to some of the requirements mentioned earlier relating to key workflows and tasks. However, looking at these from a wider process point of view helped to suggest the more general improvements and service developments that could enhance the research process. Although the ability of the project to change and improve research related processes was limited, it nevertheless could carry out an analysis and make suggestions. A broad process simplification exercise using a Lean Sigma approach was used. This focused on the overall goals of the processes and sought to eliminate unnecessary or inefficient steps and system components. Where there was conflict, root cause analysis was used to determine what needed to be done to support the goals. A further aim was to identify responsibilities and deliverables and ensure successful handoff between steps and that the necessary flow of information took place.

3.3.3 SERVICES AND TOOLS

i. Networking Services

A key principle of the project was to ensure that its technical aspects flowed from and were always seen in the context of its wider community building and other aspects. However, apart from what was learned through the experience of the use of the services and tools deployed by the project, even the technical development that took place on their own provided many lessons of value. The requirements analysis carried out indicated the need for some kind of networking environment into which various tools and services could be integrated. As indicated earlier, the project adopted a very low key attitude towards any new developments in this area because of the variety of systems already in use. The project used the approach of working with users and demonstrating several options to ascertain what would meet their requirements best, especially if users already had experience of a particular system. Thus the project assisted groups to use a variety of social networking systems, such as Google Groups, Ning and Linkedin. The University also used SharePoint as its main system of this kind and in some cases this proved suitable for research purposes. In one case of an important new University initiative, the project was asked to use the system it had developed because SharePoint did not have the flexibility required. However, because we considered it the most suitable system for other reasons, the project actually organised the developments necessary to SharePoint to remedy this. However the project did identify the need for a flexible and lightweight system of its own that could be more closely linked with the University research community and which also could provide integrated facilities to support other collaborative requirements.

The project carried out much investigation and implemented various prototypes using different technologies, looking at the experience of other national and international projects - such as the JISC HeLMET project based at Manchester University, the EU FP6 Palette project and those being developed by the EU Responsive Open Learning Environments (ROLE) project – as well as looking at systems such as Sakai and Liferay. In the end the system implemented by the project which formed the basis for its deployed system, CircuitNet, was an integration of WordPress/BuddyPress and various other applications. This was chosen after several discussions with Joss Winn of the University of Lincoln who had developed the JISCPress project using similar technology, primarily because it fulfilled the core requirements that have been identified but also had a huge library of available plug-ins allowing flexible enhancements and modifications to be easily implemented. Development of new plug-ins or modification of existing ones, which was done in a few cases, was also relatively easy. Again because of the stress on interoperability and connection, interfaces from this system with SharePoint and other systems were developed.

Although CircuitNet has proved satisfactory in the main, the project also has reservations with the underlying platform, particularly in production use. This is because a consistent development model does not exist for this system, although some improvements continue to be made to this, and new versions of the software can render existing plug-ins inoperable or unstable without warning. The project thus has had to deploy a working configuration with a certain release of the software without necessarily being able to update this without changes to the functionality of the system as a whole.

A considerable amount of development - much longer than originally envisaged, was also done on providing the required infrastructural connections for this system and other linked ones. This was required, for instance, to allow existing users at the University to authenticate to the system using their normal login credentials, but also to provide external access if required using OpenID and other systems - the only University system that provided this facility. Because the University did not have an authentication infrastructure in place to support this, a significant amount of work was required, using Kerberos and other techniques. One important lesson learnt from this was the importance of having a suitable infrastructure to support developments of this kind. The project considered in detail developing this infrastructure (using CAS) as an offshoot of the project, but was precluded from doing this eventually because of the time that would have been needed.

For the reasons described above, extensive usage of Circuitnet was not aimed for or expected. Rather it was targeted particularly to complement other systems or for particular niche requirements. Some major networks, such as the one mentioned elsewhere on Waste, used it significantly - but its particular strong point was providing lightweight flexible systems which could be set up and maintained by users. This was a particular issue with systems such as SharePoint, which required system administrators to be involved extensively. The project was keen on developing a much more devolved and user driven service. The heaviest use of the system was for short-term requirements around events or activities or where particular auxiliary facilities, such as the ability to upload and share files to support e-mail discussions, were required. Again, the ability to support a variety of different types of groups – open, closed and private groups that could not be seen by the rest of the network, was an advantage. One of the philosophies that the project tried to encourage was that discussions and networks didn't have to be considered as heavyweight or long-term, but could be set up easily and quickly and easily terminated as well if not needed. A typical example of its successful use was for discussions around a project on Digital Archiving, where the experience of a previous successful project which was videoed and put on Youtube by the project could be easily discussed and other content added and commented on easily.

ii. Tools to Find Expertise and Connections

In the main the project concentrated on the integration of existing tools and services. One major requirement for which no suitable existing application could be discovered was one to search for required expertise and to find connections between researchers. The tool that was developed, called ConnectApp, became one of the major software developments of the project and was released both as a stand- alone application as well as a web-based one later. The principles behind the development of this is described in a publication of the project [See References: Jim Hensman et al., 2010] so a detailed technical discussion is not provided here. Because this tool had a number of powerful features, such as being able to find unusual connections between researchers, besides the more conventional ones through common authorship of papers etc, it attracted considerable attention and allowed other aspects of the project to become better known.

Although its effect was hidden beneath the surface, where the information that this tool relied on came from was very important and had a number of general lessons of wider interest. Until the project carried out its work, some of this information had been completely inaccessible and combining and aggregating the information was a significant problem because of the lack of appropriate linking data and because of the poor quality of some of the information. Some of the lessons from this are reflected in the discussion on process. Dealing with this problem, however, also benefited the project as new techniques were developed to deal with less structured information sources. This in turn allowed the scope of tools like this one to be extended, for instance to be able to find links that included businesses and researchers from other institutions, using information available on the Internet.

iii. Immersive Spaces to Support Discussions

A central aspect of the project was developing communities and a particular study was made of the best techniques to support both physical and virtual discussions. One area that was of particular interest was how these could be combined using immersive spaces. The development work that the project did in this area also illustrates some of the principles that the project was trying to follow and instil in those it engaged with. One of the first major events the project organised covered one of its

designated focus areas relating to Serious Games and Virtual Worlds. This was entitled "Between Physical and Virtual" - about the use of Immersive Spaces for learning and other purposes - and was chosen because our user requirements work had indicated that this was a theme that would attract interest from many different disciplinary areas. This was a successful event involving demonstrations and discussions and one of the companies participating, Get Real Solutions, offered to demonstrate some work it had been doing on immersive spaces to help facilitate the discussion session. Later, as part of the work the project was doing with another company, it was able to introduce Get Real Solutions to them resulting in the development described in Section 3.2.4 (ii). This in turn led to the project engaging in a joint exercise to integrate its tools and services with these immersive space developments and the results of this were used for a major evaluation event towards the end of the project. This work proved very useful to the project for many reasons. Discussed in the next section is the issue of how evaluation can be done, and undoubtedly one of the problems in this area is how to elicit user feedback in an authentic manner rather than it being seen as just a formal exercise. This activity was able to use a number of the developments of the project and collect user's views without them necessarily perceiving this as the main objective of the exercise - thus obtaining a more natural set of responses. For this development, the project created variations of some of its tools to be used as web services for the immersive space system, as well as some new services. Considerable experience was thus gained in various aspects of interoperability and in optimising this kind of hybrid development.

iv. Evaluating Tools and Services

A considerable amount of effort was directed towards evaluation of services and tools created, particularly because of the project's methodological approach of continuous improvement through user feedback. Because requirements gathering continued throughout the life of the project, to some extent this could also include an evaluation component, especially later on as users could be asked about the projects outputs or would comment on them naturally as part of the discussion. The discussion on methodology referred to the importance of evaluating tools in relation to how they were used in specific cases, and much feedback about tools and systems was obtained indirectly as part of activities, discussions and events which were primarily about other issues but where the project's outputs had impacted in one way or another. However, some Focus Group and other events were specifically organised for evaluation purposes. For instance, one event which included participants from other universities and businesses, demonstrated the integration of the services developed with the immersive collaborative thinking environments, mentioned earlier. Because various characteristics of the system and tools could be changed on the fly, this allowed a detailed comparative evaluation of various aspects of the development to be obtained very quickly. In addition the project has been able to take advantage of interest in what it was doing and invitations to research groups and other bodies, such as Senior Managers' Groups, to include evaluation activities within the sessions organised.

To a considerable extent the rapid development and close feedback loop with users has also facilitated the evaluation process. Often users would provide carefully considered evaluation because they knew this would be taken into account and would improve the tools and services they were using. Many of the online responses that the project has received as part of its evaluation exercises reflect this. They comment on a number of features, and then add a list of suggestions for improvements or new features. A very brief example says for instance, "*It's very easy to use. I really like it. Can I just ask if users will be able to easily alter information held about them?*" Another longer (edited) example says, "*It works great here - Google Chrome ... The thing I'd like to see is a way to explore. So, when I click on a person, I'd like to be able to then click on an item from their list of publications or interests and have the graph refocus on that. Maybe even the authors in the publications? …*" Communications like these would provide the opportunity for a more extensive discussion on what users particularly liked as well as obtaining more detail about changes and enhancements desired.

In some of the group evaluation sessions, various methods could be adopted to provide particular information of value. In one of these, users were very complimentary about the project tools and services. Although we were not averse to such a response, it was also clear that we were not learning very much! We also realised that because what we provided was not available in any other way, people were perhaps just grateful to have anything at all. We thus introduced a rule for a certain time

that we were only interested in critical comments, which provided a sobering - and perhaps more realistic set of evaluations!

Overall, the project has been very encouraged by the response received about the tools and services developed, which have been incrementally improved over a considerable period through user feedback and interaction. However, we are also very aware through the evaluation process and general response from users that they are many improvements and additions that could be implemented, as well as a whole range of other requirements which are still not met – discussed in Section 6.2.

3.3.4 THE PROJECT AS A WHOLE

The type of work the project got involved in wasn't necessarily exactly what had been envisaged at the start. This caused the project to have to reassess its role to some extent and perhaps this helped it to understand better what a VRE actually needed to be. Some examples of work the project carried out related to the Research Evaluation Framework will give an indication of this. The project had not planned any specific work related to the REF at the start, as a separate set of developments and Working Group had been put in place by the University. The University Director of Research nevertheless invited the project onto the Working Group and the project initially considered its role to be principally a watching brief. However, because of the other activities of the project and the expertise it had developed in a number of areas, the project got involved in several areas of work. As described elsewhere the project was mapping various research areas and the connections between researchers within these. We were asked by some research groups to look at how their work would link to others within the various Units of Assessment that had been proposed and help them decide which might be the most suitable. The University had set up on its Research Portal a set of discussion areas to support the REF exercise and the research groups involved. Some groups found the structure too rigid and wanted something to complement this that would be more flexible and suited to their needs. This again was something the project could offer through its CircuitNet service. Another key issue was how publications referenced in submissions would link to the relevant documents in the Institutional Repository. Because the project had already done work on this area as part of integrating existing services with the new ones it was developing, it again could help in this area. In fact, because the project had built up a considerable depth of expertise in a variety of areas relating to research related services and their interoperability - ranging from using the MIMAS Names Project to interfacing with graphics archives - it found itself much in demand and had to carefully control what it did.

The contribution that the project was able to make was of course very gratifying to the team. However, it also demonstrated that even though specific project developments could play an important part, it was not possible to predefine what we were going to do or what a VRE was, but rather that there was a complex interrelationship of different services and activities involving a diverse collection of interrelated groups and individuals - the totality of which actually constituted what a VRE could be considered to be. This concept therefore, of a VRE development as an ongoing and organic part of research communities and their activity, rather than a predefined and specific set of system or software developments, was thus a key one that evolved over the course of the project.

3.4 Immediate Impact

3.4.1 Institutional Impact

Within the Institution, as described in other sections, the impact of the project has varied according to the aspect of the project involved and the area of the University concerned. In relation to University research as a whole the project can point to the fact that all the plans for the new University research direction incorporate the work of the project and that they all in different ways include the project in their implementation. Within the 4 areas that the project chose to focus its work, as well as in some other specific ones, the project was involved quite extensively in a variety of activities and can demonstrate significant impact at grass roots level both with research and with business and community involvement. It can show this impact in numerous examples of working with existing research groups, businesses and other organisations, as well as in relation to new research collaborations and funding generated. However, in other areas and with other research groups the

impact of the project has been small. Some research areas and groups are enthusiastic users and proponents of the work of the project while we still occassionally find others who have not even heard of it – despite the fact that the project and its activities have featured on the University information pages seen by all staff on numerous occasions.

The underlying aim of the project was to develop communities and the lessons from this and the evaluation of the project in this regard is probably the most important. In one sense again the evidence about this can be considered to be contradictory. The project demonstrated in a number of cases that almost exclusively through its influence successful communities were engendered. Section 3.2.4 (i) outlines the work done on waste and the community arising from this. This came about because of a request to the project to find suitable researchers to send to an external meeting which had been organised with a visiting international speaker. Because the normal channels that were used to find appropriate staff came up with only a handful of people, an early version of ConnectApp was used and proved very successful in finding a variety of relevant individuals working at the University, who in a number of cases were not even aware of each other. The CircuitNet system and other services and project initiated activities have played a key role in helping develop and maintain this as a viable and dynamic group. However, on the other hand, examples like this are relatively rare and a thriving "community of communities" - the vision of the project, would still seem a long way off.

However, perhaps a different perspective provides both a more realistic view of what projects like this can achieve and also how real communities of research and innovation will be built. A large number of formal and informal groups of researchers and researchers with other partners exist at the University, using a myriad of different processes, techniques and technologies. Through the work of the project generally and particularly through the opportunity afforded by the new initiative to reorganise research, what at the end of the day was a small project has been able to impact in one way or another on a very significant proportion of this work. What encourages the project as well is that now, even though there is a large amount of work still to be done, we have at least some solutions we can provide relatively easily for many of the requests we get for help on different aspects of collaborative working and community building. The project is also pleased that it has developed enough of an infrastructure and has sufficient exemplars to point to as well as a broadly based network of supporters and enthusiasts to build on for future development.

3.4.2 The Wider Community

From the first month of the project in April 2009, it has involved itself in external events, at the start predominantly discussing the vision of the project and inviting suggestions and advice and later disseminating its findings and demonstrating it outputs. Again from early on in the project's life when it was contacted by a comparable project running on a national scale in New Zealand, the project has sought to develop external contacts at every level, from exchanges of information to joint developments and is proud to have discussed collaboration in detail with institutions from 5 continents. It was not till later in the project that potentially shareable outputs were demonstrable and available and this, as would be expected, has increased the level of interest and the associated possibilities. There has been happily a progressive chain reaction in relation to dissemination activities as well. Some mainly informal presentations at a conference in June 2010, when developments were still at a relatively early stage, led to invitations to other conferences. Following presentations at one of these in September 2010, there were a number of invitations to the project from institutions and groups worldwide, as well from a number of institutions in the UK, to help implement some of the services it had developed within these. As examples, the Open University of the Netherlands and a major innovation conference in California, the Big Ideas Fest, asked the project about this. Particularly gratifying for the project because of its business and community orientation has been the interest in the work of the project from this area. This includes the work with WMHive described in Section 3.2.3 (iv), which has led to a formal partnership of this initiative with the University, but also work with a number of other businesses and business networks, including a major one from China, as well as several pieces of work with local councils and other public bodies.

In practice, because the project has had to concentrate on internal University work and in completing the development and suitably packaging of the tools and services it has developed, these opportunities are either in a relatively early stage or could not be followed up immediately. However, they are definite possibilities for the future and some of these are discussed further in Section 6.2. It is

hoped, as well, that the dissemination of the ideas and approach that have come out of the project has made some impact in its own right. This is difficult to quantify, but again is reflected in a number of invitations to present at various conferences and events and invitations to be part of the Programme Committee for others.

3.4.3 Stakeholder Attitudes

The ground for the project had been prepared by the earlier small project mentioned that had included a number of senior stakeholders in those it had discussed with and whose views about the potential for a project like Brain had strongly influenced its planned direction. However, it was true to say, that there was very much a "wait and see" attitude and even a certain degree of scepticism among many stakeholders about what the project would actually achieve when it first started. The project has worked through a number of formal as well as informal stakeholder groups that it has initiated, as well as working with separately constituted management and other bodies and has through these been able to monitor attitudes towards the project. Even though, as has been stated, the project feels it is still at a relatively early stage in terms of what could be achieved, nevertheless it can point to a significantly favourable shift in opinion since that time.

The main work of the project has been at a grassroots level of research, as was intended, but even among those working in areas which have not had direct experience of the work of the project, there has been an interest and positive attitude shown by a number of both documented and informally reported opinions. At senior stakeholder level, where there has been responsibility for areas of research or with the roles such as the Head of Corporate Partnership and Director of Research, both as a reflection of the support at lower-levels as well as perhaps because of an understanding of the strategic role of the project, much help and encouragement has been given to the project. This has been shown not just by messages of support but also in terms of allocation of resources during the project and for the continuation of aspects of its work. The project plan was based on a substantial institutional contribution in terms of time in particular and at the project's commencement it was a consensus view among senior stakeholders that this would be difficult to provide because of other demands on resources. However, in practice, this has not proved a problem at all, undoubtedly mainly because the project was able to convince groups and individuals through its work that the investment in resources they were making was worthwhile in terms of what they would get back. Being involved in some high-profile activities, as well as now having a number of enthusiastic champions, has also helped to create a very positive attitude in general about the project. Also, as mentioned previously, the reorganisation of University research - although a challenge, could almost have been designed to provide a platform for the work of the project, and in this sense fortuitous circumstances have also played their part.

3.5 Future Impact

With the various provisos mentioned earlier as well as despite the unfortunate impact of financial constraints on Higher Education, there is much to be optimistic about the future of the project. The key strategic research area at the University where the outputs of the project have been used, the new Grand Challenge initiatives, are still at their initial stages of implementation. All of them have planned aspects continuing this usage and some of them have new major developments specifically including the work of the project. Some major University research initiatives are even based mainly around the work of the project. This is the case for instance for a major research initiative for non-academic staff which centres on broadening the coverage of some of the Brain tools and services. This is of particular significance for the project because it identified this at the start of the project as a substantial hidden asset which it hoped to be able to help realise. Similarly, the project targeted particular developments at postgraduate student researchers. Although only a limited amount of work could be done in this area over the project term, it is hoped that this can work can be extended in the future. Particularly, as discussed further below, based on the interest that it has received, the project hopes its outputs can be used in developments in other institutions. Thus overall it hopes that it can extend its activities within the core areas it is now working in, as well as in some of these newer areas.

Because it is difficult to forecast what will happen to the project and the project team members in the future, how much of this will be able to be tracked as part of the continuation of the work of the project

is difficult to know. However, there is certainly a commitment among the project team as well as others it has worked with to monitor these future developments.

4 Conclusions

4.1 Conclusions - Specific Areas

A number of important conclusions were drawn from the different areas of work of the project which have arisen from the experience at Coventry University but which could have relevance to the work of other institutions, both in relation to building a VRE but also more generally.

4.1.1 User Requirements

Apart from the specific requirements identified through this work and outlined in Section 3.3.1, a number of key general conclusions could also be drawn, including the following:

- Users had many requirements that were not met. Where solutions were provided, there often were significant divergences from what users wanted. Engagement with users to find out what they needed as part of an ongoing interactive process was clearly insufficient.
- There was extensive good practice at the University but it was often not shared and re-used.
- Organisational and cultural factors were important obstacles, particularly for collaborative activities and where resources and funding were concerned. A representative quotation expressing this was, "*All our systems and culture militate against collaboration between different areas*".

The project laid a lot of emphasis on finding and analysing user requirements of researchers. One unmistakable conclusion from this work was that many user requirements, even ones which on first inspection seemed to be satisfied, were in fact not met adequately. Why was this? A typical scenario, drawn from actual examples, illustrate what can go wrong. A research group want a collaborative tool to allow them to create structured content for the area in which they are working. They believe that a Wiki may be suitable and set one up or are provided with one. This is normally the end of the story and the requirement is believed to have been satisfied. The Brain project included a number of different Wikis in the systems it provided, but found that they rarely met actual requirements of the type described. There are many reasons for this but one of the important ones is that Wikis are primarily designed for the creation of publicly accessible information rather than to support the more controlled and fine-grained internal discussions of research groups. This also illustrates a very prevalent issue, that because certain types of application, Wikis, Blogs, Social networks etc are considered the obvious "solutions", the actual problems in many cases are not properly considered and analysed.

There are many lessons from this and similar examples, but one general conclusion which the project came to was that user needs analysis has to be an interactive continuing process. Many of the real requirements of users that the project worked with actually did not emerge sometimes till a long period after the original discussions and after many iterations with different "solutions". The project found that this was a major issue because often the real problems, which could be very mundane in some cases, were often ignored in an attempt to provide sophisticated, but ultimately unsatisfactory solutions.

4.1.2 Research Process

The project found that it was relatively unusual among other past and current VRE projects in having process as a key focus. Yet, if anything, by the end of the project it had concluded that process was even more critical than it had originally thought. The reason for this was that ultimately given sufficient expertise and time, technical solutions for the major requirements of researchers can be found. However, without adequate processes relating to information and other areas, in practice these solutions will not be consistent, accurate or sustainable, as discussed in Section 3.2.2.

A simple example from the experience of the project will illustrate this. The project was carrying out some developments aimed at postgraduate students. Because this used techniques and tools already developed for other purposes, in principle this should have been a relatively straightforward exercise. However, because there was no known process - not even a set of manual instructions - that could produce a list of all postgraduate students and their details, this became impossible to implement satisfactorily. This issue in turn related to a number of more general infrastructural system issues, such as Identity Management. Because of the critical influence of factors like this on many aspects of research, both in the user requirements work and in the engagement with stakeholders generally, it is suggested that any VRE development must consider and raise these issues, especially with senior managers who can influence the research process. Some of the conclusions for actions regarding this are shown under Recommendations in Section 5.1.

4.1.3 Systems and Services

A number of the conclusions in this area are included in the sections on recommendations and on future work below. However, a few general observations are presented here.

- The project came across many examples in its work where otherwise adequate or even very capable systems were let down and sometimes even made effectively unusable by poor user interfaces. One memorable quote illustrating this from a user was, *"It's a great system – but nobody can use it."* This prompted the project to draw up guidelines, such as those expressed in the Four Principles of Usability shown in Appendix E, and a key conclusion of the project is that this aspect of systems must not be considered as peripheral and often is probably even more important than the underlying functionality of a system in terms of actual usage and impact.
- Despite the colossal number of services and applications available, one of the corollaries of the conclusions relating to unfulfilled user requirements stated earlier is that the development of new systems and services - provided they meet real user needs, is still required, in addition of course to the ever increasing task of evaluating and integrating services from other sources.

4.2 General Conclusions for the Community and the JISC

4.2.1 Models for Future VREs

The Brain project was based on the fundamental premise that the vision and strategy of Coventry University held out extensive possibilities for developing research - particularly relating to the university focus on Applied Research and Business and Community engagement. However, supporting processes and systems within the framework of a VRE had to be developed and put in place to help realise this potential. This premise is undoubtedly valid to a greater or lesser extent for most HE Institutions.

The project believes that it has at least begun to help fulfil this goal at Coventry University. However, perhaps more than anything else, a conclusion that has come out of its work is that there is even more potential than was originally envisaged and the project has only begun to scratch the surface of what is possible. In particular, the development and consolidation of dynamic and self-sustaining community of communities of research and innovation - which was the vision of the project, is only in its early stages, but still believed to be key to fulfilling this objective.

As indicated in some of the previous sections, the project had to revisit its original conception about its role and what a VRE was. The "Community of Communities" model it had suggested was important and supported by what took place in practice. However, a real VRE has to be considered in a broader context of requirements and needed to merge seamlessly with a variety of other facilities and services supporting research. Even just on the technical side, something that was highlighted by the work on process was that research-related services tied in with many other systems and infrastructural components and that the development of a successful VRE could not be separated from this underlying framework. The project would suggest, again within the context of the work of each specific Institutions, that this would be a generally applicable conclusion and that this should constitute at least part of any future model for VREs.

4.2.2 Sharing Experience

Over the duration of its work, the project made contact with many JISC and other projects working in the area of building VREs. It also attended a conference for JISC VRE and VRERI projects in London in February 2010 and an international Knowledge Exchange Workshop organised by the JISC, SURF and others in Rotterdam in June 2010. These activities proved immensely valuable to the project and raises the question of how to extend these benefits over a longer term than just the period of particular project programmes and especially to the wider community who may be interested or involved in building VREs of one kind or another, but may not have the benefit of being involved in funded projects relating to this. One suggestion that the project had - which was accepted in principle after it was proposed at the Rotterdam event, was that what was needed was a community to support this, a kind of VRE of VREs in one sense.

The Brain project had adopted the use of techniques based on pattern languages as one means of representing and sharing the experience of its own practice, following particularly from the work of a previous project, the Planet project, in which members of the current project team were involved (see References: JISC Planet Project Report, 2009). A number of considerations are relevant to this, but one important one relates to the granularity of experience from any project, with perhaps particular relevance to VRE projects. Anyone undertaking work in this area would principally seek to access information and experience on a particular facet of this work, rather than that of an entire project, for instance in a Project Report or other document. Thus it would be important to disaggregate the experience of the project in a usable and accessible way and supporting this is one of the key attributes of pattern languages. This was suggested as one of the methodologies that could be considered by the wider VRE community to share its practice at the Rotterdam event mentioned above, and this was accepted in principle by the Workshop. One of the important conclusions that the project would thus like to state is the importance of developing a community or communities around the VRE theme, as well as considering the methods of collectively sharing and developing expertise in this area.

5 Recommendations

5.1 Recommendations - Specific Areas

A number of recommendations based on the experience of the work of the project in specific areas, which it is believed could have relevance to the work of other institutions are given here. Some of the important and continuing tasks necessary to tackle issues at Coventry University which could also have wider relevance include:

- As discussed in Section 4.1.1, ongoing engagement with research users and user communities to identify requirements and issues is essential. Solutions to satisfactorily meet requirements can only be developed by a process of continuous improvement within such an interactive framework.
- As outlined in Sections 3.2.2 and 4.1.2, research processes play a vital and often underestimated part in the effectiveness of research as a whole. Processes need to be mapped and documented, using models at different levels and building target models for efficient management of data. Research related processes, particularly those associated with data quality and integration, need to be analysed and optimised to enable the provision of reliable information to help create and support communities. Improving the quality of a relatively few key data elements will often greatly improve the reliability and effectiveness of a significant number of important processes they support.
- The relevant core system issues relating to these processes need to be analysed and measures implemented to improve them if necessary. Key areas would include:
    - Identity management – to have consistent and unambiguous information about individuals and their roles.
    - Interoperability and Service Orientation – to have a standards-based infrastructure to support the reliable interchange of data. Based on this underlying framework, core

services could provide and maintain accurate and up-to-date information for tools and facilities.

- As raised in Section 4.1.1, important and often critical issues that users often felt inhibited collaborative research were organisational and cultural barriers, often even within a single institution. Efforts to mitigate these are vital for any realistic strategy for successful research.
- Because of the importance of process and infrastructural systems to any VRE development, a key recommendation is that buy-in and commitment to change is sought and obtained from the appropriate senior managers and groups responsible for these areas, from as early stage of a development as possible.

5.2 General Recommendations for the Community and the JISC

The vision which the project held at its start but which also evolved through its experience, provides what it believes is the basis for a wider vision which the next generation of VREs will be part of and will make an important contribution to. Key aspects of this are:

- Knowledge–enabled universities, with joined-up and optimised processes and services are essential to support research.
- Research and learning have increasing overlaps and commonalities, especially with the increasing prevalence of new approaches, such as activity-led learning. Research environments must be seen in this broader context. As expressed by one user "*Research is about something nobody knows, learning is about something you don't know. So to you, learning is research*."
- New academic and business models for research must be developed to support wide and generalised integration of academia, business and the community, with sophisticated systems and services to support new types of collaboration and collective intelligence.

Section 4.2.2 discussed the importance of building a community to support and take forward the development of the next generation of VREs. A key recommendation the project would put forward is that the JISC, perhaps as the only body with the scope and remit to do this, should take on and co-ordinate this initiative, based around the kind of vision and principles suggested.

6 Implications for the future

6.1 Implications of the work for others

The Brain project believes it has made a significant and beneficial impact on research at Coventry University. The project and Coventry University were privileged to be able to be able to carry out the work described with the financial and other support of the JISC and it undoubtedly would have been difficult to do this without this support. However, it is believed that any institution would also benefit from such an exercise to implement a VRE and it is hoped that the project's outputs, both in terms of software and services developed as well as the broader lessons and experience of the project, can assist other institutions in such an endeavour.

The project took place in the specific context of Coventry University and one of the aims of the project was to highlight and focus on the particular elements that differentiated the University, such as its Applied Research and Business and Community orientation. This was intended to be of particular value to the community as it was identified as an increasingly important requirement for the community as a whole. However, the experience of the project more generally and in the types of work that are more common in other institutions will also be of value it is hoped. Compared to the work of other parallel projects in this and earlier phases of the VRE programme - which has covered areas such as the Grid and large scientific collaborations, some of the issues and problems considered may seem rather mundane. However it is felt that there are perhaps more similarities than differences in research practice than often recognised. Certainly the project has found over its course that it has learnt very much itself from the work of very different types of institution.

6.2 Further development to build on the work of the project

Through ongoing feedback and evaluation of its current work by users both at Coventry University and outside, the project has begun to obtain a good idea of the kind of further development based on what it has already done that would be of benefit to the user community. These suggested developments are categorised by the specific and more general areas to which they refer.

6.2.1 What Needs to be Done - Enhancing Existing Tools and Services

A number of the developments of systems and tools that the project implemented have been outlined in other sections, together with some of the continuing developments and requirements that the project was unable to tackle because of time and resource constraints. Listed here are some of these that are more significant and were seen as priorities by users.

i. Networking and support for collaborative communities

- Improving the integration of services provided with other social networking systems, such as Linkedin, Facebook, Twitter etc. The aim should be to create as seamless a user experience as possible where all systems used are seen as part of a single interface and user input for information common to several systems is only required once and is appropriately distributed to the relevant applications.
- Including support for new collaborative models, such as Open Innovation models.
- Improving and simplifying user interfaces and optimising user activity and effort. Work carried out by the project investigating intuitive interfaces using visual metaphors and cues for common tasks and activities seemed particularly promising.
- Supporting common workflows and creating integrated user interfaces for these.
- Extending connection and integration with library and information services. The project did initial work with the University Library in setting up some appropriate processes for this. Fully integrating information services with collaborative research communities is an essential requirement.
- Providing new types of tools to cover areas where existing facilities did not meet requirements, including in the areas of:
    - Collaborative real-time document editing and management.
    - Easy to use integration with repositories and archives.
    - Collaborative design.
    - Collaborative thinking and creativity.
- Developing new types of immersive environments and spaces to support physical and virtual collaboration and the combination between the two. The developments described in Section 3.3.3 (iii) have proved effective even in their current early stage of development and hold out a great deal of promise for the future. Details for a phased continuation of this work, particularly to enhance features for interactivity and user engagement, have been drawn up and it is hoped that this can be carried out over the next period.

ii. Tools and services to find expertise and discover connections

- Developing an integrated exploratory environment allowing connections between researchers, businesses etc and the resources associated with them, such as publications and projects, to be flexibly and progressively explored.
- Widening the types of expertise covered to include other skills and competencies, thus extending the scope of systems to include non-academic staff in universities and businesses and other organisations.
- Enhancing expertise searching and matching tools developed to include other information sources, such as funding opportunities, which could trigger appropriate actions to help bring together potential internal and external research and business partners with relevant resources.
- Developing online notice board systems with intelligent personalisation and filtering features. Users would be able to post questions, expertise requirements, capacity available etc, and be notified of appropriately matching information.

- Embedding systems and services developed in other systems and further developing service based interoperability. Important systems to consider here are knowledge/information management and CRM systems, with the aim of creating integrated user-friendly environments.
- Broadening the type of information and knowledge systems can use, to include, for example:
    - Informal information and connections.
    - Knowledge that cannot be made public because it is sensitive, or for security or other reasons - by including techniques to handle knowledge about knowledge, for instance.
    - Tacit knowledge.

6.2.2 What Needs to be Done - Wider Integration and Extending Benefits to Other Areas

- Deploying and implementing systems developed by the Brain project within other institutions and organisations. Section 3.4.2 mentions some of the considerable interest generated in this, and such work would not only be of benefit to these groups, but would also help further develop aspects of portability and the generalisation of project outputs.
- Developing and demonstrating integration between the VRE systems of different universities. This is undoubtedly one of the major aspirations of the VRE Programme and the project has carried out some proof of concept work with other projects in the programme on how this could be done. This work would also raise important issues about how different VREs maintain information - for instance in database form or as RDF triples and how these different approaches can interoperate. Creating prototypes and demonstrators for this wider work and learning and building on this experience must be one of the most important aims following from the current work.
- Developing integration with businesses and business/community networks. The project has carried out some work on this mentioned earlier, but further work is required to demonstrate the benefits of both applying the techniques developed mainly for research networks to business and the community and particularly demonstrating the overall benefits of integrated academic and business networks to all parties involved and its role in meeting key social and economic agendas. These systems could constitute a gateway to allow further integration with other systems supporting particular collaborative facilities, such as the major EU developments Synergy and ID-Space mentioned earlier.
- Extending the information and service coverage of systems. Discussion elsewhere has referred to the continuing work to extend the scope of tools and services developed so that starting from information about a single institution, wider and wider areas can be included - tackling the major issues such as scalability that this raises. Taken together with the above three points, this will help to move towards the ultimate goal and vision of ubiquitous VRE systems encompassing and integrating academic, business and other relevant communities on a worldwide scale. As the next phase of this development, including national sources of research information, for example from the JISC PIMS database, could be a suitable step forward.

6.2.3 What Needs to be Done - Methodology and Analytical Developments

- Investigating and developing models of collaborative communities and team formation. Drawing on the experience of our University of Leeds partners, the project has begun to develop models to consider how factors such as diversity of knowledge/experience, communication (including that provided by knowledge bridgers and influencers) and decentralised participation, impact on the development of teams and communities. Active VRE supported and mediated communities are the ideal environment for such an investigation.
- Developing methodologies and systems for sharing practice, particularly relating to research environments. As mentioned earlier in Section 4.2.2, work on pattern languages and similar techniques was one of the key influences on the Brain project. Developing and employing techniques of this kind to allow the experience of this and other VRE projects to be reused effectively, should be considered an important priority. Providing the appropriate online services to make this information accessible, as well as supporting the wider community of those engaged in VRE development, are essential complementary tasks.

6.3 Project Sustainability

Sustainability and embedding outputs of the project within the Institution was one of its key original objectives. Detailed handover arrangements to transfer development facilities to production use for the main project outputs have been drawn up, tested and implemented. Resource pressures are obviously very substantial at the present time, but the project has been able to obtain some resourcing to help it continue its work beyond the term of the project period. As mentioned in Section 3.5 on Future Impact and elsewhere, a number of key developments at the University plan to use and build on the work of the project, apart from the very considerable external academic and business interest mentioned.

Based on this interest in both applications of the project's existing work, as well as on new developments that have been requested, the project has firmed up on and extended its original Sustainability Plan and is expecting a combination of internal University resourcing, external Benefits Realisation, new project and possible commercial funding, to provide the basis to continue its activities.

6.4 Project Contact and Management of Outputs

The ongoing contact for the project is: Jim Hensman, Coventry University, (j.hensman@coventry.ac.uk). Section 3.1 provides information about the released software outputs of the project. Additional information about further developments taking place will be provided by updates to the information referenced in Section 3.1, as well as on the main project website as appropriate. As suggested in Section 5.2, it is also hoped that the JISC can help create and maintain a community for those involved in past, current and future VRE work. The members of the Brain project team will attempt to play a full part as possible in such a community if it was set up and any other relevant network or community.

7 References

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JISC DINCoP Project Report, 2007: *http://reports.jiscemerge.org.uk/Download-document/6-Innovation-Networks-and-Communities-of-Practice.html*

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Scott Wilson, Patterns of Personal Learning Environments*, Interactive Learning Technologies Journal*, October *2009*

8 Appendices

Appendix A - Research Process Related Information Sources

Illustration 1 - Principle Research Project Information Sources

APPENDIX B – Tools and Services Developed by the Project

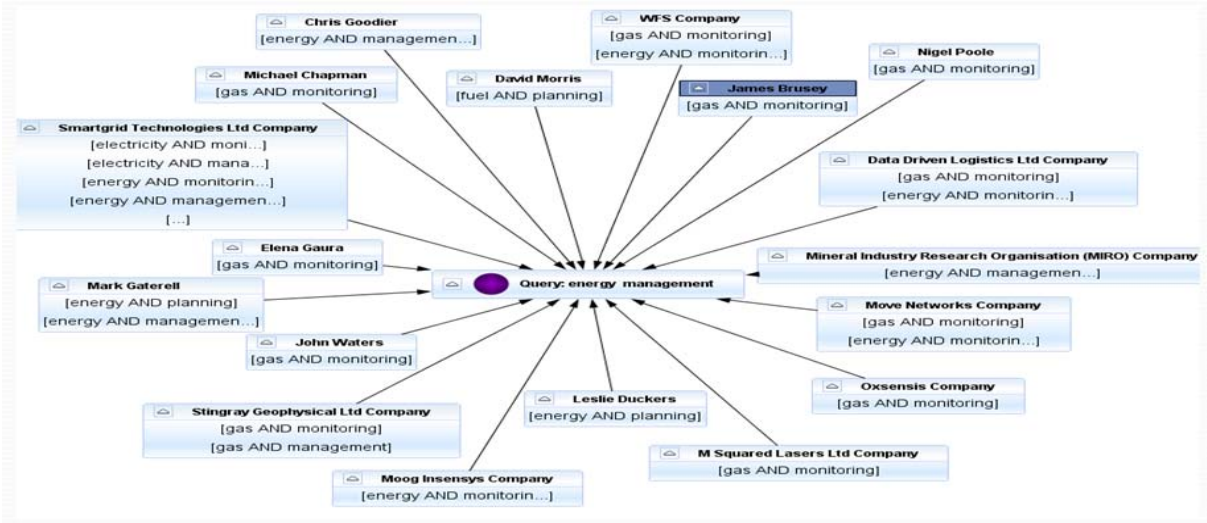

Illustration 2 - Expertise Search Tool (Stand-alone version)

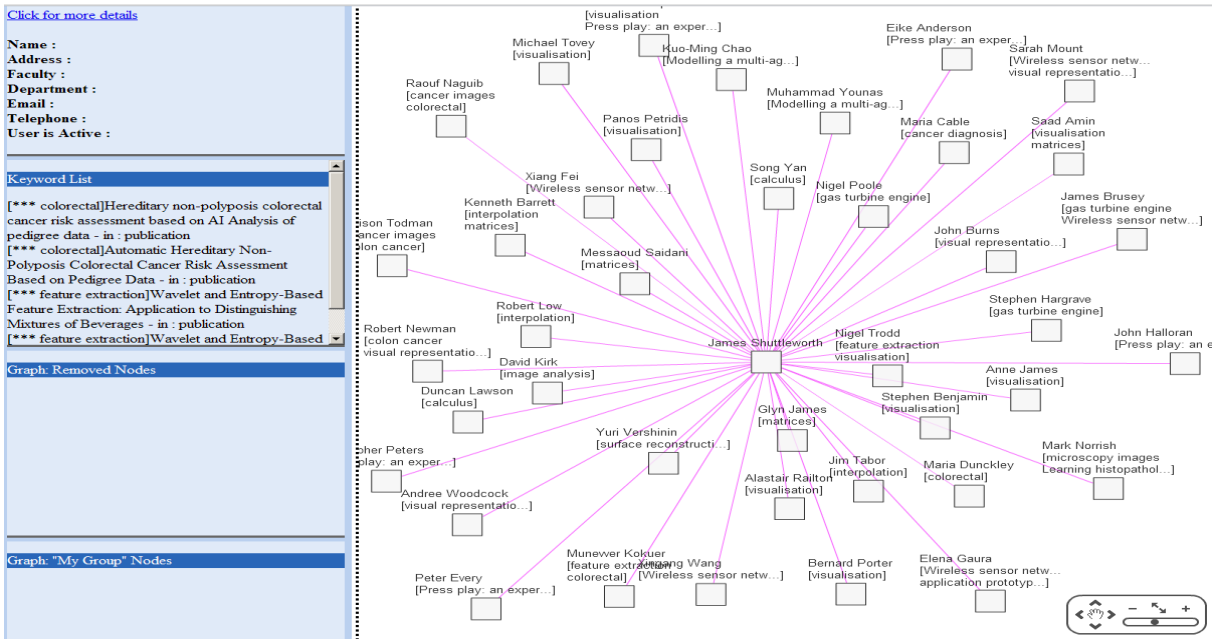

Illustration 3 – Researcher Matching Tool (Online version)

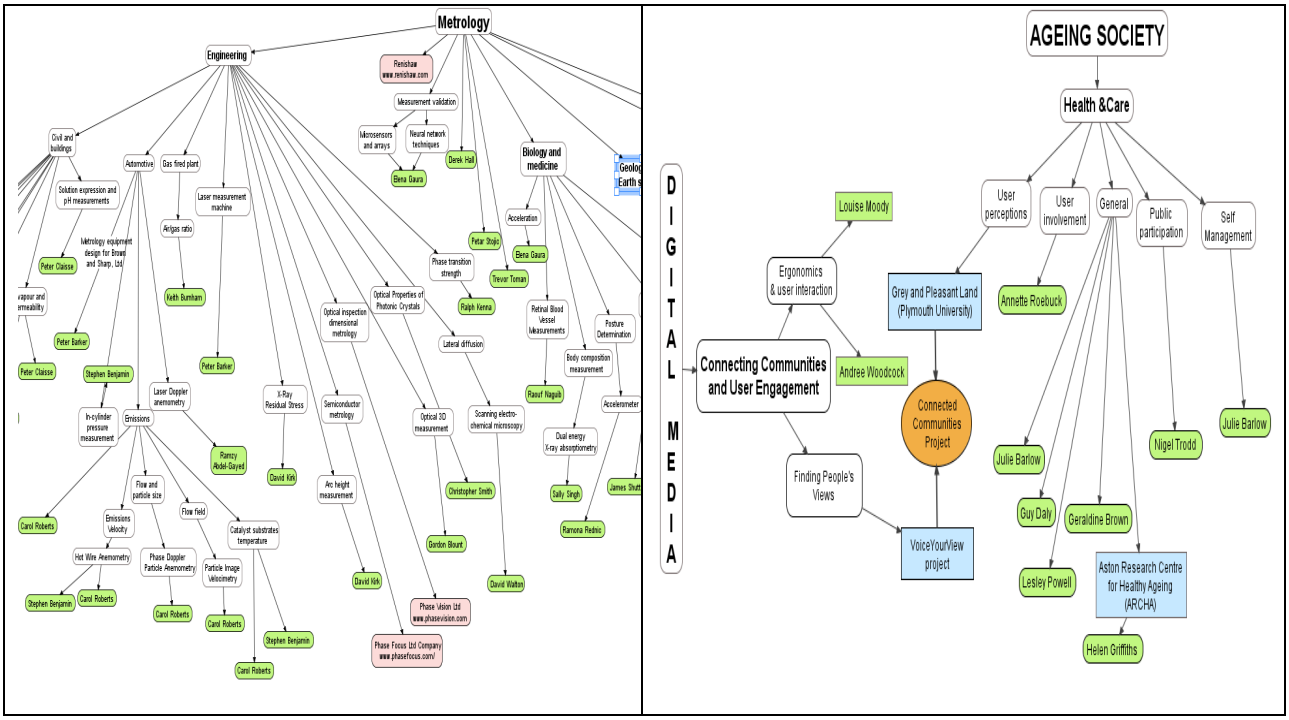

Illustration 4 – Expertise Maps

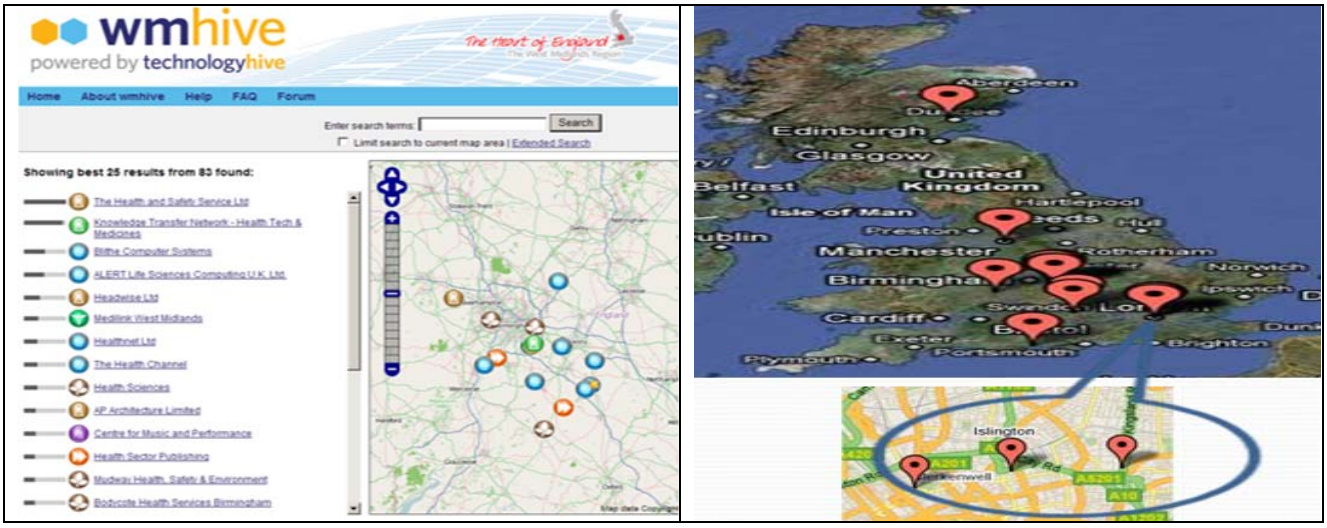

Illustration 5 – Business Network Links and Information Mashups

APPENDIX C - Supporting Communities

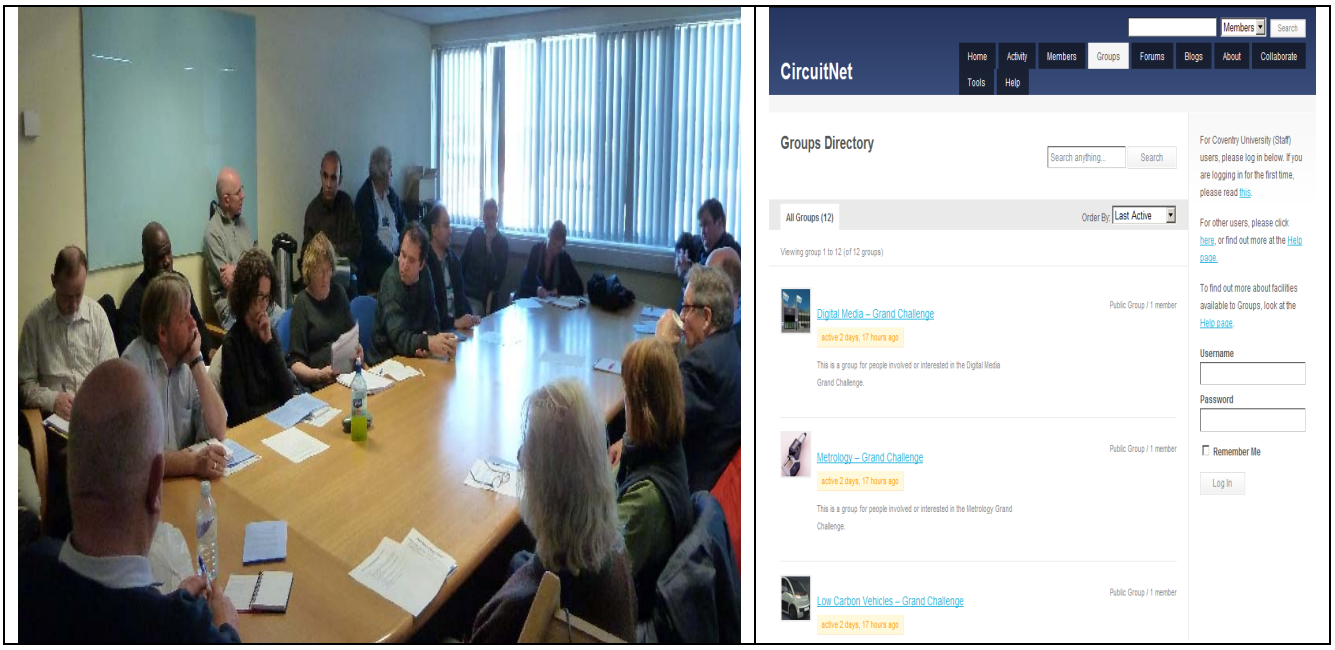

Illustration 6 – Physical and Virtual Community Support

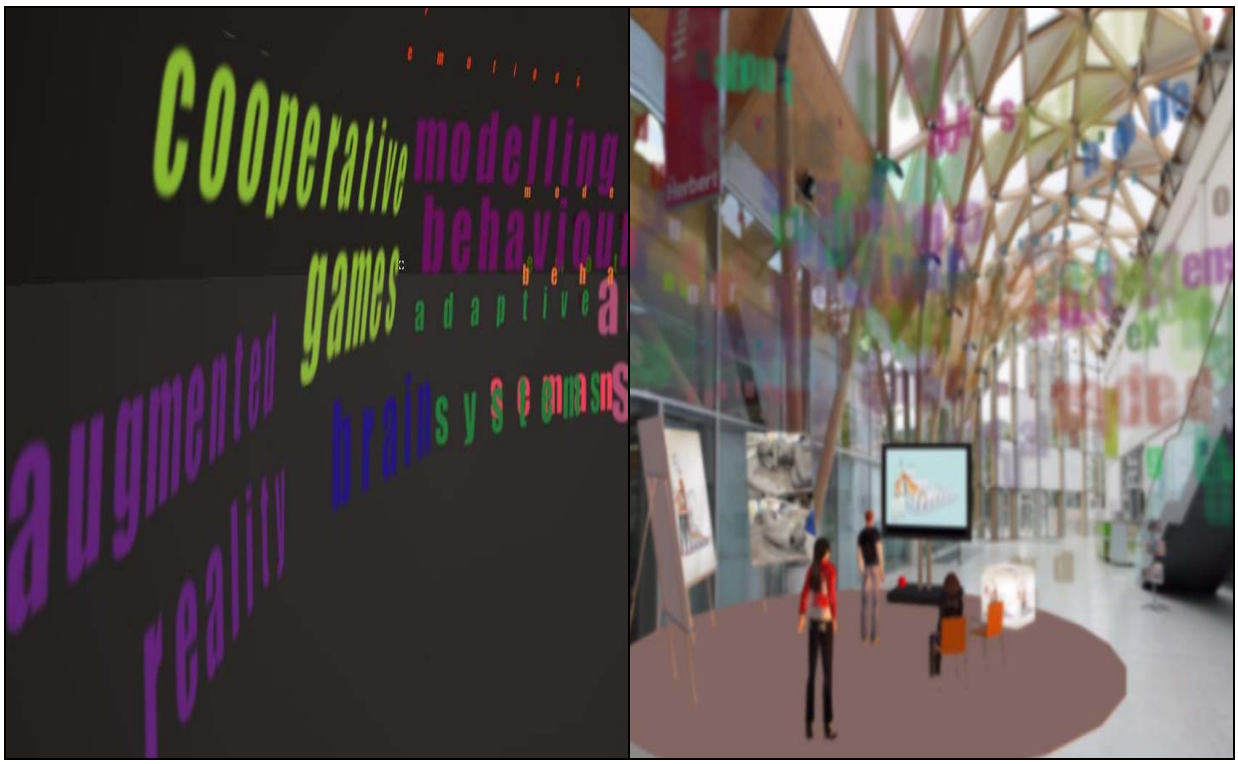

Illustration 7 - Innovative Systems to Support Collective Thinking and Interaction (with Get Real Solutions)

Appendix D - Services and Tools Used and Requirements Expressed by Users

Functionality	Personal	Network
Create/Edit content	Wordprocessor, Graphics Editor	
		Collaborative document editor, Collaborative Whiteboard
Create/Edit – Structured		Wiki
Publish/Publicise	Website, Blog, Intelligent Notice board	
Publish/Publicise - Push		RSS Feed
Communicate/Connect /Discuss	Individual to individual (e.g. e-mail)	
		Group/network systems (e.g. Conferencing system, Social network), Ad hoc network creator (e.g. Google wave) Network to Network linker, Networks around artifacts (e.g. Flickr), Meeting support tools (e.g., Crowdvine)
Find/Match/Browse	Search for related literature/research	
		"*How do you find the person you want to talk to*?", "*How do I find who's done something similar?" -* Tools to link expertise to requirements, Tools to mine information (personal profiles, articles read etc.) to suggest connections, Virtual Speed Networking, Tools to link groups to funding, Tools to link business requirements to relevant research. As part of this an integrated database of expertise/ capabilities/interests/activities/ requirements
Filter/Select	Spam Filter, Personal information Filter for electronic notice board	
Tag/Rate/Review		Social tagging system (e.g., Delicious), Semantic Wiki, Virtual World Dragon's den
Aggregate	Personal Portal (e.g., iGoogle), Personalisable user interface	
Integrate	Mashup/Widget framework, Identity integrator, Single sign-on	
Monitor	Individual activity tracker	
		Network history/trail monitor
Visualise		Social mapping tool, Idea/Concept map, Structure-Function map of individuals involved in research process
Think/Problem solve		Collective creativity tools
Design		Collaborative design tools
Convert/Translate		Format/Platform converter
Manage/Organise	Time manager	
		Group/Multiple Project management software
Link to Physical world		Virtual/physical immersive systems - including using GPS, RFID etc.

Appendix E – Principles of Usability

Based on discussions with users and experience with existing systems, four key usability criteria were formulated to help guide the development and choice of systems to be introduced.

- **Principle of Costs and Benefit**
  - For a facility to be used, the perceived benefits to the user must equate to or exceed the costs - considered in its widest terms.

- **Principle of Simplicity and Integration**
  - Unless it is easier to use than what they're using now, and will fit in with existing workflows and processes, people won't use something new.

- **Principle of Information Overload**
  - Too much information of any kind will be ignored and is often worse than none at all.

- **Principle of Feature Overload**
  - Users generally prefer the smallest set of features that are sufficient for their requirements.