Report of the Working Group on

Virtual Research Communities

for the

OSI e-Infrastructure Steering Group

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1 Executive Summary

Virtual Research Communities (VRC) are a new concept but early research suggests that they have the potential to open exciting new opportunities to collaborate in research and thus realise significant gains at institutional, national and international levels. International comparisons have revealed that the UK is well advanced in its understanding of the area and has the world's best structured programme of developments under way. Further programmes to develop their full potential need to examine issues of human behaviour, the role of government and other policy makers and closer links with commercial organisations, as well as continuing to pursue development of technology and standards. Five inter-related programmes of work are recommended to maintain the UK's leading position in this area, and retain our ability to carry out world-class research:

1. Establish a major programme of activities to understand the behavioural and social issues associated with greater take-up and transferability of developments in VRCs. The importance of reflecting the real needs, habits, preferences and aspirations of researchers themselves cannot be underestimated (see 6.1).
2. Continue and enhance current VRE development programmes to explore and understand concepts, techniques and their applications to e-Science and research, using opportunities for joint international programmes where possible (see 6.2).
3. Extend the e-framework activities of the JISC to encompass the full range of requirements of a VRC and establish whether a single, generic framework is possible or whether several, discipline-based frameworks are necessary (see 6.3)
4. Encourage greater cooperation between research and the commercial sector to ensure good practice in computer-based collaboration in business enterprises can be transferred into e-Science, to provide a vehicle for developing user-friendly commercial VRE applications and to enhance knowledge transfer activities (see 6.4).
5. Establish a task force to monitor developments in VRCs and similar activities in e-Science to recommend to government and funding organisations how policies and reward mechanisms can be shaped to promote take-up of opportunities, and to encourage the development of young researchers able to use the full capabilities of e-Science when they enter their field (see 6.5).

2 Definitions

The concepts of Virtual Research Communities and Virtual Research Environments are, in 2006, at the cutting edge of the use of technology to support research. As a result, there are no commonly agreed definitions, nationally or internationally. Within the United States, for example, they are frequently referred to as 'Collaboratories' with 'Cyberinfrastructure' synonymous with 'e-Infrastructure'. The concept of a 'Virtual Organisation' is also a current development and a definition has been included here to contrast collaborations established to produce goods or services and those designed to support research. Several scenarios have been constructed to demonstrate the concepts described above and are available in Annex A. The following definitions have been agreed by the working group as the best current definitions, given available knowledge.

2.1 What is a Virtual Research Community and what does it provide?

A Virtual Research Community (VRC) is a group of researchers, possibly widely dispersed, working together effectively through the use of information and communications technology. Within the community, researchers can collaborate, communicate, share resources, access remote equipment or computers and produce results as effectively as if they, and the resources they require, were physically co-located.

A VRC will be able to cope with the cultural and methodological differences of different disciplines. It will enable effective team work that can be as open and participative, closed and private, formal or informal and structured or unstructured as required; it will change between these states dynamically, depending on the nature and the stage of the research process. The community will have at their disposal tools to identify potential co-workers, interact with research support and finance staff in institutions and create links to commercial enterprises. Access to a VRC will normally be through the researcher's personal Virtual Research Environment.

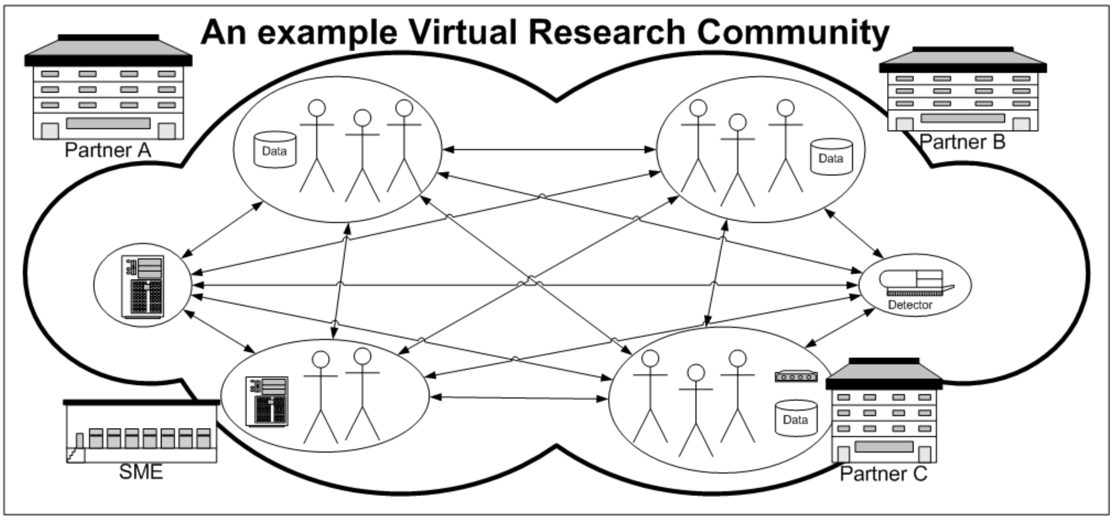

Figure 1: Example Virtual Research Community

2.2 A Definition of a Virtual Research Environment

A VRE is a set of online tools, systems and processes interoperating to facilitate or enhance the research process within and without institutional boundaries. The purpose of a Virtual Research Environment (VRE) is to provide researchers with the tools and services they need to do research of any type as efficiently and effectively as possible. This means VREs will help individual researchers manage the increasingly complex range of tasks involved in doing research. In addition they will facilitate collaboration among communities of researchers, often across disciplinary and national boundaries. The research processes that a VRE will support include: resource discovery, data collection, data analysis, simulation, collaboration, communication, publishing, research administration, and project management. Through the use of common standards, VREs will link with the broad digital context within which they sit, ensuring compatibility with other key systems such as those of research funders.

2.3 Virtual Organisations

A Virtual Organisation (VO) is geographically dispersed while appearing to others to be a single unified organisation with a real physical location. Its operation depends on similar software to that which supports a VRC and it shares many other attributes. It seeks to leverage complementarity, core competencies and pooled resources to create productive companies, be they corporate, not-for-profit or educational.

2.4 Collaborative Virtual Environment

The notion of a Collaborative Virtual Environment (CVE) stems from the concept of a distributed virtual reality system, the development of which has as its goal to provide a new and more effective means of using computers as tools for communication and information sharing with others. A CVE is one that actively supports human-human communication in addition to human-machine communication and which uses a virtual environment, including text-based environments, as the user interface. An enhanced role for these in VRCs of the future can be envisaged.

3 Current UK and International Position

The Working Group carried out extensive research on the status of developments in Virtual Research Communities and Environments in the UK and elsewhere. Detailed information is provided in Annexes B and C. The following is a synthesis of the research and presents a number of observations on the current state of understanding.

In the UK most of the research and development has been funded by the JISC, the Research Councils and a number of professional bodies (Annex B). The JISC programme is structured, to gain an increased understanding of VREs, produce tangible products and tools, start moving the technologies into a wider community and begin to change cultures and behaviours. The intention is to treat the activities as a coherent whole which can feed into future programme planning. The other two bodies have a more ad-hoc series of projects within enthusiastic communities to address specific problems facing researchers in specific disciplines. UK developments have included work in both the sciences and humanities; work in the latter area is somewhat rare elsewhere in the world

Elsewhere (Annex C), the USA's National Science Foundation (NSF) and Department of Energy (DOE) have been the principal funders of research and several tens of collaboratories have been funded across a range of disciplines, nearly all in the fields of science and engineering. There have been no systematic attempts to coordinate the programme, to gather together and share the lessons learned from different projects or use them to develop future work programmes. The fact that collaboratories are much more successful in some disciplines than others demonstrates significant differences in behaviour and attitudes to collaboration amongst different groups of researchers. The most successful is SPARC, the Space, Physics and Aeronomy Research Collaboratory, http://www.si.umich.edu/sparc/collaboratory.htm.

The NSF Cyberinfrastructure Office has recently launched the CI-TEAM programme, 11 projects of around $250,000 each, to promote the education and training of a new cyberinfrastructure workforce. The DOE created a framework project in 2000 to create a common software infrastructure to promote inter-working and reduce duplication across four national laboratories. Work in addressing issues of the Humanities is expected to begin soon, following the publication of the Draft Report of the American Council of Learned Societies' Commission on Cyberinfrastructure for Humanities and Social Sciences (2005), http://www.acls.org/cyberinfrastructure/cyber_report.htm.

Elsewhere, the concepts of a VRE are only just beginning to be considered and what research or development there is, is sparse and generally uncoordinated, except in Finland where the unique culture and approach there has led to a centrally provided set of research resources although it does not yet provide collaborative facilities. In Australia coordinated development of e-Research infrastructure and projects is being promoted by government to provide access to data, resources and collaboration within Australia and globally.

A number of commercial companies, notably Intel, Microsoft, IBM and HP, are developing collaborative environments to support activities within their own organisations or as marketable products. Currently there is little interaction between leading edge applications of technology to support scientific and other research and those supporting commercial activities; creating better understanding and working between the two sectors would be an early win but will need a push from government via the educational and research sector and an adoption of some reasonably basic standards to ensure efficient uptake of the software. Many current tools, commercial, open source or free, are described in Annex D.

4 Current Issues

Many research functions that are expected to be provided within a VRE, including for example resource discovery and data retrieval, have been considered by other e-Infrastructure working groups. Linking these services into VREs seamlessly will need to be achieved at some stage but unless there are specific issues related to these services that will affect the development of VREs directly (such as flexible access management) they are not considered further here.

Collaborative environments and communities are at an early stage of development. It is not even clear at this stage whether generic models for research through VREs can be developed, or whether each major discipline will have to have its own unique framework of attributes, tools and methods of working. There has been little testing outside of the UK (where some JISC work is at an early stage) about the extensibility of developments beyond the originating discipline and the receptiveness of researchers to materials or tools developed elsewhere. Major behavioural and social studies, in several disciplines, will be needed to improve understanding of this key issue.

It will be necessary to bridge the gap between sciences, humanities and social sciences in terms of provision and adoption of tools and addressing their varied needs. e-Social Science and humanities researchers are a particular example where more incentives and training are needed to encourage adoption of collaborative technologies, though the need is seen to varying degrees in all domains.

There are, as yet, no standards to apply to tools, products or applications in this emerging field. It will be some time before market-leading products begin to emerge, although there is merit in considering closer collaboration with commercial suppliers in the UK to stimulate that development and to support the OSI and HEFCE initiatives to commercially exploit world-class research. The UK, through the structured JISC approach to its VRE programme and the e-Science activities, is better placed than any other country at the moment in its understanding and applications in this area and it is worth investing to increase returns on this investment and maintain our lead. Also, it has already been noted that research needs to learn from the experiences of companies developing solutions to collaborative working.

The UK is also well placed in the provision of an effective, flexible access management with the launch of a new service, based on Shibboleth, in 2006. Security and trust are key issues for the success of VRCs but, at present, there is insufficient knowledge of how to make current systems flexible, robust and easy to use. No significant obstacles to developing services with these characteristics are foreseen, but understanding of the issues of copyright, shared ownership and other legal issues created by the digital revolution are lagging behind the technology and will require major effort to resolve, a pre-requisite if VRCs are to flourish.

One of the biggest challenges to the widespread adoption of VRCs, and indeed the exploitation of the opportunities of e-Science developments in all types of research, is the human factor. The difficulties of engaging researchers across the board in using the new applications have already been alluded to. The biggest obstacle to take up will remain ease of use for the foreseeable future and poor human-computer interfaces in many current products. It will be possible to address this issue in several ways, including improvements to early prototypes, but it will be some time before 'off the shelf' applications or toolkits will allow rapid prototyping of applications to address specific collaborations.

For the foreseeable future, researchers will need to invest significant effort in their attempts to use the new technologies. Support for researchers, by institutions, by research funders and through national services, has the potential to accelerate engagement and take up significantly. Appropriate reward mechanisms and supportive institutional policies may be two of the most effective drivers.

The emergence of new roles is also to be expected: new types of technologists with the expertise to join-up services to enable communities to function and flourish, and collaboration facilitators and managers (for informal and formal consortia respectively) who can provide the 'social' support required to deal with human issues during collaborations.

However it is important to realise that attempts to bolt on 'usability' after technical development are doomed to failure. Because this is the current norm in developments in this field, there needs to be a paradigm shift in attitudes before real progress can be made. Funders will have to encourage developments that are user rather than technology driven, to pay proper attention to user engagement as part of development process, and employ user-focused design methodologies if there is to be a breakthrough in this area.

Currently, most of the work on VREs has concentrated on the research itself. However VREs have the potential to help manage the whole research process from finding partners and bidding through research itself, and provide links to research administration, budget management and management by the researcher and by institutions. There is more work needed in this area, both to understand the issues and develop solutions. There are also opportunities to link virtual research environments with virtual learning environments to assist the training of the next generation of researchers.

All of the development work to date has concentrated on establishing proof of concept and the development of individual technologies needed to support and underpin virtual environments and communities. Several more years of experimentation and testing will be required before some remaining fundamental issues can be resolved. It is therefore important for the UK to ensure that continuous analysis of progress in the field across the world is carried out and used to inform a structured, national set of programmes that target key areas of uncertainty and, simultaneously, provide a balanced approach across disciplines and between technologies and human issues.

VRCs will only come into being when VREs are normalised, and tools to enable VRCs are widely deployed, robust and stable.

5 VRCs by 2016

When preparing this section, the group considered a number of global factors, which are listed below, that helped inform the ideas regarding the desired state of VRC technologies in ten years time. As mentioned earlier, several scenarios were also created describing the likely usage of VRC technologies within specific scientific areas, which are presented in Annex A.

5.1 Factors Influencing the 2016 Vision

- *Globalisation and increased researcher mobility.* International research activities have grown significantly over the last two decades. Recent years have also seen an increased number of scientists working in countries other than the country of their origin. The importance of the technological advances needed to carry out research has, therefore, considerably increased, particularly in providing flexible access to knowledge, skills, data and computational resources.
- *Multidisciplinary nature of research.* Multidisciplinary research involving increasingly global collaborations of scientists are becoming more important. Removing barriers to multidisciplinary research by effectively supporting multidisciplinary collaborations is a key challenge for emerging technologies.
- *The changing roles of public and private research*. There has been an increase in public private partnerships and knowledge transfer initiatives in the UK in recent years with a strong emphasis on business-led collaborative research. As well as the benefits of this type of partnership there is an added complexity of multi-sector collaboration. Interoperability of institutional applications will be critical as well as the need to address the differences in institutional cultures and practices.
- *Increased volume of research data.* Technological advances allow for the collection and storage of large quantities of research data. The development of tools for shared manipulation of large data sets and for cooperative knowledge management has to keep pace with the exponential growth of materials in digital form.
- *Changing nature of network technologies*. The advent of e-Science and Grid technologies has revolutionised the way research is being conducted. The convergence of computer platforms and networks and the shift to non-desktop systems, such as mobile and wearable devices and the move towards more intelligent infrastructures will also present new opportunities for collaborative work.

- *The evolution of urban and work spaces development*. Wireless networks and other advances in the area will create the ability to link physical spaces across the globe to support richer experiences for people.

5.2 Trends Emerging from Scenarios

The scenarios described in Annex A reveal a number of emerging trends in research practices and highlight a number of challenges resulting from the potential changes. These are summarised below.

It is apparent that the future of scientific research will increasingly depend on the interaction between globally distributed teams of researchers. The main advantage that VRC technologies can bring to research is the enabling of increased interactivity between researchers and access to skills, knowledge, research data and computational resources situated in remote locations. Time will be saved since researchers will not need to travel to work with others or access resources. Data is collected increasingly by using instruments at remote sites in real time. The real time capability will also allow researchers to quickly validate results. The effectiveness of research partnerships is therefore likely to be influenced more and more by the available institutional and national infrastructures. The increased reliance on connectivity, however, will create pressure for some academics.

New forms of collaboration are also emerging, particularly those of self-selected and self-organised communities of researchers of various disciplines. The use of distributed collaboration technologies is likely to shift the locus of scientific innovation to such distributed groups of experts. Radically new applications will be needed to process, communicate, store, analyse and visualise the huge amount of data produced by global teams of researchers. Supporting researchers to work on multiple projects and interdependent work tracks will also be crucial, as well as introducing new management structures to support the changing nature of research. The potential for more rapid innovation will be greater; however participants will need to be given incentives to engage in such collaborations. There are also a number of social, legal and ethical issues to be resolved, e.g. copyright protection of ideas generated in a virtual space and protection of data privacy.

The main challenge to be resolved will be the support of the change in culture by creating a climate of trust amongst distributed members of research communities. Removing barriers and introducing incentives which will encourage researchers to share the results of their work and receive adequate recognition for doing so, will also be critical.

5.3 Desired Technological Capabilities for 2016

To deliver the benefits of VRCs and address some of the challenges discussed above a number of capabilities need to be built into future VRC technologies. The list below contains the most important capabilities, which are grouped in the following categories:

Community Management

- Support the operation of a community through all stages of its lifecycle – from formation through to closing down. This would include providing facilities for members joining and leaving, and community workspace management;
- Allow the management of multiple research teams, including combining integrated calendars.

Support for Distributed Research

- Support the integration of research processes across the research lifecycle, including the management of research;
- Allow distributed persistent usage and support mobility of researchers across various locations and research sites;
- Support researchers to work on multiple projects and interdependent work tracks;
- Have integrated and secure personal and community workspaces and provide easy ways to switch between the two;

- Facilitate locating of researchers with compatible interests;
- Facilitate easy flow of information between members and resources within the community.

Support for Collaboration
- Support collaborative collection, manipulation and management of data, as well as collaborative knowledge creation;
- Provide facilities for asynchronous and synchronous collaboration and allow the ability to switch between them;
- Support different types of collaborations (from formal to informal);
- Facilitate social bonding especially amongst members who have not had face-to-face contact.

Context Awareness
- Support social context awareness by providing information on the social situation of a collaboration;
- Support presence awareness by providing the notion of identity, location, and time zone;
- Allow awareness of the availability of resources and devices and their status.

Personalisation and Adaptation
- Support tailoring of the environment by individuals or groups to reflect their interests and preferences;
- Be self-adaptable (prior to interaction) and self-adapting (during interaction) to contexts, user abilities, cultural characteristics, and tasks.

Human-Computer Interface
- Provide an easy to use and natural interface to all resources;
- Provide an integrated interface for different access devices;
- Allow long term usage without interrupting social interaction cues, especially during synchronous collaborative sessions;
- Ensure representations are realistic and adequately simulate the richness of face-to-face interaction.

Interoperability and Other Technical Capabilities
- Ensure the seamless integration and access to tools and resources across institutional and national boundaries;
- Be modular and extensible;
- Be secure and trustworthy. This will necessitate interoperation with federated cross-institutional authentication and authorisation mechanisms;
- Be reliable and robust;
- Allow seamless roaming through heterogeneous networks.

To achieve the above capabilities, a flexible, extensible and secure open architecture of resources, tools and services is required. This architecture should allow anytime anyplace access to experts, knowledge, collaboration tools and computational resources to match user needs, preferences and tasks. Each VRC is likely to have different requirements on the type of resources and tools needed to support their activities. Therefore, a mechanism needs to be devised for the flexible creation of a layered architecture of distributed resources and tools, which interoperate with each other, addressing issues such as authentication and authorisation.

There are a number of emerging collaborative tools and technologies which could be integrated into a VRE architecture. Examples of these tools are given in Annex D. Many of these are still in development stage and they do not address the full range of requirements needed to support distributed communities of researchers. A number of issues, therefore, still remain to be resolved including their usability, robustness, reliability, and security. A considerable amount of effort also needs to be spent to ensure their interoperability and seamless integration.

6 Steps to 2016

Virtual Research Communities enable human-human collaboration and communication, supported by the underlying e-Infrastructure and, in particular, VREs. The issues of human behaviour, and associated elements such as policy drivers, reward systems, legal and IPR issues, relationships and trust, therefore have equal importance with the technology itself. A complex and interacting set of developments covering all of the areas identified in this paper is required to move forward VRCs over the next ten years. While technology development is the highest priority activity in current activities, any future programme must pay equal or greater attention to, and anticipate, the importance of non-technical issues.

The Working Group's research shows that the UK is ahead of the world at the present time in this field. Although the US has invested significantly more in collaboratories than the UK, our coordinated, national approach, with a strong application led agenda, has given a higher return on the money invested so far. A continuation of this approach over the next ten years will help the UK maintain a world-class position in research capacity and output. Work needs to be carried on in five principal areas, as shown below:

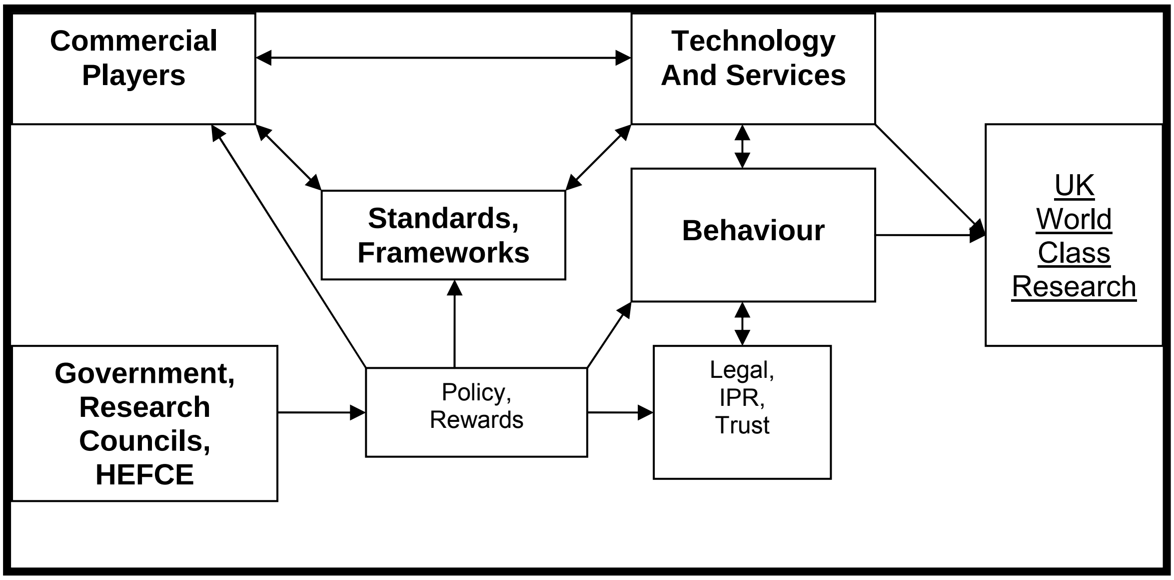

Figure 2: Key Areas for Development

6.1 Behavioural and Social Issues

These are the most important areas of research for the future. They are also the areas which will take the longest to achieve significant progress; previous experience with cultural change on the scale required here suggest that a 10 year (or longer) programme will probably be required to achieve any significant level of success. The role of government and funding organisations in enabling and stimulating change is critical, and is discussed below.

A series of studies is needed, based on existing and earlier programmes, to establish what behavioural issues exist that prohibit or significantly reduce the acceptability and extensibility of tools and services developed in one discipline from migrating to others, and to identify mechanisms to minimise or remove these. This work needs to be closely coupled with the development of frameworks, models and standards above.

A second thread of research and development will be to improve the human/computer interaction in VRC / VREs. At present these are often difficult to master, non-intuitive and a major barrier to improved take-up. One possible method of ameliorating these problems is to encourage the use of design methodologies that involve the end-user from the outset.

A major set of barriers to increased take up are the human problems of collaborative research – establishing trust, establishing ownership, copyright and intellectual property rights, appropriate recognition of contributions and the need to publish to establish and maintain academic reputation. Policy and reward mechanisms as drivers for change are discussed below but all the technology programmes proposed above need to include a thread that investigates the problems the developments raise in this area and seek to incorporate means to alleviate them.

Finally, the need for promotion and encouragement to improve the take-up of the new opportunities by researchers across the board has to be recognised and addressed, backed up by services that will provide practical assistance to actually use the new methodologies. Without appropriate support, the effort required to change and adapt will remain a hurdles to increased take-up and the full value of the investment in technology will never be realised. A programme to develop suitable support, probably allied to the existing e-Science support centres, requires consideration.

6.2 Technology and Services

There is still a great deal of research and development to be done in the concepts and technologies that will support collaborative working using high speed networks, access to high performance computing and an increasing range of digital resources (see 5.3). A continuation of current development programmes will be needed for the foreseeable future at a higher funding rate than at present if there is a desire to increase the pace of change. These programmes will continue to be opportunistic over the next few years, applying techniques and technologies to solving particular research problems. However, as experience grows, coupled with greater understanding of frameworks and the establishment of standards, it will be possible to develop more generic approaches and solutions.

For the maximum return on investment a planned, coordinated set of VRC / VRE activities across all areas of science and engineering will be needed, building on the work already started by the JISC and others. It is essential that the programme also seeks to incorporate into VREs the other technological developments required by researchers, including resource discovery, access to remote data and computing resources, etc.

A particular thread of development activity needed is to increase the flexibility of the current generation of access management tools. To function effectively, collaborative research needs to move seamlessly between closed, private periods of activity to more open, collaborative work. Enhancements to the services currently being trialled will permit this to happen.

Any technical development programme will need to address two other issues as it moves forward. Firstly it needs to reach out to other disciplines and communities and encourage the use of the new research paradigm in an expanding range of disciplines. Secondly it needs to keep a close watch on technical developments elsewhere in the world, both in education and research and in the commercial application of similar technologies. Experience has shown that jointly funded programmes with other significant international players, both in the USA and Europe, can deliver significantly enhanced returns and must be encouraged.

The development programme will identify new services that will be required by users of a VRE to support the entire research process, from locating partners, through bidding and research, to final publications. An effective strategy, and funding, to establish these will be needed to deliver the tools required for VRCs to function effectively.

6.3 Standards and Frameworks

The JISC, with a number of other partners, is developing an e-framework that seeks to create a model that describes the various services needed by a large range of activities in education and research and create an architecture that shows how these are linked and can be extended to incorporate new activities where needed.

A VRC will need a complex, interoperating set of services and resources to function. A programme of work to determine extensions to the e-framework to support the concept of a VRC is therefore needed over the next two to three years, with continuing development as new concepts and practices are understood. One key area of early research needed is to establish whether it is possible to draw up a single, generic framework for VRC / VREs or whether different disciplines will require separate frameworks, because of their own distinctive sets of activities and interactions.

A key part of the development of the e-framework is the identification of where standards are needed and can be implemented, particularly to improve interoperability. Most of the players in the field recognise the value of internationally agreed standards to increase the value of investments in this area. It will be important to engage the government, funding bodies and the commercial players in encouraging the adoption of standards in development work, applications, tools and services to support research.

6.4 Commercial Engagement

Engagement with the commercial sector can be effective in two ways. Firstly a study of the use of new technologies to support collaborative activities in commercial organisations and the characteristics of virtual organisations needs to be carried out. This will not only identify where e-Science can benefit from the experience of other organisations and where suitable tools already exist, but it can feed into any technical development programmes for VREs to support VRCs that encourage closer inter-working with commercial companies (3rd Stream)

Secondly, partnership with the commercial sector to develop and market promising tools and application must be encouraged. Researchers have a poor track record in taking products successfully to market, and work with commercial players who understand this element of the development process will create more attractive, well supported and user-friendly applications, which will, in turn, encourage greater take up across research.

6.5 Government and Funding Organisations

The role of government, research and funding councils and institutions in promoting policies and reward schemes that encourage greater use of new research tools has already been noted. A high-level task force is recommended to monitor developments in e-Science and advise these bodies on the policy shifts required to stimulate more effective use in developing UK Plc. Government also has a role in stimulating closer collaboration between research, universities and the commercial sector.

A further role for the research councils and HEFCE is to encourage the emergence of young researchers who can enter their field fully equipped to use the latest e-Science tools and collaborative facilities immediately. Developing close links between virtual learning environments and virtual research environment will be one possible method of achieving this, and encouraging the development of suitable courses and modules to stimulate and equip new researchers is essential.

6.6 Concluding Remarks

It is important to realise that while the Internet shrinks space (and time) it does not necessarily make “place” irrelevant. Some research issues are global and are directly facilitated by the communications technology, as there will be many interested parties in diverse locations. However, other issues are mostly relevant to researchers in a particular time and place and in these cases remoteness will still play a significant role in segmenting research no matter how much the speed of communication increases and the cost falls – exchange of information does not necessarily replace exchange of physical and human resources.

Annex A

Scenarios demonstrating how research may be enabled by the uses of virtual research communities and environments

The laboratory scenario illustrates in detail how an individual researcher will interact with the laboratory, institution, colleagues and the global community. Other scenarios illustrate how these general concepts apply across many areas of research from science and engineering to social science, media and humanities research; they highlight different aspects that are of prime importance in collaborative work in these areas.

A1 Small Science – Small Groups Laboratory Based

e-Research and the Chemist: A vision for 2016

The impact of technological advances will be most significant in the way information is organised and disseminated. Advances in experimental techniques will be less significant in that we are well used to new experimental and analytical processes and the process of ‘doing chemistry’ has been well able to integrate these in to its methodology without deep seated changes.

Chemistry Laboratory Research in 2016

Chemistry research is a combination of individual efforts, ideas and insight, building on a vast collection of material, supported by group contributions, including local experience to accessing a world wide network of expertise, derived from personal contacts. The e-Research agenda will impact on all stages in the chemical knowledge cycle – (a) initial conception & planning, (b) experimental practice & discovery, (c) information integration, (d) knowledge extraction and (e) dissemination. The cycle is closed by the interaction between the first and final steps.

A research study – a view from inception to dissemination

A ‘virtual tea room’ discussion over email/video suggests that an observation may have been miss interpreted, and further follow up of the material (drilling down through the publications etc) by one or more of the interested group, throws up a number of issues that impact on the current work of the initiating researcher. Over time this leads to the generation of a research idea and a research proposal, which is in due course funded (well it is a dream vision going in here), pulling in industrial collaborators to the project. In writing the research proposal the semantically-aware chemical version of word processing or typesetting systems supplied by the VRE, enables a short but richly linked document to be prepared, which provided the reviewers with all the necessary background material they need, to whatever level of detail is appropriate for their individual expertise. This document starts to formalise the VRC.

Applications for central facilities needed for the research are made at the same time and the proposal is linked to the institutional archives to provide in the future a context for the results. The secure store provides the necessary infrastructure for patent (USA style) proof in due course.

Experimental planning now underway, meetings taking place between the researchers are supported by software that allows concept maps to be used to organise the information, allowing for ready prioritisation of the material, and providing a framework for recording the discussion. The degree of formality introduced at this stage depending on the commercial sensitivity of the project. From this framework the individual experimental plans day by day can be developed that form the basis of the digital model that would look after the electronic notebooks (ELN).

The experiments undertaken with the aid of context sensitive, easy to use ELNs, which are tied in to the automated equipment (when it exists) and the specialist systems, which will always be needed. The quality and reliability of the data and metadata capture will thus be significantly enhanced. Within this approach the opportunity for timely safety intervention in planning is also increased.

The review of the experimental material can then take place in the context of all the back ground material being available from both the initial planning meetings and the ELN record, with the analysis being collected in a similar manner aiding the processes by which a theory is abstracted or confirmed from the available data. The volumes of data that need to be assimilated can be large, especially if combinatorial experiments are involved or large scale model fitting has been undertaken.

Visualisation is increasingly a concern, but one which is probably not limited by technology but by the arrangement and organisation of the data. This again prompts the researcher to make use of the flexible and fast data storage and retrieval to investigate the data sets and their context. This try it and see element, that goes against a planned experiment, will still be an essential part of data analysis, and the modern capture tools will be able to record and allow, review, re-use and improvement, of the approaches attempted.

To achieve this in the modern interdisciplinary world, much expertise outside that of the original researcher may be required (extending the VRE). The exchange of information is then facilitated not only by electronic means, but by explanations of the data for others not expert in its generation.

In particular, the growth in computer power and simulation technology means that many experiments can be usefully carried out that requires a simulation model in order to extract important fundamental information. Increasingly these simulations will be carried out in parallel with the experiments. An important impact of the e-Research infrastructure will be to facilitate exchange of information between experimentalist and theoretical chemists. Ensuring that the data is exchanged with all necessary background to ensure that as far as practical the same systems under the same conditions are actually being studied.

Once significant results have been obtained, all the information is already by the nature of the processes described above, linked in upwards in a pyramid, to this conclusion. Presentations of the data are then possible to sponsors, at conferences and other similar events, and ‘publication’. The context aware information means that a concise exposition of the theory can be prepared for publication with the understanding that all information required to backup the theory can be readily made available to the public. This completes the cycle by providing all the data back to the overall virtual chemistry community. The same software that supported the ‘rich text’ needed in the applications, the information exchanged on the project, supports the ‘final’ publication. Access to the paper and to the data is recognised as essential and is acknowledged.

A2 Enhancing Interpretation Through Multidisciplinary Research in the Humanities

Researchers in the arts and humanities are concerned with human culture and the products of the imagination. The range of 'data' with which researchers work is complex and the scale huge. Literature, music, film, architecture, pictures, and material culture provide much of the source for humanities research. Practice-based disciplines in the arts are also producers, as well as consumers, of cultural artefacts.

Given that much of the research within the humanities is about interpretation, contextualisation and reconstruction, individual data sources are rarely considered in isolation. In practice, the humanities deals with composite, multimedia objects (themselves a mixture of digital and physical components). Whilst the digitisation of primary and secondary sources will remain high on the requirements list, the intellectual quality, rather than simply the quantity, of the collection remains important. Large-scale digitisation programmes raise questions about intellectual re-usability as well as concerns about resource discovery, sustainability, preservation and access.

Over the next ten years, only a fraction of the world's cultural heritage will be available in digital form and much of that will be as surrogates where interaction with the original physical artefact will remain the ideal. Heritage sites, library and archive special collections, studios and performance spaces will remain key locations in which arts and humanities research is undertaken. It will be normal for researchers to use mobile, networked devices in these locations.

The mobile device will permit access to a personalised virtual research environment, co-located with the physical research environment. The virtual research environment will support many components of the research process.

Weaving Together Human Culture, Place and Multidisciplinary Research

The day starts in the library but that fact almost immaterial save that that is where the manuscript is (the researcher could be anywhere as far as she and her colleagues are concerned). Whilst the research library has completed the digitisation of its detailed manuscript catalogue, and incorporated automatic links to published secondary sources, the digitisation of its many thousands of manuscripts is not yet complete. The researcher is therefore in the library with the manuscript and a mobile, networked personal knowledge manager. The device is aware of its physical location and has tailored the virtual research environment accordingly. Any increased use of active RFID tags together with RFID detectors within mobile devices offers the potential for personal knowledge manager devices dynamically tailor the VRE with information and workspaces relevant to objects in the vicinity.

The manuscript is ancient and the researcher is keen to provide a detailed analysis of its provenance since its intellectual content may contribute to a better understanding of the emergence of Islamic alchemical literature. The colours are particularly striking. Her notes are entered, transmitted and held within her institution's research repository. She has chosen to permit access online by anyone and to encourage annotation by members of her immediate research family.

The library permits non-intrusive digital photography for research purposes, now at a resolution appropriate for scholarly study. Sometimes the manipulation of the digital image can enable her to spot features not immediately discernible to her naked eye. The folio under inspection appears to contain palimpsest ('ghost') text partially obscured by a foreground drawing. She is quite excited by this find and uses her alerting tool to notify research colleagues in various locations about this discovery.

A virtual discussion takes place and moving images are transmitted. Is the palimpsest contemporary with the rest of the manuscript? Colleagues take a multi-disciplinary approach. For example, a previous grant has enabled the library, which houses a major collection of manuscripts, to support the latest Raman microscope system with a remote access facility. With the curator's permission the manuscript is placed under the Raman probe. The probe is controlled by a post-doctoral humanities researcher who has previously benefited from a placement in a multi-disciplinary doctoral training centre. Finding such a person was relatively easy, using a federated research discovery service.

Colleagues participating in this virtual meeting can watch as the results from the microscope are compared against the relevant data libraries. Tools jointly developed with or appropriated from computing science enable the researchers to make suggestions for the reconstruction of the text through image manipulation controlled by the available Raman data.

Layers of quick annotations are laid down and dynamic links made to supporting literature. The knowledge structure is being built by many remote hands. At some point a formal presentation is planned The entire process as well as the preliminary results has been captured and will be re-presented via learning interfaces for the teaching of palaeography and through open interfaces for the public's better understanding of the humanities.

A3 Intrinsically Geographically Distributed Science: Water Resources

Large Scale Science of an intrinsically geographically de-localised nature encompasses such problems as: global warming, ozone depletion, environmental disasters, and limited water resources. The study of these will all benefit from virtual research communities enabled by e-Infrastructure. Following the lead set by collaborations in areas such as earthquake engineering and tsunami research, e-Science will greatly aid the research into phenomena that are intrinsically worldwide, either because they occur on a global scale or because they occur in many places across the world. Issues that require the interaction of laboratory studies and environmental observations (so also those that require the observation of people in different environments) will benefit particularly from the deployment of an e-Research infrastructure supporting VRCs. The major issues of energy, water and disease that confront humanity globally fall in to this category.

Research in this area requires the combination of a very wide range of disciplines and technology. The physical communications infrastructure needs to be augmented with knowledge technology to ensure that groups as wide apart as environmental climate scientists, social scientists, hydrodynamic engineers, farming and food technology, political concerns, can all communicate, store and record environmental and social information and develop models that can be used collectively. Furthermore these models need to be improved collaboratively, harvesting information from all these domains, about the way people need and use water, feeding it back to the model in a way that should improve prediction in other areas of the models. Linking on a global scale will give communities individual ownership of one of their most severe environmental concerns, while allowing them to belong and contribute to a global effort to understand and then apply research in this area. Each geographical area will have its own problems and solutions, and these provide a basis for understanding the global water problem in a much wider context if the full scope of the information can be recorded, distributed & understood by others. The infrastructure required must have global reach in to areas that are not simply extensions of the technologically developed world. Observation and interaction will be needed with people in all areas – satellites may show the world's water reservoirs and even indicate the uses made of the water but do not show the attitudes to these resources.

A4 Clinically-driven Laboratory Research to Laboratory-driven Clinical Treatment

Supporting the interaction between the laboratory and the environment is an idea that extends to the medical arena. We can imagine a much closer collaboration between clinical practice, clinical research, biochemical investigations and fundamental chemical research. Taking an example of a recently proposed investigation between Southampton and UCL: studies of the kinetics of key HIV protease mutant enzymes is of fundamental interest to the analysis of chemical reaction dynamics but has a clear clinical importance in the issues of resistance to inhibitor drugs. Steering the laboratory mutants by observation of the rise in resistance in the infected community provides for the opportunity to influence clinical practice directly from laboratory results, via of course all of the necessary pharmaceutical trial infrastructure and with due regard to ethical issues. All of which requires the efficient flow of information across these varied domains. The e-Research infrastructure a decade hence, linking with the NHS e-information networks, would enable the information present within the epidemiological area to be much more readily linked to work undertaken in fundamental areas.

A5 Engaging the Community – A truly large scale VRC

We can all become part of the research community. Traditionally trained scientists have made measurements carefully in laboratories or selected sites. An alternative approach is to make a very large number of measurements with less trained personnel and accept the concomitant errors, which are overcome by the statistical treatment of the huge samples.

One of the most reliable and extensive data sets that is held by the Met Office is the results from giving many schools a snow stick and asking them to measure the height of snow fall and snow drifts around the UK. Until the advent of web based infrastructure for rapid and cheap communication of instruction and results, even the most optimistic researcher in a publicly appealing domain could only hope to enlist a few enthusiasts to use GPS for location (or the effective proxy by mobile phone). The global high-density coverage could not be obtained. Now the problem is the reverse, public uptake can be so high that the ability to process the data becomes the limiting process. Adventitious science may become one of the most effective research endeavours – e.g. how to use sensors provided in a mass market for other uses for fieldwork. The use of mobile phone cameras to record the time and place of events or the use of cheap or inbuilt temperature sensors for laptops to record working environmental temperatures could be just the start of global scale monitoring. The community involvement in research will have other benefits in terms of the potential for outreach and the encouragement of science and technology.

A6 Towards Personalised Virtual Research Environments for the Humanities

Key processes within the humanities research cycle will increasingly take place via a community-based virtual research environment including, online discussion seminars, shared image manipulation, and the flow of information to and from distributed but interoperating databases. The humanities will increasingly adopt and adapt concepts and tools originally developed within other disciplines, including the capture, secure storage and flexible access to a record of the research process. Multidisciplinary doctoral training centres will, at an early stage, help knowledge transfer and application to and from the scientific and culture-based subjects. Collaborative research teams including members drawn from disciplines currently as diverse as classics, engineering, history, chemistry, literary studies and computing science will be less exceptional. Virtual research communities breaching the disciplinary boundaries will enable the sharing and integration of artefacts, methods and infrastructure. The boundaries between research, learning, administration and public environments continue to dissolve resulting in a more effective public understanding of the humanities.

A7 Creating Global Virtual Theatres for the Creative Arts

The use of e-Infrastructure to enable virtual research communities will extend to the creative arts. Practice-based researchers in the performing arts, for example, will take advantage of advances in broadband and video-conferencing technologies to collaborate on theatrical and musical performances where the directors, actors, musicians and audience members are scattered globally. The success of such performances, which have the potential to reach new audiences, are dependent on network capacity and speed. The development of a virtual research environment for collaborative music, for example, will itself be a multi-disciplinary activity, bringing together experts in acoustics, computer science, musicians and researchers in theatre and performance. The VRC will be expected to facilitate rehearsals and coaching. The bringing together of so many participants, audience and performers alike, from desktop to theatre, in a virtual space for a single live event, is itself a highly visible symbol of the virtual research community. The 20th February 2016 marks the bicentenary of the first performance of Rossini's *Barbiere di Siviglia*. By that time the technology will be available to undertake the research and realise the performance within a global virtual theatre.

A8 Building Virtual Centres for Innovation and Enterprise (Third Stream)

Building on existing business partnership activities, universities will invest third stream funding in the deployment of virtual research community e-Infrastructure to support virtual centres for innovation, knowledge transfer and business outreach. Such virtual centres will be particularly effective as regional virtual organisations which combine the bringing together of expert groups from amongst multiple institutions with the maintenance of a strong local presence. Virtual centres have the potential to provide a clear entry point into universities for business and a conduit for technology and knowledge transfer between business and academics. Membership of a virtual research community offers additional opportunities for business people to participate in the life of universities whether through access to registers of expertise (and potential non-executive directors), online training and skills development, access to shared services such as technology observatories or .IP management and licensing, and access to remote facilities and tools offered via the corresponding virtual research environment. For universities it is an opportunity to market their research and teaching to business, and provide an additional means of maintaining relationships with graduates and other alumni. The VRC for innovation and enterprise contributes to the building of regional e-Infrastructure for collaborative research and development projects. Establishing successful partnerships through a virtual centre for innovation and enterprise will help ensure the realisation of business-university partnerships within any one of the preceding scenarios.

A9 Professional Bodies

Professional bodies and learned societies across all subjects are making increased use of email and web to communicate with members and ensure their members are aware of, and can respond to, current trends, funding opportunities, career developments, interactions with local, national and international bodies. Such organisations are IT literate and will make increasing use of commercial systems. They are not, however, the innovators in the development of such technologies but, in certain areas, may be considered early adopters. The organisation of conferences and the production of journals will be almost entirely using network technologies. The dissemination of information and research via electronic means will be the norm. Reliability and credibility amongst broad communities will remain a priority for professional bodies.

Annex B

Current UK Activities in Virtual Research Communities

B1 Current JISC Activities in Virtual Research Environments

In 2004 the JISC commissioned £3.2 Million into a development programme which aims to build and deploy collaborative, multi-disciplinary Virtual Research Environments. The programme aims to bring together VRE tools and technologies to demonstrate how researchers can manage better the increasingly complex tasks which they are being called upon to perform. Fifteen projects have been funded which are currently developing different VRE solutions. A short description of each is provided in the table below. A further £2 Million of capital spending funding from HEFCE has been allocated to extend the current VRE activities of the JISC.

Project Name	Brief Description	Lead Institution	Level of Funding £k	End Date
Sakai VRE for Educational Research	To extend the Sakai framework and exploit it for large, distributed social sciences research projects. The focus is on activities to investigate the needs of the TLRP researchers and to evaluate the extent to which Sakai meets those needs.	Cambridge	£290	Dec 2006
VRE for the History of Political Discourse	To develop a VRE capable of expansion and of facilitating multiple participation in the field of the History of Political Discourse. It combines the capabilities of the Sakai platform and the Access Grid to achieve this aim.	East Anglia	£150	Oct 2007
Sakai VRE Portal Demonstrator	To address the requirement for a single point of access to a comprehensive set of Grid and collaboration services in a VRE.	Lancaster	£299	Jan 2007
VRE for the Integrative Biology Research Consortium	To develop a VRE demonstrator to investigate the utility of existing collaborative frameworks to support the entire research process of a large-scale, international research consortium in Integrative Biology.	Oxford	£300	Mar 2007
Building a VRE for the Humanities	To build a VRE for the Humanities by investigating how Humanities research can benefit from ICT and by constructing demonstrators in specific fields.	Oxford	£91	Oct 2006

Project Name	Brief Description	Lead Institution	Level of Funding £k	End Date
Integrating Digital Library Technologies with Sakai and Kepler	To identify and integrate a number of tools and technologies for the data grid and digital library communities which will support collaborative e-Research across institutions and domains using Sakai and Kepler scientific workflow system.	Liverpool	£148	Feb 2007
Silchester Roman Town: A Virtual Research Community	To develop a system to facilitate archaeological research by synchronising the three processes of gathering information, co-coordinating expertise, and managing the resulting body of data. This is achieved by establishing interoperability of different digital resources and the use of wireless technologies.	Reading	£60	Nov 2006
GROWL: VRE Programming Toolkit and Applications	To build upon the existing prototype GROWL library to produce a truly lightweight extensible toolkit which complements other solutions.	Cambridge	£150	Jul 2006
EVIE: Embedding a VRE in an Institutional Environment	To test the integration and deployment of key existing software components within a portal framework.	Leeds	£299	Oct 2006
ELVI: Evaluation of a Large-scale VRE Implementation	To produce and demonstrate a practical framework for the effective deployment of a generic VRE.	Nottingham	£198	Jan 2007
MEMETIC: Meeting Memory Technology Informing Collaboration	Extend the Access Grid's VRE infrastructure with new collaboration functionalities from the CoAKTinG project.	Manchester	£200	Oct 2006
CSAGE: Collaborative Stereoscopic Access Grid Environment	To construct and use a portal semi-immersive stereoscopic solution to create an increased level of ‘presence’ within the Access Grid environment and the recording of the performance, in the same format, within a framework playable by a larger community base as and when required.	Manchester	£100	Mar 2006
ISME: Integration & Steering of Multi-site Experiments	To develop and refine the experimental steering process, shared workspace and distributed visualisation into a VRE making them deployable by dispersed teams of instrument scientists, material scientists and engineers in a transparent and robust manner.	Manchester	£150	Oct 2006

Project Name	Brief Description	Lead Institution	Level of Funding £k	End Date
IUGO: Conference Information Integration	To develop a proof of concept system to enable the integration of web-based content (and references to non web-based content), related to individual conferences and individual sessions within conferences, thus providing a means to provide far great benefit to the wider research community than is currently available from conference attendance.	Bristol	£150	Jun 2006
CORE: Collaborative Orthopaedic Research Environment	To provide integrated computer support across the research and educational cycles, because these activities are intrinsically coupled as a part of the requirements of the surgeon's Continuing Professional Development.	Southampton	£137	Oct 2006

B2 Research Council funded Virtual Research Environment Projects

The 23 projects below are drawn from the much longer list of activities funded by the Research Councils as part of the e-Science initiative following the 2000 and 2002 Spending Reviews. It could be argued that the entirety of this investment is of relevance to VREs; the activities that received funding ranged from large, multi-million programmes such as PPARC's AstroGrid, aimed a providing a virtual infrastructure for a large community of researchers, to smaller initiatives geared to access to computational facilities and/or the more effective distributed manipulation of datasets for particular communities. Many of the projects concern tools being developed for use in discipline-specific VREs, such as new spatial analysis tools.

The projects highlighted below are those that are more explicitly aimed at fostering VRCs (or, in some cases, VOs – as indicated above, the distinction between VOs and VRCs) and the VREs that support them. They are spread across all disciplines, and several have broad multidisciplinary applications. Their total combined value is just under £37 million.

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
ageing (multidisciplinary)	Biology of ageing e-Science integration and simulation system (BASIS)	Ageing is a complex biological process involving interactions between a number of biochemical mechanisms whose effects occur at the molecular, cell, tissue and whole organism levels. Rapid progress is being made in aspects of the molecular biology and functional genomics of ageing but an urgent requirement is now to develop an innovative biomathematical and bioinformatics system that will allow the integration of data and hypotheses from diverse biological sources. This proposal is to establish a biology of ageing e-Science integration and	Newcastle	£611	Apr 2002	BBSRC, MRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
		simulation system (BASIS) that will encourage and support the interaction between biological science, bioinformatics, IT, computer science, mathematics and statistics in this recognised priority field.				
astronomy (multidisciplinary)	AstroGrid	We propose a programme of work to develop a future Virtual Observatory infrastructure for the UK that delivers powerful analysis facilities, is matched to key facilities and missions, is integrated into the European scene, and backs UK data centres in international competition. The Virtual Observatory is conceived as a set of standards and a software framework that allows creative diversity in publishing data services and writing software tools. The current AstroGrid project is on track to produce a first working version of this ideal. In addition, we will populate the system with selected current UK databases, and provide a limited set of user tools. However, there is a clear need for a follow-on project − to extend and improve the infrastructure, to take advantage of further waves of technology, and to establish UK Data Centres as competitors in the new world, especially as we head towards competition over servicing key missions such as ALMA, GAIA, or JWST. We have designed a broad but structured project to address these new priorities.	Edinburgh	£9,000 (phases 1 and 2)	Sep 2001	PPARC
biodiversity	A problem solving environment for global biodiversity: prototype and demonstrator	The project aims to create a problem-solving environment for biodiversity research on the GRID. It will be a prototype, based at 4 main sites: Reading, Cardiff, National History Museum and Southampton and will be used to demonstrate research in a range of biodiversity investigations. Key components will be the ability to: locate data on taxa, locate and extract data from thematic data sources for these taxa and to utilise these data sets for research using existing analytical software. The main features of the prototype will be: linkage to an existing partial catalogue of life sufficient to demonstrate the system, a partial array of linked thematic data sources and a system for collating data from the sources and using it in existing biodiversity analytical tools. The test system will be trialled on three exemplar analyses: biodiversity richness analysis (using Bumblebees and Geometrid Moths), bioclimatic modeling and climate change scenarios (using Legumes) and phylogenetic and biogeography analyses (using Sundews and Legumes).	Reading	£1,119	May 2002	BBSRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
biology	myGrid: A Platform for e-Biology	The myGrid consortium has (a) successfully pioneered world-class research on the Semantic and Data Grid, and (b) developed open source high-level service-based middleware to support in silico experiments in biology that are in use by biologists and being adopted by a wide range of national projects and international partners. We have an active and vibrant end user community; have developed core infrastructure for routine use; established national partnerships; forged extensive links with the international life science community and the e-Science/Grid community; and created a substantial footprint in the community. The platform grant gives us the essential support to ensure that the myGrid platform remains cohesive and coherent, and gives us the essential flexibility to connect to other projects, leverage developments across the consortium, investigate technical problems, react to opportunities and continue our programme of dissemination to our user (Life Science) and technical (e-Science/Grid) communities and partners.	Manchester	£420	May 2005	EPSRC
biology, molecular	A GRID Database for biomolecular simulations	The overall objective of the project is to draw together and formalise relationships within the biomolecular simulation community in order to enable optimum use of resources and to facilitate training of students and postdocs. The Specific aims within this objective are: To establish a formal consortium for biomolecular simulations within the UK, building on existing arrangements to increase collaboration and foster collective efforts via workshops and via a flag-ship project based on distributed, shared data structures. To establish a biomolecular simulation database. To exploit the GRID so that the database will exist in a distributed form but can be curated and interrogated centrally. To develop software tools for interrogation and data-mining across entire distributed database. Added value from taking the GRID approach with associated metadata facilities comes from enabling data-mining across all simulations in the database and facilitating access to simulation results by non-experts e.g. in the structural biology and genomics communities.	Oxford	£730	Dec 2002	BBSRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
cancer	Artificial Neural Networks (ANN) in Cancer Management	This consortium involves 2 PIs from 2 Institutions and engages clinicians and physicists; it will apply ANN and their associated analysis techniques to predict the life expectancy of cancer patients and to identify individualised patient management schemes. The outputs should be applicable to healthcare more generally (heart disease, diabetes, obesity etc). Grid-secure technology will be used to link the various sources of patient data to ANN computer frame and vice versa. The Manchester physics team has substantial computing and network infrastructure to support the research and will use grid technology to address security authentication problems.	Dundee	£200	Apr 2002	MRC
cancer	CancerGRID	CancerGRID is a consortium to develop open standards for clinical cancer informatics. The Consortium will concentrate on breast cancer translational clinical trials, but since all informatics tools will be developed using open source, open access, open development and a federated structure it is anticipated that solutions will be portable to other clinical scenarios. The Goal of our application is to use a modular approach to provide solutions for "simple" problems using grid-based informatics: 1-Developing a template for e-clinical trials using a translational clinical trial already ongoing as a pilot (NeoTANGO); 2-Linking existing clinical trial data with molecular profiling information obtained from paraffin-embedded tumour samples; 3- Linking genetic epidemiology data with molecular pathology and clinical outcome data; ; and 4-Using GRID-based collaborative tools to run clinical trials.	Cambridge	£2,354	Jun 2005	MRC
chemistry	PLATFORM: End-to-End pipeline for chemical information: from the laboratory to literature and back again	The Comb-e-Chem e-Science project sought to provide an end-to-end knowledge pipeline for chemical data and information from laboratory creation to literature re-use by bringing the state-of-the-art in Computer Science to the workplace of chemistry researchers. The overall aim was to show what could be done and to influence thinking in the area. As a result of its work, new ideas and challenges have emerged consistent with the original aims. The interdisciplinary team of computer scientists, chemists and statisticians, now strengthened and expanded, seeks the support of a Platform Grant to maintain and develop its unique identity and to address new ideas and challenges that have emerged within the wider area of integrated chemical informatics. This will allow us the flexibility to respond rapidly to new developments in the field, for example, with pilot projects to pump prime new funding in the areas	Southampton	£415	Apr 2005	EPSRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
		such as the smart Laboratory, automation of experimental design and analysis, and the linking of experimental data with calculations and simulations.				
chemistry	Grid Based Information Models to Support the Rapid Innovation of High Value Added Chemicals (GOLD)	This project will build on existing Grid technologies to provide an infrastructure capable of supporting full lifecycle processes in extremely dynamic Virtual Organisations. Chemical manufacturers focus on new product development as a means of growth, with time to market as the key driver. The Virtual Organisations comprising the chemical industry are highly dynamic and solutions requiring significant infrastructural overhead are impractical. R&D processes spanning the entire lifecycle of some chemical product are similarly dynamic and complex. This project provides key Grid middleware components that will allow the creation and management of extremely dynamic Virtual Organisations comprising the full chemical R&D lifecycle. This will include facilities for: Trust Management, Workflow, Information Distribution, Centralised Access Control and management facilities. The project has the potential to provide a major advance in business decision-making via a step change in the way high value chemical products are conceived, developed and taken to market.	Newcastle	£2,094	Feb 2004	EPSRC
clinical research / trials	Co-operative clinical e-Science framework (CLEF)	This consortium, which comprises 11 PIs from 6 Institutions including 1 NHS Trust, aims to develop rigorous generic policies, tools and methodologies for capturing and managing clinical information in patient care (written and stored in many different ways) and for integrating that information into clinical healthcare and basic bioscience research. Whilst focusing primarily on cancer, the outputs should be applicable to other applications. CLEF is embedded within a network of e-Science/Grid projects based on the MyGrid architecture and its goal is an advanced open-source prototype built on standard middleware. The CLEF team has links with key UK/overseas Cancer Agencies, with EU programmes and with industry; the PIs contribute to numerous national/international fora and are training students.	Manchester	£4,203 (pilot and clinical trials follow-up)	Oct 2002	MRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
clinical research/trials	Virtual Organisations for Trials and Epidemiological Studies (VOTES)	Building on our previous experience of developing IT systems for all phases of large-scale clinical trials and observational studies, we now wish to develop a validated Grid-based resource that would provide the necessary infrastructure to facilitate clinical research studies. It is intended that this system would be readily accessible to investigators both in the UK and internationally, and could be tailored rapidly to meet the needs of new studies. We wish to develop a core Grid infrastructure to address three key components of a clinical trial or observational study: 1. Recruitment of potentially eligible participants; 2. Data collection during the study; 3. Study administration and coordination. Our consortium has the necessary expertise both in coordinating large-scale clinical studies and in e-Science to make this is an achievable aim. The project will be directed by a Steering Committee, supported by a Security Advisory Board, and by an Ethics and Legal Advisory Board.	Oxford	£2,861	Jan 2005	MRC
data storage / management	Describing the Quality of Curated E-Science Information Resources	E-Science involves the sharing of experimental results on a global scale. Scientists now expect to make use of information produced by other labs/projects in validating and interpreting their own results. However, many unsolved problems remain in the area of information sharing, not least of which are those caused by hidden differences in information quality (IQ) between data sources. This project seeks to assist scientists and data curators in managing the quality of their information. Rather than trying to impose a single approach and set of IQ priorities, an alternative is to provide scientists with the means of annotating their information with explicit descriptions of its quality in terms of locally relevant characteristics.	Manchester, Aberdeen	£360	Apr-Jul 2004	EPSRC
Earth science	Grid Enabled Integrated Earth system model (GENIE). A modular, distributed and scaleable Earth System Model for long-	We propose to develop, integrate and deploy a Grid-based system which will allow us: (i) to flexibly couple together state-of-the art components to form a unified ESM, (ii) to execute the resulting ESM on the Grid, (iii) to share the distributed data produced across the simulation runs, and (iv) to provide high level open access to the system, creating and supporting virtual organisations of Earth System modellers. The project will deliver both a flexible Grid-based architecture, which will provide substantial long-term benefits to the Earth system modelling community (and others who need to combine disparate models into a coupled whole), and also new scientific	Bristol	£1,379		NERC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
	term and palaeo-climate studies	understanding from versions of the ESM generated and applied in the project.				
Genomics / proteomics	Integration of Sequence and Structural Family Data	This consortium comprises 6 PIs from 4 institutions. It aims to develop research infrastructure support for protein structure data, to a) integrate and co-ordinate 5 existing gene sequencing and structural databases (SCOP, CATH, InterPro, MSD, Pfam) and b) solve data distribution and warehousing problems to facilitate sharing of Grid-borne data with good visualisation for end-users. The PIs are building a Grid infrastructure including data warehouses and high speed networking capability. The team has national/international links (including with the MyGrid project), contributes to numerous national/international fora, participates in EU programmes and organises 6 mthly progress meetings.	Sanger Institute	£2,216	Apr 2003	MRC
images	New technologies, new applications: using Access Grid Nodes in field research and training	AGNs are devices that enable visual images and audio to be exchanged in real time between different computers. Cameras and microphones at each site relay images of, and utterances by, participants to other AGN sites, with no theoretical limit to the number of sites that can be connected. AGNs display large format images to a projection screen and provide high fidelity stereo sound, the idea being to make AGN communication as much like being co-present as possible. Images of computer displays, such as Powerpoint slides and software output, can also be displayed alongside the images of people, so everyone involved can see a common object of discussion and discuss it with participants at other AGN sites. The proposal aims to assess the use of AGNs to conduct interviews and group discussions with participants at sites remote from the interviewer or discussion leader. It also aims to document the nature of AGN-mediated interaction and communication, by analysing recordings of fieldwork sessions, professional meetings, and software training workshops delivered via AGNs to students at other AGN sites.	Surrey	£37	Feb 2005	ESRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
multidisciplinary	MYGRID: Directly Supporting the E-Scientist	MyGrid will design, develop and demonstrate higher level functionalities over an existing Grid infrastructure that support scientists in making use of complex distributed resources. The project will develop an e-Scientist's workbench that supports: (I) the scientific process of experimental investigation, evidence accumulation and result assimilation; (ii) the scientist's use of the community's information; and (iii) scientific collaboration, allowing dynamic groupings to tackle emergent research problems. The workbench will support individual scientists by providing personalisation facilities relating to resource selection, data management and process enactment. The design and development activity will be informed by and evaluated using problems in bioinformatics, which is characterised by a highly distributed community, with many shared tools resources. MyGrid will develop two application environments, one that supports individual scientists in the analysis of functional genomic data, and another that supports the annotation of a pattern database.	Manchester	£3,483	Oct 2001	EPSRC
neurology	NeuroGRID	Advances in neuroimaging have already led to breakthroughs in the clinical management of neurological disorders and current developments hold comparable promise for neuropsychiatric disorders. e-Science and Grid technologies can help overcome these problems by the integration of image acquisition, storage and analysis, and by enhancing collaborative working within and between sites. The NeuroGrid consortium will enhance collaboration between clinical, imaging and e-scientists to create a grid-based network of neuroimaging centres and a neuroimaging tool-kit. Sharing data, experience and expertise will facilitate the archiving, curation, retrieval and analysis of imaging data from multiple sites and enable large-scale clinical studies.	Oxford	£2,339	Mar 2005	MRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
occupational research	Grid enabled Occupational Data Environment	A Grid enabled internet portal will be explored in order to facilitate the processing of occupational data from social survey and related outputs. The portal will utilise a number of features which are uniquely enhanced by e-Social Science (ESS) technologies. Its prospective features will include the generation and provision of automated data confrontation and management programs which allow lay users to understand and link their ‘raw’ data with a variety of sociological occupational classification schemes; the development of a virtual network acting as an international ‘depository’ of occupational information; and the exploration of operations which may facilitate the further computation of occupationally based social classification schemes for new versions of international occupational data. The portal will utilise the array of existing occupational classification resources developed for over 20 countries under the ‘CAMSIS’ (Cambridge Social Interaction and Stratification Scales’) project, and contribute to the continued development of these resources.	Stirling	£46	Jul 2005	ESRC
policy/planning	Hydra I Grid Based Spatial Planning Services	When faced with difficult decisions, planners are hampered in the search for effective solutions by the absence or fragmentation of appropriate evidence (or 'data' relating to the decision and by the lack of analytical tools ny which to interpret this evidence. This is equally true for multi-national corporations, local traders, and public sector organisations. This project seeks to present decision-makers ('planners') with grid-based tools to tackle such problems. The key objectives of the project are: (i) to deliver a software demonstrator on the White Rose Grid which can solve spatial planning problems relating to retailing, housing, transportation, and land-use under a variety of demographic and economic scenarios; (ii) to integrate data from a variety of sources and physical locations within the software architecture; (iii) to provide a variety of spatial analysis functions, including forecasting, dynamic modeling and location optimisation.	Leeds	£64	Dec 2003	ESRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
psychiatry	PsyGRID: e-Science to Facilitate Clinical Trials and Longitudinal Studies in First Episode Psychosis	Severe mental illness (psychosis) is a major public health challenge. Current health policy has a focus on early intervention in the first episode of psychosis as a way of improving outcomes. The evidence for which interventions are best is patchy. Improving this evidence base is a core rationale for the newly formed Mental Health Research Network (MHRN www.mhrn.info) of the National Institute of Mental Health England. The twin aims of this proposal are:- 1) to establish an e-Science framework and functioning e-community which integrates academic and NHS partners in MHRN, so as to enhance research and development capability in routine mental health service settings; 2) to set up an information system to ascertain and characterise a large, representative cohort of individuals with first episode psychosis to enable hypothesis-driven epidemiological and intervention research, particularly into predicting and preventing adverse outcomes. PsyGrid will provide a flexible e-Science/Grid infrastructure deployed over NHSnet using existing governance arrangements for handling clinical data. We will leverage as much existing e-Science software development as possible, working closely with our e-Science Centres and our industrial partner (Microsoft). The PsyGrid e-Science platform will inform, launch and facilitate future externally-funded, hypothesis-driven research in four priority areas in this field: longitudinal studies of risk and protective factors for long-term outcomes, including aetiological inquiry; clinical trials in early psychosis; biological studies of the nature of clinical progression; and new methodologies for evidence-based service developments.	Manchester	£2,126	Mar 2005	MRC
social sciences, multidisciplinary	Collaborative E-Science for Spatial Decision-Making in Distributed Environments	This project aims to be the first e-Science initiative on developing and testing a distributed computational infrastructure for supporting spatial decision making within an international natural resource management context. The research will be carried out through the production and presentation of a problem based course and will use distinctive social science methodologies for investigating the evolution and impact of the project. The research method is based on Soft Systems approaches for information systems development, regarded as one of the few more effective approaches to emphasise the social component of information systems development. The project will deliver enhanced grid-based open source software tools, open source e-Science capacity building	Open University	£44	Jul 2005	ESRC

Lead Discipline	Project Name	Brief Description	Lead Institution	Level of Funding £k	Start Date	Funder/s
		resources, a human-centred understanding of the application of e-Science tools, and will undertake a range of dissemination activities aimed at supporting ESRC's eSocial Science strategy.				
virtual organisation	Trusted Coordination in Dynamic Virtual Organisations	An inter-organisational business relationship is commonly referred to as a virtual organisation (VO). A VO however, blurs the distinction between 'outsiders ' and 'insiders' and yet, organisations forming a VO will want to preserve their individual autonomy and privacy. A central problem in VO management is how organisations can regulate access to their resources by other organisations in a way that ensures that their individual policies for information sharing are honoured. There is an additional complexity as the organisations might not trust each other. New forms of infrastructure support is required that will be capable of supporting interactions in a (potentially) hostile environment: interactions between mutually distrusting organisations over open networks. Given these observations, development of infrastructure support for inter-organisation interactions pose very interesting research problems. The project will develop tools and techniques to enable VOs to be formed and managed in a trustworthy manner.	Newcastle	£360	Oct 2003	EPSRC
virtual organisation	Virtual Organisations for e-Science	Virtual organisations (VOs) - temporary alliances of distinct stakeholders that come together to deliver fulfill a particular niche - are central to the vision e-Science. They provide the means to rapidly assemble services to meet a particular need, and they provide the basis for flexible ongoing collaboration in dynamic communities. However, to date, there are no techniques that can automatically support the entire end-to-end VO lifecycle (from creation, through operation, to dissolution). To this end, this proposal will undertake the fundamental computer science research that is necessary to rectify this situation. In particular, we adopt a service-oriented view in which software agents interact in a computational economy. Specifically, we will develop techniques to specify and reason about services and their composition effects, use advanced auction techniques (combinatorial auctions) to construct and re-construct optimal VOs, and dynamic coalition formation techniques from game theory to manage the VO's operation. These techniques will be integrated together in o Vfl demonstrator in the domain of e-Science.	Liverpool, Southampton	£517	Mar 2004	EPSRC

B3 Current Activities in the Arts and Humanities

Part of the AHRC ICT Programme for the Arts and Humanities, the ICT Strategy Projects fall into two types: knowledge gathering to inform the AHRC's fundamental review of ICT; and resource development to produce tools and ICT resources of broad relevance. A number of projects are relevant to the construction of e-Infrastructure for virtual research communities and relate to e.g. scoping appropriate e-Science developments; community portals; requirements gathering; tools for shared working with 3D and audio-visual materials; and electronic publishing of integrated research data and outputs.

The following are nine VRC-related activities within the arts and humanities, funded by the AHRC, EPSRC and JISC. The results from these projects will feed into AHRCs fundamental review of ICT strategy and help build capacity within the arts and humanities.

Project Name	**Brief Description**	**Level of Funding £k**	**Maturity**
AHRC: Scoping e-Science and e-social science developments and their value to the arts and humanities	Aims to identify, collate and analyse information on e-Science projects and outputs; matching these against methods and challenges in the arts and humanities; use this information to create a knowledge base for consultation by arts and humanities scholars.	£100	First year of operation
AHRC: RePAH: Research in Portals in the Arts and Humanities	Project aims to examine current information search/access strategies and patterns and then develop demonstrators to investigate future user requirements for advanced information services that will serve to facilitate greater take up and use of these resources.	£100	First year of operation
AHRC: Gathering Evidence: Current ICT Use and Future Needs for Arts and Humanities Research	Project is developing a survey and a small number of in-depth case studies to identify how scholars in arts and humanities departments in UK higher education currently use ICT in their research.	£100	First year of operation
AHRC: ICT Tools for Searching, Annotation and Analysis of Audio-Visual Media	Project is surveying technologies under development for searching audio and visual media streams, automatic annotation, and related analysis tools. It is examining how they can be put to scholarly uses, and their likely impacts.	£100	First year of operation

Project Name	Brief Description	Level of Funding £k	Maturity
AHRC: Making space: a methodology for tracking and documenting a Cognitive Process in 3-dimensional Visualisation-based Research	Project is reflecting on and analysing how in individual projects date is gathered and evaluated when creating and contextualising models and their functionalities. The project is developing the tools that will enable these experiences and analyses to be documented and then extended to provide the transparency necessary for 3D to be more widely used as a research methodology in a range of arts-based subject areas.	£100	First year of operation
AHRC: Making the LEAP: Linking E-Archives and E-Publications	Project is investigating novel ways in which electronic publication over the Internet can provide broad access to research findings in the arts and humanities, and can also make underlying data available in such a way so that readers are enabled to 'drill down' seamlessly into online archives to test interpretations and develop their own conclusions.	£100	First year of operation
AHRC: Research Workshops for e-Science in the arts and humanities	The Research Networks and Workshops scheme is designed to encourage and enable the discussion and development of ideas by researchers across and between disciplines, either through establishing new research networks or by running a series of workshops, seminars or similar events.	£100	Programme considering submissions.
JISC Arts and Humanities e-Science Support Centre	Provides advisory and training activities in support of e-Science in the Arts and Humanities	£100	Established Winter 2005
EPSRC: e-Science Demonstrator Projects in the Arts & Humanities	Small number of projects to demonstrate the possibilities of e-Science technologies for the arts and humanities.	£100	Programme considering submissions.

Annex C

International Research on Virtual Research Communities

C1 USA

The term ‘Collaboratory’ is used commonly in the USA to denote virtual research environments and communities. A simple search on ‘collaboratory’ in Google identifies several tens of examples, ranging from high end science to attempts to engage K-12 students in softer research.

The term has been in use since the mid 1990s and has been the subject of several significant funding opportunities by several major agencies, including the National Science Foundation (NSF), National Institute of Health (NIH) via their National Centre for Research Resource (NCRR), and the Department of Energy (DOE). No information on US Department of Defence research activities is available on the web.

All the collaboratories are discipline based and have concentrated on:

Access to distributed computing and data resources
Discipline specific analysis tools
Shared workspace (eg virtual whiteboards)
Communications for collaboration

The collaboratories have had mixed success, reflecting the natural tendencies of scientists in those disciplines to collaborate, or not. One of the most famous and most cited is Space, Physics and Aeronomy Research Collaboratory (SPARC). See http://www.si.umich.edu/sparc/collaboratory.htm

There has been little activity in the USA to link these separate research areas together nor to synthesise the results across different disciplines. Only the DOE has funded any work on interoperability, the DOE2000 Collaboratory Interoperability Framework (http://www-fp.mcs.anl.gov/cif), where four of their national laboratories are working together to create a common software infrastructure to promote inter-working, reduce duplication and enhance interoperability.

The results of early experiences with all these collaboratory projects has identified the following issues (see http://www.nsf.gov/statistics/seind02/c8/c8s3.htm):

- Collaboratories do not replace the richness of face to face interaction and generate concerns about trust, motivation, data access, ownership and attribution of input and results
- There are major challenges in supporting complex work in virtual settings; most existing work has been carried out in relatively simple scenarios to allow the researchers to concentrate on making things work. Scaling up to big inter-disciplinary research will create new problems to overcome.
- Collaboratories appear to help graduate students and ‘casual’ researchers the most, since they can get access to resources otherwise unavailable. By contrast, outside involvement by junior or non-professional participants in collaboratories can prove a distraction to top researchers

There is now a recognition that the new tools will not be exploited to the full unless the broader research community is educated in their use The NSF Cyberinfrastructure Office has recently launched the CI-TEAM programme, 11 projects of around $250,000 each, to promote the education and training of a new cyberinfrastructure workforce.

PRAGMA (Pacific Rim Application and Grid Middleware Assembly) is a project led by the University of San Diego and the San Diego Supercomputer Centre, a grass roots grid promoting collaborative e-Science teams among a set of Pacific Rim institutions.

It is difficult to estimate the total research expenditure in this area in the USA to date but the number of government agencies involved, the number of collaboratories in existence and the recognised importance of the work to overall US research and development suggests that it must be in the region of $100m.

As is usually the case in the USA, there is little attempt to bring together, synthesise and promulgate the experiences and products from the different research projects. Most of the spread of the expertise into the wider research community is through engagement in the various programmes.

C2 Canada

The largest program areas of relevance to the VRC Working Group come under the NRC (National Research Council of Canada) and CANARIE, both of whom are key funders of research in Canada. They are funding research in human factors associated with the Web, networks, high performance computing and Security and Privacy.

Other organisations are also pursuing programs funded through various government, industry or collaborative partnerships. These include the Canadian Institutes of Health Research and the Canadian Ministry of Industry, who are funding the Network for Effective Collaboration Technologies through Advanced Research (NECTAR) which is a new science and engineering network that will develop technologies to make virtual collaboration at a distance as productive and effective as face-to-face.

There is also a new $1.7m research programme in Collaborative Virtual Environments; its main objective is for the University of Alberta to develop one of the top facilities in the world for creating and improving collaborative virtual environments.

Canada is heavily involved in international partnership activities, particularly with the US and Europe, with more than 35% of collaborative research with the EU including more than 70 projects in FP6. There is thus a strong driver in the country for developing VRCs.

C3 Australia

Australia has a major problem with distance, both within the country and with its major trading and research partners. It has therefore adopted a very strong e-Science and e-Research programme for infrastructure, software and coordination, taking a mix of the UK e-Science agenda and the USA cyber-infrastructure approach. An extensive government (interim) report from the e-Research Coordination Group is available from the Australian Department of Education, Science and Training (http://www.dest.gov.au/) and direct link to the report pdf available is at http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/e_research_consult/interim_report.htm.

Currently a wide range of collaborative projects are supported including:

- Collections Australian Network (CAN) linking Australian museums and galleries
- InterRett (Rare and debilitating Diseases) part of a global approach to studies in this area
- GrangeNet Access Grid
- Census of Marine Life (CoML) (Global reach for a key Australian concern)
- Centre for Computational Molecular Science (to supply and use computational demand)
- Australian Virtual Observatory
- High Energy Physics (Australia – Japan collaboration)

- Paradisec (Capture endangered languages and culture of the South Pacific)
- Sydney TimeMap (Humanities)
- Securities Industry Research Centre of Asia-Pacific (SIRCA)
- The National Court of the Future Project

The future strategy highlights the following areas for further development:

- Develop human capabilities
- Better access to data
- Linking e-Research resources
- Implementing structural and cultural change
- Raising awareness and support
- Providing a focus
- Increase collaboration

C4 Finland

Finland is amongst the top R&D investors per capita and the volume of ICT-related science and research has been increasing considerably in the last few years. To support science and research the Finish the Ministry of Education has formed an IT Centre for Science, which is a central body.

CSC is the Finnish information technology centre for science. CSC is a non-profit organisation owned by the Ministry of Education. CSC runs a national large-scale facility for computational science and supports the university and research community. CSC is also responsible for the operations of the Finnish University and Research Network (Funet).

CSC offers over 200 scientific software programs and 60 scientific databases to support researchers. These are however mainly computational tools rather than collaboration and communication ones. Examples include tools in the fields of chemistry, biosciences, geosciences, physics, statistics, computational fluid dynamics, structural analysis, mathematics and scientific visualisation.

CSC also provides *The Scientist's interface* which is an extranet web service, making many special scientific applications available through an easy-to-use web user interface. These applications are also predominantly subject-specific and focus on the fields of biosciences, physics and chemistry, linguistics and drug design.

Although many services for researchers are provided centrally, there are currently no collaborative facilities available.

C5 Germany

Again, in Germany, there is no coordinated move towards Virtual Research Communities or environments. Although it is more difficult to identify relevant projects, because the web sites are rarely in English, there are a number of scattered collaboratory projects in several German universities, usually with EU funding.

The Deutsche Forschungs Gemeinschaft (DfG) has four separate projects involving virtual research environments. Interestingly, two of these are investigating the use of Wikkis as vehicles for building and sharing a corpus of useful resources amongst collaborating researchers.

C6 Netherlands

In the Netherlands, trawls of the two organisations that are the equivalent of the UK research councils (KNAW – Royal Dutch Academy of Science – and the NWO – Dutch Institute for Scientific Research) reveal little activity in virtual research collaboration. There are some projects looking at the tools that researchers may use in such environments – authentication, visualisation, video / moving image delivery – and a few, isolated discipline-specific collaborations.

The main driver for research in this area is the National Research and Education Network provider, SURFNet. They run a programme, known as Gigaport, which aims to exploit the availability of high speed national and international networks to promote Dutch research generally. They have a single collaboratory project (www.collaboratory.nl) that is exploring generic issues related to collaborative working between researchers.

There is no overall policy or programme in the Netherlands to advance this area.

C7 Elsewhere

Many other countries around the world are engaged in developing Grid capacity including:

- South Africa: High performance initiative for African Development
- Japan: Cyber Science Infrastructure (CSI) is a framework in which Japanese universities and research institutions are constructing an environment to boost collaborative research, although there are no specific VRC related activities yet.
- India: the GARUDA initiative has not yet looked at VRC issues but is active in allowing researchers to work together on a number of complex science and engineering applications
- Brazil: cyberinfrastructure is being developed to facilitate the large number of international collaborative projects currently taking place; activities have focused on the provision of HPC to date.

Annex D

Current Collaborative Tools

There are very few collaborative tools that have been developed specifically for the emerging breed of research communities and certainly none of the mainstream administrative applications systems e.g. SAP or Oracle, appear to looking to develop into this area at the moment. A definite need is emerging and, as ever, these needs can differ according to discipline. Some tools that are currently being used in the corporate world are being adapted for research purposes and many higher education institutions are creating staff portals which cater for the needs of researchers. The following list, which is not exhaustive, attempts to categorize the tools that are available or in development. Space constraints make it difficult to include a much detail about individual tools or services but wherever possible links to further information has been included.

D1 Portals

Gartner defines higher education portals as ‘enterprise portals integrated with administrative, academic and other applications of interest to students, faculty and staff’. They place them high up on the ‘slope of enlightenment’ in their 2005 HE hype cycle because, although budgetary constraints have slowed down adoption, they are emerging as key institutional interfaces for online resources and applications.

Many universities have started to develop portals, usually starting with a student portal and then moving onto other stakeholder groups, e.g. prospective students, staff, alumni. These can use portal software e.g. Luminis or can utilise the portal features of other enterprise software e.g. Oracle or WebCTl. Open source portals are in development e.g. uPortal (http://www.uportal.org/). Other organizations e.g. Research Councils are developing their own portals (e.g. ESRC Society Today, http://www.esrcsocietytoday.ac.uk/).

There are currently two institutional research portal projects being piloted under the JISC VRE programme. ELVI (Evaluation of a large VRE implementation) at Nottingham University http://www.nottingham.ac.uk/research-systems, and EVIE (Embedding a VRE in an Institutional Environment) at Leeds University http://leeds.ac.uk/evie

A typical research portal would involve effort from staff across the university and might provide seamless access to:

- MyResearch profile;
- Data warehouses that deliver business intelligence on research applications, awards and income;
- Costing tools e.g. SiriusWeb;
- Research publication databases and research expertise systems;
- Peer review tools;
- Library catalogues, bibliographic research resources and digital repositories e.g. Google Earth Pro;
- Access to shared facilities on the GRID e.g. the e-DIAMOND project and to primary research data and metadata associated with the e-science projects
- Individual portals provided by Research Councils, government departments, etc.;
- Chat/discussion boards;
- Project management tools;
- Desktop video conferencing;
- Calendaring and meeting management;
- RSS feeds;
- Blogs wikis;
- In the UK the RAE tool and the RCUK Je-S online application process.

Examples of other useful portals are:

- EU Safe Harbor Privacy Framework http://www.export.gov/safeharbor/Web research tools Virtual Salt http://www.virtualsalt.com/;
- RDN/Intute: MyIntute system (in progress) http://www.rdn.ac.uk/.

D2 Meeting/introductory services

There are very few bespoke introductory/expert systems for researchers. The most well developed for research is Academici http://www.academici.com/ and this is aimed specifically at the research community and has the potential to become a powerful system. A more targeted service is the Community of Science which contains over 500,000 researchers' profiles form 1600 institutions worldwide http://www.cos.com. Some Research Councils have useful options on their websites e.g. the ESRC has a 'find a researcher options' URL and Intute (formerly the RDN SOSIG service) has a 'like minds' options in its Grapevine section http://sosig.ac.uk

Other services which could be useful to find research partners are business to business services:

- iKarma http://www.ikarma.com/;
- Open BC https://www.openbc.com/;
- LinkedIn https://www.linkedin.com/.

D3 Meetings set up

Collaboration brings with it the need to set up meetings, often of quite large, disparate groups, and this can be a time-consuming operation. Again, a number of tools emerging in the corporate world could be investigated. Adding on meeting tools to ease the use of the Access Grid is also being explored.

- Meetomatic http://www.meetomatic.com/about.asp;
- Office management http://www.tommie.co.uk/about/index.html;
- Online meeting schedulers e.g. Meeting Wizard;
- MeetWithApproval http://meetwithapproval.com/;
- Memetic (Meeting Memory Technology Informing Collaboration) is looking to extend the functionality of the access GRID with advanced meeting support and information management tools http://www.memetic-vre.net.

D4 Blogs and wikis

The use of blogs and wikis has increased exponentially over the last two years and have many different users see, http.//www.globeofblogs.com. They are being taken up by researchers, often as a result of forming communities of practice (e.g. the Digital medievalist service has a wiki http://www.digitalmedievalist.org. The wiki is particularly useful as it is a type of website that allows users to add and edit content and is especially suited to collaborative writing.

- Blogging e.g. http://www.blogger.com/start, http://www.blog.com/;
- Wiki, e.g. http://wiki.org/. The SAKAI VRE for Educational Research project is developing a blogging tool for integration with the Sakai collaboration and learning environment.

D5 Project Management Tools

There are a number of project management tools that are used extensively in higher education but they are not always suited to all disciplines and they are not easy to use in a collaborative way across the web.

- SiriusWeb http://www.siriusweb.leeds.ac.uk/;
- Microsoft Project;
- Lotus Notes;
- Prince http://www.prince2.com/.

Web-based tools:

- Project Place a web-based http://www.projectplace.com;
- Basecamp http://www.basecamphq.com/;
- eProject http://www.eproject.com/;
- SiriusWeb a staff costing tool developed at Leeds University http://www.siriusweb.ac.uk;
- Lotus QuickPlace http://www-142.ibm.com/software/sw-lotus/products/product3.nsf/wdocs/ltwhome.

D6 Sharing documents/version control

These tools are essential for collaborative work but are more useful if they operate across the web.

- Microsoft SharePoint is increasing in popularity but there can be interoperability problems.

The following are web based

- Writely (shared documents and change in real time) http://www2.writely.com/;
- Zoho Writer http://www.zohowriter.com/Home.do;
- Writeboard http://www.writeboard.com/.

D7 Chat/video conferencing

Chat/discussion boards and video conferencing, whether it is online, audio or video, supports collaborative work and can save researchers a lot of and money. It facilitates one-to-one direct communication, small groups of collocated teams – i.e. team1 – team2 – team3 all interacting and large groups of individuals and teams, all able to interact with each other equally.

- **Data-based conferencing** - via shared workspace such as a 'whiteboard' or PC desktop.
  - NetMeeting (Windows) whiteboard (T.120 standard);
  - The SAKAI VRE demonstrator project is developing a shared whiteboard tool;
  - Commercial examples can be found at http://www.web-conferencing-zone.com.
- **Voice-only**
  - Telephone discussion – IP or POTS (plain old telephone system);
  - Audio conferencing – audio-only 'videoconference' connection (PC or department);
  - SAKAI audio tool using VoIP.
- **Video conferencing** – PC (or other hardware) based integrated systems.
  - NetMeeting (Windows H.323 and T.120 client implementations);
  - iChat (not H.323);
  - XMeeting & ohphonex (Macintosh H.323 clients);
  - openH323 & others (Linux H.323 client);
  - SOKAI.
- **"Access Grid" –** integrated high resolution audio & videoconferencing incorporating shared workspaces and applications, e.g.
  - Access Grid Toolkit – open source (free);
  - inSORS Grid 2 commercial system.
- **Internet forum** – including discussion boards and message boards to exchange ideas and pose questions, e.g.
  - MinDat Mineralogy discussion forum & others

- **"Chat rooms" & Instant messaging** – real time communication medium, e.g.
  - Yahoo 'science' chat room;
  - Messenger, AOL, Yahoo and ICQ instant messaging;
  - Jabber – implementation of XMPP IETF's Extensible Messaging and Presence Protocol;
  - IRC/uIRC e.g.
    http://www.mirc.com/;
    http://www.irc.org/;
    http://www.irc.cohttp://www/uirc.net;
    http://groups.google.com.
  - The SAKAI VRE for educational research project is also developing these kinds of tools including and audio tool using VoI.

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Annex F

Glossary of terms

Term	Definition
Academici	A global networking service linking academics, academic-related associations, societies, academic services, students and academic-related business. The service is based on searchable profiles of researchers and provides the ability to set up closed or open networks with others.
Access Grid	The Access Grid® is an ensemble of resources including multimedia large-format displays, presentation and interactive environments, and interfaces to Grid middleware and to visualisation environments. These resources are used to support group-to-group interactions across the Grid such as: large-scale distributed meetings, collaborative work sessions, seminars, lectures, tutorials, and training. The Access Grid thus differs from desktop-to-desktop tools that focus on individual communication.
AHRC	Arts and Humanities Research Council
Asynchronous collaboration	A collaboration between partners that takes place within independent time spaces.
Authentication	The process of determining whether someone or something is, in fact, who or what it claim to be.
Authorisation	The process of determining what types of activities or access are permitted for a given identity. Usually used in the context of authentication: once you have authenticated a user, they may be authorised to have access to a specific service.
BBSRC	Biotechnical and Biological Sciences Research Council
Blog	A weblog (usually shortened to blog) is a web-based publication consisting primarily of periodic articles (normally in reverse chronological order).
CAN	Collections Australian Network (Australian collaborative project)
CANARIE	CANARIE Inc. - Canada's advanced Internet development organisation - is a not-for-profit corporation supported by its members, project partners and the Federal Government.
chat rooms	A chat room is an online forum where people can 'chat' online (talk by broadcasting messages to people on the same forum in real time).
CI-TEAM	NSF cross-cutting research programme - **C**yber**i**nfrastructure **T**raining, **E**ducation, **A**dvancement, and **M**entoring for Our 21st Century Workforce (CI-TEAM)
Collaborate	a working relationship involving critical individual responsibility and group responsibility with collaborators adding to the value of work of others
Collaboratory	An amalgamation of Collaboration and Laboratory, conveying the concept of a collective research organisation where a high value and focus is placed on the sharing of effort and findings such that the quality and progress of the research is highly optimised and relevant, and every member of the research organisation receives benefits greater than their actual investment.

CoML	Census of Marine Life (Australian collaborative project)
CSC	Finnish Information Technology centre for science
CSI	Japan's Cyber Science Infrastructure - the next generation academic information environment, coordinated by the National Institute of Informatics in collaboration with Japanese universities and academic institutions
CVE	Collaborative Virtual Environment
Cyberinfrastructure	The (US) term describes the new research environments that support advanced data acquisition, data storage, data management, data integration, data mining, data visualisation and other computing and information processing services over the Internet. In scientific usage, Cyberinfrastructure is a technological solution to the problem of efficiently connecting data, computers, and people with the goal of enabling derivation of novel scientific theories and knowledge
DfG	Deutsche Forschungs Gemeinschaft - German Research Foundation
DIAMOND project	DIAMOND, the new UK synchrotron light source which is being built at Rutherford Appleton Laboratory near Oxford
DOE	US Department of Energy
e-Infrastructure	The term refers to a spectrum of developments that will underpin research and learning in the future. It embraces networks, grids, data centres and collaborative environments and includes the supporting operations centres, certificate authorities, training and help-desk services.
ELVI	Evaluation of a large VRE implementation – JISC VRE Programme
EPSRC	Engineering and Physical Sciences Research Council
e-Research	This is a broader category than e-Science which encompasses e-Science and also the development of e-Infrastructure necessary to meet the requirements of global collaboration within the social sciences, arts and humanities.
e-Science	Refers to the large scale science that will increasingly be carried out through distributed global collaborations enabled by the Internet. Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualisation back to the individual user scientists.
ESRC	Economic and Social Research Council
GRID	Grid computing (or the use of a *computational grid*) is applying the resources of many computers in a network to a single problem at the same time - usually to a scientific or technical problem that requires a great number of computer processing cycles or access to large amounts of data.
HEFCE	Higher Education Funding Council for England
ICT	Information and Communication Technology - used to describe a range of technologies for gathering, storing, retrieving, processing, analysing and transmitting information
Identity (federated)	The process of a user's authentication across multiple IT systems or even organisations
Instant messaging	A form of electronic communication which involves immediate correspondence between two or more users who are all online simultaneously

Jabber	An open, XML-based protocol for instant messaging and presence.
JISC	Joint Information Systems Committee
KNAW	Koninklijke Nederlandse Akademie van Wetenschappen – Dutch Royal Academy of Arts and Sciences
MRC	Medical research Council
Multidisciplinary research	Research that incorporates scientists or studies from a number of disciplines
NECTAR	Network for Effective Collaboration Technologies through Advanced Research (Canada)
NERC	Natural Environment Research Council
NIH	US National Institute of Health
NRC	National Research Council of Canada
NSF	US National Science Foundation
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek - Netherlands Organisation for Scientific Research
OST	Office of Science and Technology
PPARC	Particle Physics and Astronomy Research Council
PRAGMA	Pacific Rim Application and Grid Middleware Assembly (Australia)
RSS	RDF Site Summary, or Rich Site Summary, or Really Simple Syndication – A lightweight XML format for distributing news headlines and other content on the Web.
SAKAI	The Sakai Project is a community source software development effort to design, build and deploy a new Collaboration and Learning Environment (CLE) for higher education
SAML	Security Assertion Markup Language is an XML standard for exchanging authentication and authorisation data between security domains
Shibboleth	Shibboleth is an Internet2 Middleware Initiative project that has created an architecture and open-source implementation for federated identity-based authentication and authorisation infrastructure based on Security Assertion Markup Language (SAML). Federated identity allows for information about users in one security domain to be provided to other organisations in a common federation.
SIRCA	Securities Industry Research Centre of Asia-Pacific (Australian collaborative project)
SPARC	Space, Physics and Aeronomy Research Collaboratory
Synchronous collaboration	A real-time collaboration between partners e.g. video-conference.
VO	Virtual Organisation - A temporary network of companies, suppliers, customers, or employees, linked by information and communications technologies, with the purpose of delivering a service or product.
VRC	Virtual Research Community
VRE	Virtual Research Environment
Wiki	A website or similar online resource which allows users to add and edit content collectively. “Wiki wiki” means "rapidly" in the Hawaiian language.

Annex G

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