Accelerating Transition to Virtual Research Organisation in Social Science (AVROSS)

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Executive summary

This report is the fourth deliverable of the AVROSS study (Accelerating Transition to Virtual Research Organisation in Social Science, AVROSS) aimed at delivering "A study on requirements and options for accelerating the transition from traditional research to virtual research organisations through e-Infrastructures" to the EC under EU Service Contract No. 30-CE-0066163/00-39.

The study responds to a European Commission call to report on the state of the art in applying e-Infrastructure to social science and humanities (SSH) in at least four fields. The aim of the study was to research, select and analyse a significant number of the most promising applications of e-Infrastructure which can trigger transition to virtual research organisations and motivate sustained e-Infrastructure use in these disciplines. It also is focussed on paying special attention to opportunities for computer-supported collaborative learning (CSCL). The ultimate goal was to provide recommendations as to the possible scenarios for a large scale roll out of technologies and applications supporting virtual research organisations and novel services for students based on CSCL.

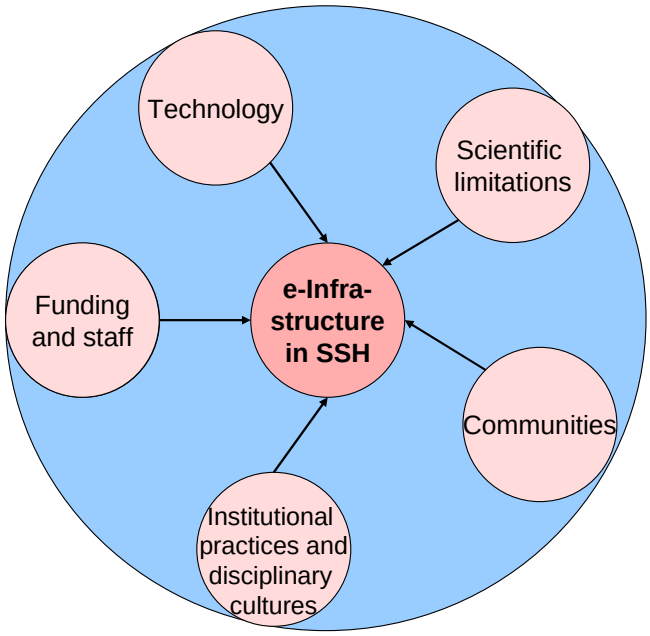
The reason for this focus is that it is clear that "soft" sciences have both much to gain and a key role to play in promoting e-Infrastructure uptake across the disciplines, but to date have not been the fastest adopters of advanced grid-based e-Infrastructure. Our recommendations to EU policy-makers can be expected to point the way to changing this situation, promoting e-Infrastructure in Europe in these disciplines, with clear requirements to developers and expected impact in several other disciplines with related requirements, such as e-Health.

Theoretical framework

Previous theoretic and empirical work identified four factors likely to be influential in shaping the use of e-Infrastructures in the social sciences and humanities. These are illustrated in Figure I and include:

1. *Technological frames and communities:* Technological paradigms of developers and users which are shaped by the capabilities of previous technologies and the demands of the user communities constitute an influential frame on which the introduction and spread of e-Infrastructures takes place. Technological constraints limit the extent to which user needs can be implemented.
2. *Scientific shaping of technology:* Scientific progress for instance in computer science and computer linguistics is still a pre-condition for producing applications for the social sciences and humanities and dealing with confidentiality and privacy problems which are particularly virulent in the social sciences.
3. *Funding and staff:* In addition to funding needs for the sustainable development and provision of e-Infrastructures there are other resource-related issues: learning costs, availability of qualified staff, and training of personnel and prospective users on the capabilities of the technology.
4. *Relationship to institutional practices and disciplinary cultures:* Technologies may have inbuilt political purposes and the activities of political institutions and intermediaries – in science for instance research and higher education ministries, research foundations, scholarly societies – shape their spread and use. Moreover, they need to be integrated into proven work routines, institutional practices and disciplinary cultures which requires functioning cross-disciplinary communication and collaboration between engineers and domain scientists.

Figure I: Social shaping of e-Infrastructures in the social sciences and humanities



Source: AVROSS.

Adoption of e-Infrastructures in the social sciences and humanities in Europe, the USA and beyond

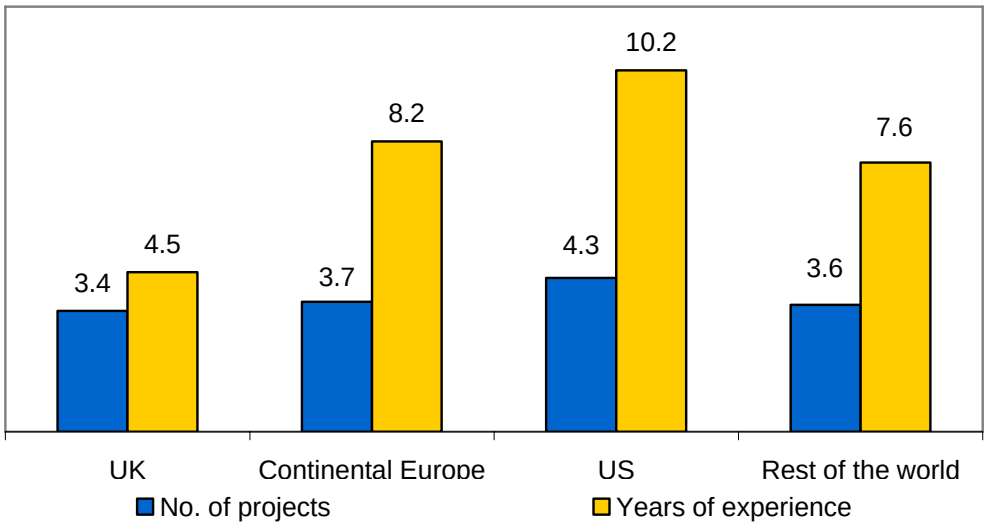
The first part of the empirical work in AVROSS consisted of an exploratory survey among the early adopters of e-Infrastructures in the social sciences and humanities that was carried out to provide a stock-taking of e-Infrastructure projects in Europe and beyond. The survey was sent in the spring of 2007 to roughly 2,000 individuals who had been identified as potentially involved in e-Infrastructure work. The aim was to cast a very wide net to generate the maximum number of responses, and over 560 responses were received - 448 usable responses (23.4% of the sample). The survey yielded several striking findings on e-Infrastructure adoption in social sciences and humanities and the type of e-Infrastructure projects carried out so far.

e-Infrastructure adoption

There are some regional differences in length of experience with e-Infrastructure (Figure II). Most strikingly, US respondents to the survey are on average more experienced than their colleagues from other regions, with an average over more than 10 years experience and more than 4 projects. Despite the fact that there are currently numerous e-Infrastructure projects in the UK, the relatively recent nature of this phenomenon is evidenced by the fact that the typical e-Infrastructure user has a relatively short experience with e-Infrastructure, and has worked on relatively few projects.

A couple of other findings on adoption are interesting: First, survey respondents identified a number of key sources of information about e-Infrastructure and stressed the importance of other scientists in spreading information (see table I). Printed information, on the other hand, is of comparatively little importance. Only for scientists who are predominantly collaborating at the non-local, national and international, levels and – supposedly – less integrated in their local communities printed information on e-Infrastructure plays some role. It might substitute local meetings and workshops from which they less often benefit.

Figure II: Experience in e-Infrastructure projects by region of the respondent (arithmetic means)



Responses to QA9 and QA10
Source: AVROSS WP2 survey.

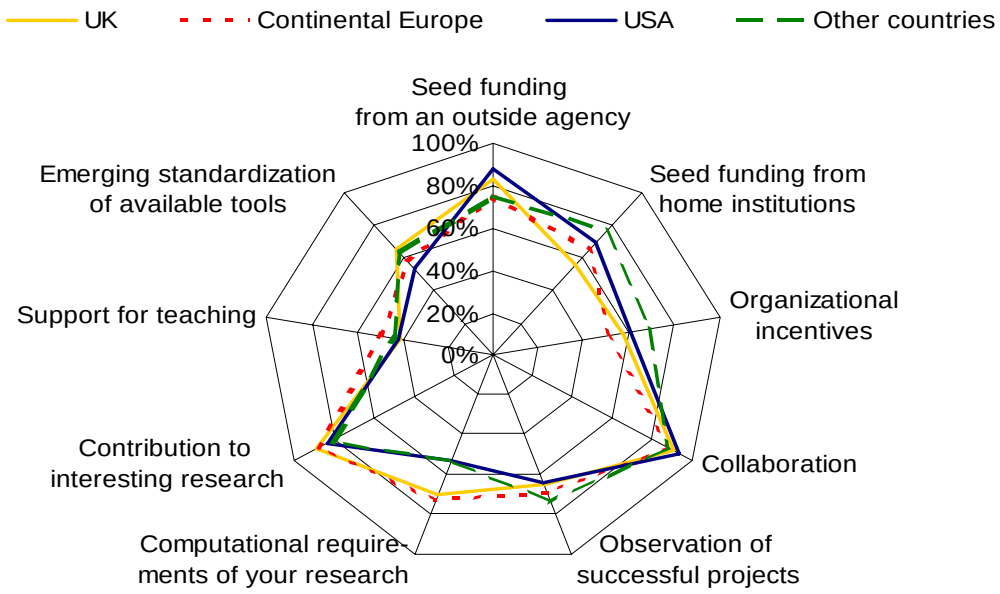
Table I: Sources of information about e-Infrastructure (in % of responses)

Source	Very important	Somewhat important	Neutral	Somewhat unimportant	Not at all important
Meetings or workshops which provided information on e-Infrastructure	29.0%	29.0%	20.8%	9.7%	11.6%
Infrastructure or administration people at your own org.	31.6%	28.2%	13.6%	11.2%	15.5%
Infrastructure or administration people from other org.	32.4%	38.1%	17.1%	4.3%	8.1%
Journal, magazine, or other printed or electronic information source	13.2%	30.4%	26.5%	12.7%	17.2%
Other scientists, colleagues, or collaborators	54.5%	32.9%	9.4%	1.9%	1.4%
Other (see annex I.4)	52.8%	2.8%	30.6%	0.0%	13.9%

Source: AVROSS WP2 survey.

Second, the respondents highlighted a number of factors as key catalysts: seed funding, collaboration, interesting research, and collaboration. Only few differences exist between different respondent and project categories. Seed funding is more important in the US and in other countries than in the UK, and least important in continental Europe. The computational requirements of the research, on the other hand, are more important in the latter regions (see figure III).

Figure III: Catalysts for e-Infrastructure adoption by country of the respondent
(% of respondents who considered this catalyst as very or somewhat important)



See table A.13 in annex I.3 on the data.

Source: AVROSS WP2 survey.

Third, the respondents identified a number of key barriers to e-Infrastructure adoption. Almost uniformly most important, regardless of discipline, length of project, and date of adoption are three factors: lack of funding, costs, and lack of qualified staff. Staff issues include the availability of qualified staff as well as the motivation and enthusiasm for the project. Budgetary issues referred to are for instance problems of obtaining long-term funding, inflexibility in managing funds and larger development costs than expected among others. Lacking information on the usefulness of the technology was more often observed by the humanities and confidentiality problems less often.

Fourth, it is essential to take the needs of users and other stakeholders into account. Early adopters frequently remarked that community-building is an important task in the realization of an e-Infrastructure project. The ability of a project to connect to a user community appears to be easier when that discipline is also represented in the project. Bridging disciplinary boundaries, above all between computer and domain scientists, is not always easy, but it is necessary and possible for advancing e-Infrastructure and beneficial for exploring new areas of knowledge. In addition, user feedback should be sought early; actually some respondents commented that tool development should be user-led to secure the uptake of the results.

Fifth, supportive institutional and scientific environments are important assets: local IT staff and university administrations, deans and senior leaders in the home organization as well as in the broader domain environment need to be more responsive to the challenges and possibilities of e-Infrastructure development.

Sixth, technological limitations of e-Infrastructure tend to be exacerbated by deficient service models of computing services as well as the reliability and user-friendliness of the technology. Flexibility of technical solutions, openness to software revisions and information exchange and mutual learning across e-Infrastructure projects are important.

Shifting the focus from individual respondents to projects we can summarize the following key findings.

e-Infrastructure projects

We found that research foundations and councils were the dominant source of funding across the board. The median project was initially funded at just over 335,000 Euros; the median annual budget was just over 122,000 Euros. The projects in continental Europe and the USA are larger than projects in the UK, both with respect to funding and staff. Scholars, survey respondents using equal amounts of working time for research and teaching, were more likely to be involved with small projects; these are also the ones with the proportionally highest scientific personnel input. Professionals, survey respondents who are mainly engaged in professional work and only little in research and administration, appear to more involved with application-oriented projects, whereas projects described by researchers and scholars are stronger in the science dimension. The administrators' projects seem to integrate both, science orientation and user focus.

The most frequently used e-Infrastructure items included communication and collaboration tools, as well as distributed data, and required high bandwidth. High performance computing, which is a feature of other sciences, was not as important, nor were the innovative data collection methods. Some level of variation was visible by country of the project: learning environments and virtual/3D environments play a larger role in US-based projects. Continental European projects more often contain data repositories, whereas videoconferencing is relatively unimportant – it is used more than twice as often in UK-based projects. The items varied also by project length: virtual/3D environments were of notably higher relevance in long-term projects, lasting for three years or longer. This is consistent with a view that the provision of interfaces for learning and practice becomes more important when the development phase is completed and the actual user involvement gets more and more critical.

Respondents reported a variety of outcomes from their projects, including publications, new methods, new data, follow-on collaborations, and new tools. They also reported a very broad user constituency ranging from 3.8 – 4.8 academic domains. Interestingly, almost all disciplinary constituencies that are reached are reached by a project that includes participants on the team with the same discipline as the user constituency. There are a number of possible interpretations of this intriguing result. It could be that projects are developed by researchers in given disciplines because they have specific disciplinary needs in mind. It could also be that researchers in a project already have a dissemination network in place that is discipline specific, and that knowledge about the project is transmitted through such disciplinary networks. These different possibilities have useful, but differing, implications for the structure of funding and should be explored in a broader scientific study.

With regard to the fields which were one of the specific focuses of the survey, archaeology, economics & business, sociology, social and economic geography/ regional science, and linguistics, we find a couple of remarkable differences indicating that the needs and practices vary across fields (see also figure IV):

- *Archaeology.* Projects with archaeology participation are very small in terms of budget (150'000 €) and personnel (14 people) and with the shortest duration. They also need much non-scientific staff. However, they are still output oriented, with three quarters of the projects indicating the existence of a user constituency and the production of publications, new methods, new data, new tools, or follow-on collaborations. When it comes to their technological profile, archaeology projects show some very specific features: high bandwidth, frequent use of virtual/3D environments and innovative data collection methods distinguish these projects from the others.
- *Economics and business.* The high scientific component – nearly three quarters of the involved personnel are scientists or graduate students – contributes to an

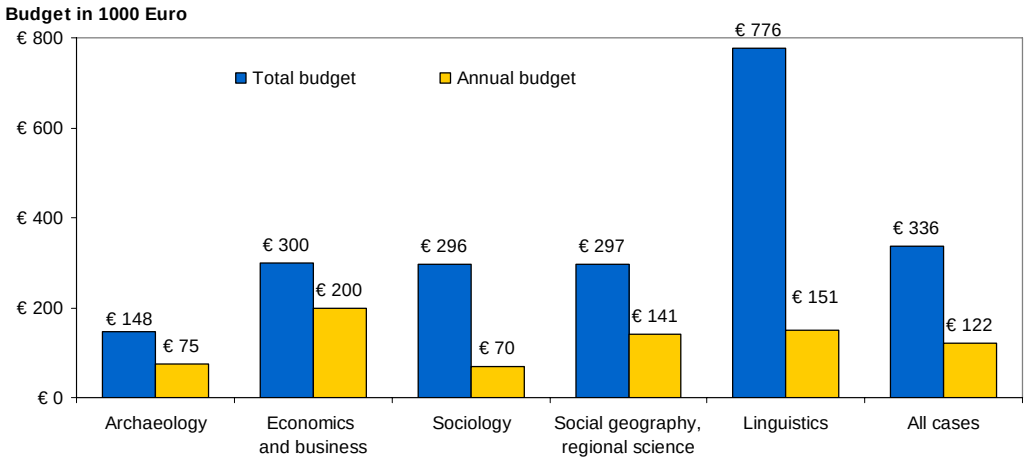
average project size of projects with economics and business participation, though the projects are of relatively short duration. Neither the technological profile nor the outcomes of these projects differ in any way remarkably from the overall dataset. However, the respondents stated notably less often that the project already had identified a user constituency.

– *Sociology.* Sociology projects have larger budgets than archaeology projects, but they also last longer and their annual budget is therefore just about as large as in the latter field. In regard to personnel they are the smallest ones (12 people on average). They use all technological items except for data collection methods less often than projects in other fields.

– *Social & economic geography, regional science.* Projects in this field are of average size and duration. Particular technological features are difficult to discern. Grid-based video conferencing sticks out as does the more frequent use of high performance computing.

– *Linguistics.* Projects in these fields are the largest in regard to budget and personnel among the fields considered. They are also the ones with the longest duration. These are their most remarkable features. Neither their technological portfolio nor the outcomes that they produce show any additional patterns. Only – like the considerably smaller archaeology projects – they also rather often said that they address a specified user constituency.

Figure IV: Average total and annual project budgets in 1000 Euro by field



Source: AVROSS WP2 survey.

Promising approaches to using e-Infrastructures in the social sciences and humanities

The second empirical contribution of AVROSS consists of eight case studies on very promising e-Infrastructure projects and initiatives in the social sciences and humanities. The cases were selected from a list of projects and initiatives obtained from the WP2 stock-taking survey, additional desk research, and interaction with e-Science experts worldwide. The selection was done through ranking the identified projects in regard to their technology, size, success, and accessibility and an informed discussion of their virtues and vices in the AVROSS study team.

Data on the cases was obtained through semi-structured interviews with developers, principal investigators, and users of the infrastructure; in addition, both published and internal project material was obtained from different sources such as the interview partners, project websites or other sites containing project descriptions and presentations. Three of the eight cases are presented in an

anonymous manner either because of institutional regulations or because the interview partners expressed the wish to remain anonymous.

Key results of these case studies are summarized below.

Technology

The main technological problems in the investigated cases resulted from guaranteeing data security and reliability of the technology. Protecting data and controlling access to it required new developments of tools and applications as these had not yet been implemented at this time in the existing middleware. Technological solutions were found when it came to regular numerical or textual data, however, for new types of data, like audio or video recordings, technological solutions for masking the identity of the recorded individuals without invalidating the recordings are less straightforward and not yet established. The second key technological constraint, the reliability and usability of the applications related to the often negative experiences of the (pilot) users when using the applications. These negative experiences resulted for instance from complex user interfaces (UI), low stability of the applications, and difficulties in integrating existing applications and standards into the new environment. Solutions to technical problems were also often sought in the technical sphere, e.g. re-designing UI, adding and re-launching applications, quality testing programmes etc. In few cases the developers and providers also engaged in training events with the users.

Too little computational power was not a general problem, though the need for more computational power was an issue in some of the projects. More computational power does not imply, however, that the approach to computing is of the same scale and mode as in the fields that currently drive grid developments in Europe, in particular high-energy physics (HEP). On the contrary, interviewees from the case studies remarked that it is very difficult to align the different approaches to computing followed by social scientists and HEP. These approaches are engrained in field-specific cultures and practices and SSH rather discontinue to use the grid and set up new or use existing small-scale clusters that serve their computational needs very well than adjust their practices in order to use the grid.

User communities and involvement

A key challenge for most projects is the formation of a user community. Only two of the investigated eight projects have large user communities at the moment. One is to some extent a special case offering free services to users of a proprietary technology and the other one managed to establish a large user community among the language researchers of the languages included in the project. Projects in early stages rely on pilot users which work with prototypes and testbeds.

The strategies for recruiting users are rather weak and little developed: projects tend to rely on what is offered by their funding or institutional environment. In some cases the developers and PIs expect that the application speaks for itself and that word-of-mouth advertising at conferences or other events will do the trick. Systematic user-user interaction as a mechanism that makes the merits of an infrastructure visible to potential users is mostly lacking. Involving leading domain scientists in the diffusion of an e-Infrastructure and forming of a user community might be another good strategy – peers and scientists in the field are the main information source on e-Infrastructure, as we learned in the early adopters' survey. This could be a mechanism to reach new users through their peers.

Funding and staff

Sustainable funding schemes are an essential ingredient to success, but in the investigated cases also mostly not yet created. Social scientists and humanities

researchers mainly demand advanced computing and support services. The success story of the Access Grid (AG) Support Centre, a duplication of room-based AG nodes every year since 2004, confirms the value of robust, resilient services to academia, in particular when it comes to supporting collaboration. An ingredient to this success seems to be that the service is offered free or close to free of charge for the users. Of course, if the users themselves don't pay, alternative funding schemes need to be found that ideally provide long-term funding to secure the continuity and improvement of the service and make sure that users' investments into a technology don't get lost. The investigated cases do not provide any guidance on possible solutions as they are still mainly funded through public research (and development) grants. As historical studies of other infrastructures such as road, rail, water, energy and telecommunication networks have shown, it was often public investment or funding arrangements that coupled private investment with public regulation that led to the establishment of a network (Edwards, Jackson, Bowker, & Knobel, 2007).

The recruitment of staff was not a problematic issue in the investigated cases. Training activities are carried out only informally and on the job if at all. Only one project is an exception offering regular and more formal training courses for its staff. Similarly, the inclusion of graduate students is not institutionalised (see below).

Relationship to established practices

Some of the investigated cases encountered problems either in regard to existing practices and the culture within their field or in regard to aligning the demands from the interdisciplinary collaboration with tool developers with the established routines. One example for the conflicts that might be created stems from the necessity to share data, methods or other products: this was considered less problematic and more in line with established research practices in the humanities cases than in the social sciences cases. The latter encountered problems stemming from data privacy and access restrictions, high costs of producing metadata and making data usable for third parties, or no tradition of sharing at all. These problems are not superficial and point to slow processes of change that need to take place before new sharing practices become accepted.

Another issue that is also not solved in any of the reported cases is the appropriate compensation for tool developers, data producers, or methodical contributions. The assignment of academic credits and rewards for such tasks is not common in SSH. Though some of the interview partners were aware of the disincentives that might result from this for e-Infrastructure development, they did not propose, not to mention implement any solutions in their projects.

The handling of problems of communication and collaboration across disciplinary borders was more sophisticated, possibly as these were more pressing and disrupting project progress. The problems appeared in particular in the communication between developers and principal investigators or users, or when applications developed for other fields were meant to be transferred to SSH without taking their particularities into account. Our cases also developed or proposed solutions, like micro-teams of developers and domain scientists, institutionalised collaboration, or engaging "translators".

Impact on research and learning

Leaving behind the quite ambitious visions, we see that the actual impact of the investigated cases on research and teaching has been in most cases rather modest. This can partially be explained by the fact that some of the projects are still in an early phase of development. As a matter of consequence their research-related impacts are limited to raising interest in the field, establishing relationships

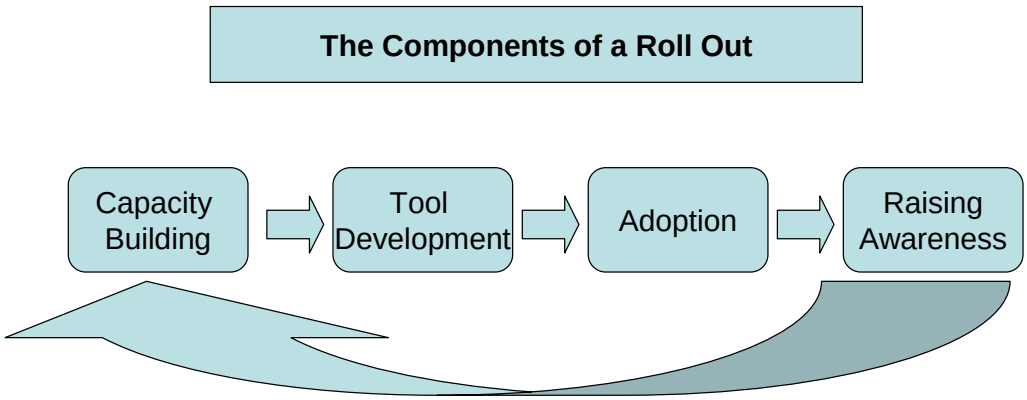
to other projects, or involving pilot and test users. Moreover, some leave traces in other ongoing e-Infrastructure development activities. However, this cannot hide the fact that making a measurable impact on the field is actually one of the main challenges for any e-Infrastructure project in SSH. Publications are the key output measure in SSH as in other academic domains. Because data sources and tools are still rather neglected in research publications, it will be difficult to prove the impact through this channel.

The connections to teaching and learning activities are not very well developed in any of the investigated projects. Graduate students were mentioned as users in some projects; however, except for one project, they do not receive special attention, for instance through courses that teach the use of the infrastructure.

Policy recommendations

We note that any roll out that requires domain scientists to take up a new approach has several separate components that each independently need to be successful. These include (see figure V):

Figure V: The components of a roll out of e-Infrastructures in social sciences and humanities



Source: AVROSS

1. Capacity building for e-Infrastructures in the social sciences and humanities: the base of motivated scientists and skilled technicians trained on e-Infrastructures needs to be broadened through education and training – with an important role for CSCL – and funding needs both, to take the specific demands of SSH into account and to move on to sustainable funding schemes.
2. Developing appropriate tools: Tool development must be done in close, permanent and effective interaction with the users. Use barriers are lower if users are familiar with tools which “only” have been ported on the grid environment; standardisation raises the confidence in sustainability.
3. Fostering the adoption of the approach by domain scientists: Incentives need to be given and barriers that hinder adoption need to be reduced. Such incentives should be instituted in funding schemes – e.g. to reuse existing data and make new data available through repositories – and become part of SSH research practice, for instance in publishing and evaluation. Barriers require at least as often organizational solutions as they require technical solutions, for instance when it comes to reducing the language barriers between technical developers and domain scientists.
4. Making domain scientists aware of e-Infrastructures: Awareness needs to be raised above all through demonstrating the benefits of e-Infrastructures. This is most effectively done through field-specific information channels and

between peers. Institutional environments, of course, need also be responsive to the pay-offs of e-Infrastructure investments. Last but not least, the knowledge on what type of infrastructure and support SSH researchers actually need and where they stand in the adoption process needs to be broadened (also raising awareness in the process of doing so).

We propose a set of measures in each of these four components which are summarised in the table below.

Table II: Overview of policy recommendations

Capacity Building	Tool development	Adoption	Raising awareness
1. Develop dedicated training events for SSH 2. Step up the role of e-Infrastructure in graduate education 3. Increase the use of CSCL environments 4. Support small-scale initiatives 5. Design effective funding and programme coordination structures 6. Fund field-specific flanking measures in general, multi-disciplinary e-Infrastructure programmes 7. Support the development of service-oriented business models	8. Involve users at all stages 9. Mandate user-centred design 10. Port existing SSH tools to e-Infrastructures 11. Target vertical areas to ensure tool adoption across sub-fields 12. Support standardisation	13. Institute activities to promote the reuse of SSH data 14. Assign scientific credit and ownership rights 15. Reduce technical barriers through providing organizational solutions 16. Promote understanding of SSH among IT specialists 17. Improve cross-disciplinary communication and collaboration	18. Create supportive institutional environments 19. Increase user-user interaction 20. Increase the information exchange across projects 21. Involve lead users in community-building 22. Institute an ongoing analysis of computational needs and resources in European SSH 23. Institute an ongoing evaluation program with scientific analysis of adopters and non adopters

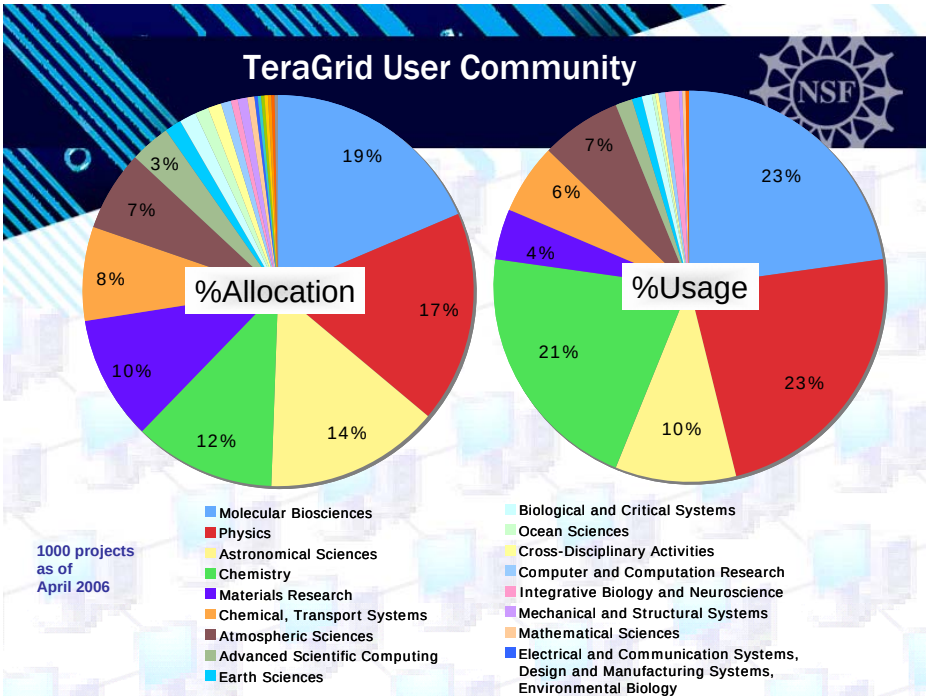
Source: AVROSS.

1. Introduction

1.1 Current e-Infrastructure use in the social sciences and humanities

In a 2006 presentation[1] Charlie Catlett, the Director of TeraGrid, showed the usage by different disciplines of the TeraGrid, a large scale project to integrate high-performance computers, data resources and tools, and high-end experimental facilities around the United States (see Figure 1.1). Neither social sciences nor humanities are mentioned in the figure. A few months older, from November 2005, is the overview assembled within the GridCoord project (http://www.gridcoord.org) listing Grid related projects within FP5 and FP6 as well as national level projects from France, Germany, Hungary, Italy, the Netherlands, Poland, Spain, Sweden, and the UK. Applications in the social sciences and humanities are also virtually absent in Figure 1.2.

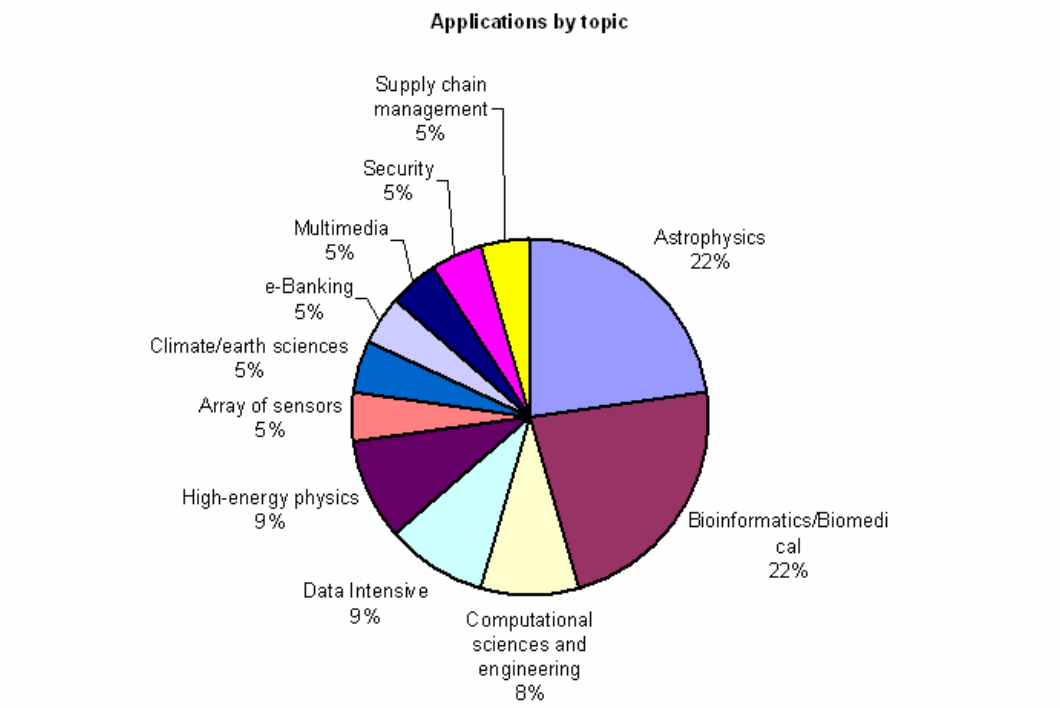
Figure 1.1: TeraGrid user community



Source: Catlett, 2006

[1] TeraGrid All Hands Meeting, June 13, 2006.

Figure 1.2: Grid applications by topic



Source: Vanneschi, 2005, p. 8.

By and large, in Europe and in the United States social scientists have yet to adopt and use grid technologies and high-speed networks. This is also documented in several reports undertaken on behalf of the National Centre for e-social science (NCeSS) in the UK[2] and the National Science Foundation (NSF) in the United States[3].

1.2 Definition of e-Infrastructures in this study

The focus of our approach is to shed insight into the reasons behind the low level of adoption of the e-Infrastructure concept in the social sciences. For the purposes of this study we adopt the e-Infrastructure definition promoted by the e-Infrastructure Reflection Group (Leenaars, Heikkurinen, Louridas, & Karayannis, 2005). They use a rather broad understanding of e-Infrastructures as "integrated ICT-based Research Infrastructure" (ibid., p. 9). It consists of several components including networking infrastructures, middleware and organisation and various types of resources (such as super computers, sensors, data and storage facilities). This definition includes "old" components like supercomputers, the World Wide Web, or e-mail, but also takes a new perspective and considers them as an integrated system (see Figure 1.3).

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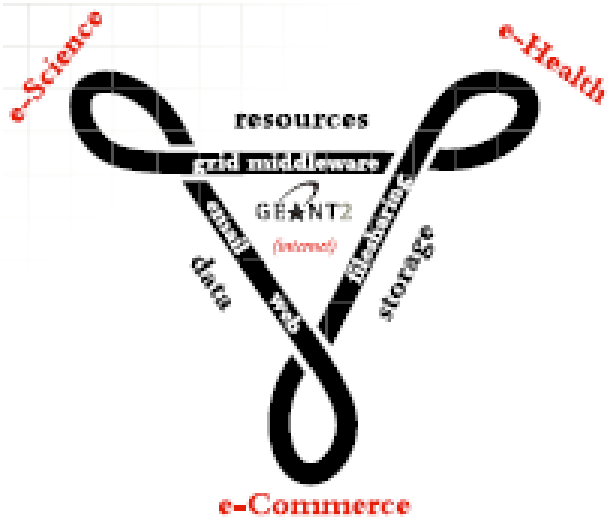
[2] E.g. the Economic and Social Research Council's "e-science and the Social Sciences Framework Document" (http://www.esrc.ac.uk/ESRCInfoCentre/Images/Escience%20Background%20Information_tcm6-5783.pdf), the development of an "Awareness and Training Environment for e-social science in the UK" (http://www.jisc.ac.uk/whatwedo/programmes/programme_eresearch/project_redress.aspx), JISC's e-Infrastructure programme plan (www.jisc.ac.uk/capital_einf.html), and NCeSS's successful e-Infrastructure for the Social Sciences proposal (http://www.ncess.ac.uk/research/hub/einfrastructure/).

[3] E.g. Berman & Brady (2005), the workshops on cyberinfrastructure organized by NSF in the fall of 2004, the 2005 NCSA workshop on social networks and cyberinfrastructure, as well as the Atkins report (Atkins et al., 2003) and the NSF's Cyberinfrastructure Council's "Cyberinfrastructure Vision For 21st Century Discovery" (National Science Foundation [NSF], 2006).

Figure 1.3: A schematic overview of e-Infrastructure components



Source: Leenaars, Heikkurinen, Louridas, & Karayannis, 2005, p. 10.

The networking infrastructure such as GEANT and the NRENs are at the centre of this system supporting scientific communication, collaboration and special uses (which include the grid and distributed supercomputing). The next layer is symbolized by the black triangle; it is the level of protocols which permit the sharing of information and tasks between the distributed resources. These resources cover everything that is of interest to science from computers, storage facilities, telescopes, or satellites to data collections, artificial intelligence agents and others – data and storage are listed as examples in figure 3. The only requirement for any resource is that it should be able to exchange information at some point through a standardized interface like a grid protocol. The middleware connects the distributed resources in a seamless way. The application domains are shown on the outside of the figure in red to exemplify the parties served by the e-Infrastructure. In our case the focus will be on the social sciences as the user community.

We are particularly interested in understanding how to optimize the use of Grid and GÉANT developments, firstly by providing an analysis and assessment of the current patterns of use and secondly by providing guidance on how e-Infrastructures may be better deployed and exploited, notably by the social sciences and humanities research community. We believe that it is essential to provide a forward looking analysis to develop scenarios based on real trends in the evolution of e-Infrastructure applications.

1.3 Contents of this deliverable

This deliverable is the fourth and final report within the AVROSS study. It consists of three more chapters and several appendices:

The second chapter presents the theoretical framework of the analysis. For this purpose we reviewed the literature on social shaping of science and technology, together with published work and other available documents on disciplinary and country-specific approaches, and documents on e-Infrastructures, technologies, applications, and projects.

Chapter three contains the methodology and results of an exploratory survey among close to 2000 individuals who can be considered early adopters and enthusiasts of e-Infrastructures in the social sciences and humanities. The survey covered four fields in the social sciences and humanities (computer linguistics, economic and social research, archaeology, geography and regional science), but also several projects from other SSH fields in Europe and beyond.

In chapter four we present eight case studies of promising initiatives to using e-Infrastructures in SSH fields. The cases were described on the basis of interviews with key players and published and internal material. The chapter is concluded with an extended cross-case comparison.

Chapter five presents the policy recommendations which are based on the empirical work in AVROSS – the early adopters' survey and the case studies – as well as on other recent literature in the field.

2. Theoretical framework of the study

2.1 Different models of technological innovation

The theoretical framework that we developed had to be broad enough to encompass the different influences on providers and users and structure the empirical work. Social studies of technology and science provide several starting points for such a model.

Deterministic models focus on the social changes caused by the introduction of a new technology. They have a dynamic perspective on society and consider technological innovation and organisational change as a process of adoption to environmental conditions (McLoughlin, 1999). In these models technology is seen as an exogenous variable that is not influenced by social actors. Consequently, technological determinism is frequently criticised for underestimating the complexity and malleability of technologies (Edge, 1995). The decisions of inventors, investors, or early users that invariably are observed to shape any new technology or application are largely ignored in deterministic approaches. This was in evidence, in particular, in respect of advanced information and communication technologies, like multimedia applications and broadband, in their early stages (Williams, 1997). Moreover, technological determinism is accused of oversimplifying the relationship between technology and users by overstating the transformative power of technologies (Edge, 1995; McLoughlin, 1999). Technology generation, introduction and diffusion are wrongly conceived as linear processes.

Opposing the deterministic conceptions of the relationship between technology and society and replacing the linear model by evolutionary perspectives, a set of alternative models has been developed that can be summarised under the notion of *"social shaping of technology" (SST)*. The overriding strength of these approaches is that they ask how "technology" comes to be "technology". Common characteristics are that they do not conceive of technology as exogenous, or fixed by "nature" alone, but shaped also by non-technical factors. Social shaping describes the developmental process of a technology as an alternation of variation and selection. The linear order of invention, innovation and diffusion is disrupted in social shaping studies. An innovation is not considered as a fixed product, process or organisational configuration that is diffused if it matches the requirements of the potential adopters as in diffusion studies (Rogers, 1995). Rather, SST highlights that a new technology will still be shaped and reconfigured during innovation and diffusion:

> *"A social shaping perspective, however, focuses on the ongoing dynamic between a technology and a community, as the technology is developed, used, shaped, reconfigured, and reconstituted within the community." (Kling & McKim, 2000, p. 1311)*

Thus, a major contribution of SST approaches to the analysis of technological innovation is that it brought the users back into the picture. The users are not seen anymore as mere adopters of a fixed product, but they are influential constituents (Molina, 1997) whose needs and requirements are incorporated into the technology (Fleck, 1994; Fleck, Webster, & Williams, 1990). The importance of user-supplier interactions has been particularly demonstrated in IT innovations (Williams & Edge, 1996).

A very similar theory, namely the *social construction of technology* (SCOT) approach, also focuses on the social influences of technological innovation. It perceives the latter as the outcome of an ex-ante multidirectional process, from which a specific solution is selected through processes of negotiation and re-negotiation between the relevant social groups (Pinch & Bijker, 1987). The

members of these relevant social groups, institutions, organisations, organized or unorganized groups of individuals, share the same set of meanings in regard to the innovation. However, between the groups dominate different meanings and interpretations of the technology ("interpretative flexibility") (R. Kline & Pinch, 1999). They perceive the strengths and problems differently which leads to conflicts about the right solution. For instance, in the early days of the bicycle there were different requirements in regard to speed and safety by young men and women (Pinch & Bijker, 1987). Some of these conflicts might be solved through new technical solutions, e.g., in the case of the bicycle the pneumatic tire that increased speed and safety at the same time, whereas others might lead to a differentiation of products. Then, the innovation becomes stabilized, at least as long as no new problems and conflicts appear on the scene.

However, the social constructivists have been criticized for social one-sidedness:

> *"...in explanations of technical change the social should not be privileged. … Other factors – natural, economic, or technical – may be more obdurate than the social and may resist the best efforts of the system builder to reshape them. Other factors may, therefore, explain better the shape of artifacts in question and, indeed, the social structure that results." (Law, 1987, p. 113)*

In *actor-network theory* (ANT), developed by scholars like Michel Callon (1986, 1991), John Law (1987) and Bruno Latour (Akrich & Latour, 1992), this prioritisation of the social is opposed and all components of a network – texts, technical objects, human beings, or money – are considered as potential actors. What makes an actor an actor is its capacity of transforming and creating network components: for instance, the Chernobyl nuclear power plant became an actor that transformed the lives of millions of people and animals all over Europe (Callon, 1991). As the Chernobyl example clearly shows, the transformation is often not in line with the components' own "will" and it requires "heterogeneous engineering" (Law, 1987) to combine unhelpful components into self-sustaining networks.

From the perspective of actor-network theory, the invention, innovation and diffusion of a technology is the result of a co-evolution of the network, at times driven by human actors, at times by machines, written texts or other actors. The technology will be implemented and diffused if actors build a supporting network that is sufficiently strong to overcome all the barriers (Law & Callon, 1992). In the innovation process, the technology will be continuously shaped and adapted (Latour, 1986).

The next section will explain how these different models of technological innovation informed the current study on the adoption of e-Infrastructures in the social sciences and humanities.

2.2 The social shaping of e-Infrastructures

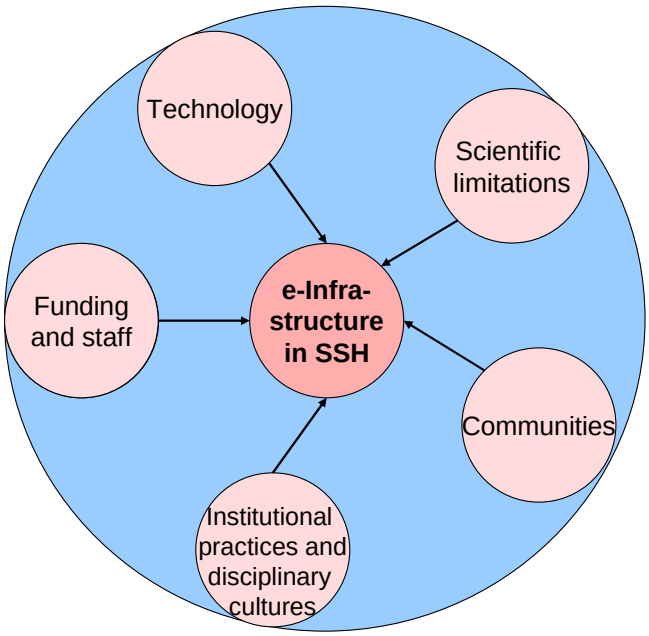
SST theorists highlight the social determination of technological innovation using a broad conception of 'social':

> *"It is becoming increasingly clear that the answers to these shaping questions - the factors influencing the rate, directions and specific forms of technical change - are social as well as technical. The evidence for this is overwhelming: economic, cultural, political, and organisational factors - all of which we subsume in the term 'social' - have been shown to shape technological change." (Edge, 1995, p. 15)*

Edge (1995) goes on to list in total eight types of social influence on technological change: geographic, environmental and resource factors; scientific advance; pre-existing technology; market processes; industrial relations concerns; other aspects

of organisational structures; state institutions and the international system of states; gender divisions; and cultural factors. MacKenzie and Wajcman (1999) include scientific, technological, economic, and state-related influences in their overview of social shaping. Williams and Edge (1996) distinguish between social, institutional, economic and cultural factors that shape the direction and rate of innovation, the form of technology, and the outcomes of technological change. It is not crucial whether a particular influence is pegged as technological, cultural, or scientific, as all are considered to be in some extent socially shaped if not determined. Based on the theoretical work and previous empirical analyses of technologies, in particular IT and e-Infrastructures in the sciences, we differentiated between the following influences:

Figure 2.1: Social shaping of e-Infrastructures in the social sciences and humanities



Source: AVROSS.

- Technological frames and communities: Technological paradigms of developers and users which are shaped by the capabilities of previous technologies and the demands of the user communities constitute an influential frame on which the introduction and spread of e-Infrastructures takes place. Technological constraints limit the extent to which user needs can be implemented.
- Scientific shaping of technology: Scientific progress for instance in computer science and computer linguistics is still a pre-condition for producing applications for the social sciences and humanities and dealing with confidentiality and privacy problems which are particularly virulent in the social sciences.
- Funding and staff: In addition to funding needs for the sustainable development and provision of e-Infrastructures there are other resource-related issues: learning costs, availability of qualified staff, and training of personnel and prospective users on the capabilities of the technology.
- Relationship to institutional practices and disciplinary cultures: Technologies may have inbuilt political purposes and the activities of political institutions and intermediaries – in science for instance research and higher education ministries, research foundations, scholarly societies – shape their spread and use. Moreover, they need to be integrated into proven work routines,

institutional practices and disciplinary cultures which requires functioning cross-disciplinary communication and collaboration between engineers and domain scientists.

Of course, any particular technology decision is likely to be driven by a combination of these factors. However, the classification does serve to reduce the complexity of the model to some extent. The following sections will discuss each of these factors in some more detail.

2.2.1 Technology and user communities

One of the key arguments of SST is that a new technology is not a black box which has fallen from heaven into the hands of an expectant user community, but is shaped by the demands of the users and that relationships between social groups, material objects, and other components of the network are crucial in the innovation process. The idea that a new technology is typically a result of sudden inspiration and discovery is rejected by the social shaping theorists (MacKenzie & Wajcman, 1999). In their opinion, a gradual development takes place in which an existing technology is changed, improved, re-designed, adapted to new needs, etc. This development takes place, however, within the context of a "technological frame" or paradigm that determines what the involved social groups perceive.

> *"A technological frame is composed of, to start with, the concepts and techniques employed by a community in its problem solving. … Problem solving should be read as a broad concept, encompassing within it the recognition of what counts as a problem as well as the strategies available for solving the problem and the requirements a solution has to meet. This makes a technological frame into a combination of current theories, tacit knowledge, engineering practice (such as design methods and criteria), specialized testing procedures, goals, and handling and using practice." (Bijker, 1987, p. 168)*

In other words, the features that developers bestow on a new technology are influenced by what they perceive as feasible and desirable. This perception depends on the capacities of previous technologies which are used for the same or similar purposes, as technological development does not take place in a vacuum. The degree of innovativeness of a technology, whether it constitutes a radical or "just" an incremental innovation, will influence how much opposition it raises and whether and to what extent it is implemented (Molina, 1997).

Moreover, what a particular technology does also depends on its systemic character. Williams (Williams, 1997; Williams & Edge, 1996) distinguishes discrete and integrated applications in information technology: Discrete applications are subject to highly fluid and uncertain innovation processes and designed to fit existing work organisations and specific objectives for changing them. Integrated applications, such as computer-integrated manufacturing (CIM), are more complex configurations which consist of packaged systems that need to be customised to the situations into which they are introduced. Hence, for discrete and integrated applications the degree and point in time of user involvement during the development process differ.

This relates to another perspective on technological innovation for which Fleck has coined the term "innofusion", the concurrent realization of innovation and diffusion (Fleck, 1988). Technologies resulting from innofusion are configurational technologies, complex arrays of technical and non-technical components which need user input to obtain working status (Fleck, 1994). Good examples in case are highly usable sharing environments such as mySpace or myTube, i.e. the emergence of "Web 2.0". They are clearly showing the power of social processes in shaping web products in the consumer segment. In our study environment,

research communities in the social sciences, rights and opportunities for sharing of content and the usability of shared tools are also playing a role in innofusion.

All these concepts have in common that the functional characteristics, the degree and the quality of task-fulfilment, of a new technology are judged not on technical grounds, but in relation to affected social groups, in particular among the developers and users, as well as in relation to other components in its socio-technical network, like the existing "old" technology and other elements of an integrated technological system. The key message here is that the best technical solution is not necessarily the appropriate solution of a problem. Second or third best technologies might be superior in the light of the surrounding conditions.

This is not to say that such factors have not been ignored altogether by developers of e-Infrastructures. Many of the prototype tools and services generated within e-Infrastructure programmes have benefited from the close involvement of committed groups of users. This has contributed enormously to understanding user requirements and to the evaluation of prototypes. However, the involvement of committed users is not, in itself, sufficient to ensure that these prototypes are ready for deployment more widely. First, requirements identified by these users may not be representative of the requirements of the wider user community. Ways of doing research may vary, not only between disciplines but even between groups of researchers working within the same discipline. Hence, prototype tools and services are likely to privilege the needs of those users who were involved in their development. Expecting other researchers to accept these as their own is unrealistic and likely to be an obstacle to wider adoption. Second, early adopters may be more tolerant of limitations in new tools and services, being prepared, for example, to work around 'bugs', or to cope with poor usability. This raises the question of how prototype tools and services can be 're-factored' to meet the requirements of the wider user community. Where tools and services offer significant innovations over existing work practices, requirements are liable to evolve rapidly as users undergo a process of learning how best to exploit these opportunities. In some cases, new requirements may emerge as novel applications are found for tools and services. It is important also to examine, therefore, the social organisation of e-Infrastructure development. It might be of key importance whether this is managed so as to ensure the continued, close interaction between users and developers essential for effectively tracking and responding to changes.

2.2.2 Scientific shaping of technology

The idea of a linear succession from basic research to the market, via applied research, technical development, production and marketing has since long been abandoned in the sociology of technology (Edge, 1995; MacKenzie & Wajcman, 1999) as well as in evolutionary economics (Kline & Rosenberg, 1986). Though some technological areas might be driven very much by science, e.g., for biotechnology (Owen-Smith, Riccaboni, Pammolli, & Powell, 2002; Zucker, Darby, & Brewer, 1998), the influence of science on technology is generally seen as limited. Science and technology are rather considered as interlinked activities (S. J. Kline & Rosenberg, 1986), where science might benefit from technology as much as the other way around (Brooks, 1994; MacKenzie & Wajcman, 1999).

However, the analysis of the (potential) use of e-Infrastructures in the social sciences should not be blind in regard to the influences of science – in particular computer science – on technology development. There are several issues here. The first issue is the question of whether the 'state of the art' in computer science limits how social scientists might benefit from the availability of e-Infrastructure. The straightforward answer to this question is 'yes'. On a mundane level, the seamless access to resources promised by the e-Infrastructure vision has yet to materialise. This certainly has impacts on all potential users but, arguably, these are greater for those in the social sciences and humanities who are generally less technically

proficient at making good the 'gaps' in the realisation of the e-Infrastructure vision. The challenge to the achievement of seamless access is to be able to represent in some formal and machine processable form descriptions (i.e., the semantics) of e-Infrastructure services and resources so that they can be made discoverable and composable without users having to grapple with the complexities of their underlying implementations. The realisation of the so-called 'Semantic Grid' remains core computer science research, specifically in the development of tools (both conceptual and practical) for knowledge management (De Roure, Jennings, & Shadbolt, 2001).

In relation to the research agendas within social sciences, while these are quite diverse, advances in computational linguistics will be fundamental to the development of more effective tools, such as text mining, for data analysis. Another major result of the advances in e-Infrastructure could be the expansion of the ability of social scientists to collect information from a wide variety of different sources, as well as measure human behaviour in very different ways. One of the reasons that social science research has produced "softer" results than research in physical sciences is that in the latter disciplines, molecules don't have minds of their own and make decisions by themselves. The new capacity that e-science offers social scientists to measure human minds and human decision-making – to go beyond simply numerical representations to visual and textual information to describe human behaviour – is potentially transformational.

Thus, although data collection on individuals and organizations has historically consisted of either survey based or administrative data, e-Infrastructure advances might fundamentally change the way in which scientists are collecting information and modelling human behaviour. Indeed, a recent National Science Foundation solicitation, entitled "Next Generation Cybertools" noted that new ways have been developed to improve both domain-specific and general-purpose tools to analyze and visualize scientific data – such as improving processing power, enhanced interoperability of data from different sources, data mining, data integration, information indexing. And a calculation at the recent NSF supported workshop[4] about how many terabytes of data would be necessary to capture an entire life on video found that if the life were recorded on low web video, at 50 kbits/sec, the total space required would be 15TB. Even with DVD quality recording, at 5Mbits/sec, the total storage would only be 1500TB. Clearly, an entire life can now be captured and stored on existing media. Indeed, academic social scientists could increasingly use these tools to combine data from a variety of sources – including text, video images, wireless network embedded devices and increasingly sophisticated phones, RFIDs[5], sensor webs, smart dust and cognitive neuroimaging records.

The opportunity has been taken up in some cases – examples in the social science disciplines of successful archiving and data dissemination projects include:

- The Allele Frequence Database (ALFRED) (see http://alfred.med.yale.edu/alfred/index.asp);
- Matlab (see http://www.mathworks.com/products/matlab/);

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[4] SBE/CISE workshop, Match 15-16 2005, http://vis.sdsc.edu/sbe/About

[5] Radio frequency identification, or RFID, is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it (see http://www.rfidjournal.com/article/articleview/207).

- the Inter-University Consortium for Political and Social Research (ICPSR) (see http://www.icpsr.umich.edu/); and
- the Linguistic Data Consortium (see http://www.ldc.upenn.edu/).

Data curation and privacy & security issues are problems which are particularly critical when it comes to sharing data related to human beings, as is usually the case in the social sciences and humanities. In the US, Federal statistical agencies have devoted substantial resources to both statistical and technical ways to protect confidentiality (Doyle, Lane, Zayatz, & Theeuwes, 2001); the Social and Behavioral Research Working Group recently drafted a report entitled "Achieving Effective Human Subjects Protection and Rigorous Social and Behavioral Research" (Unpublished working document) for the Human Subjects Research Subcommittee of the Committee on Science, National Science and Technology Council; PITAC recently issued a report on cybersecurity that addressed some confidentiality issues and there have been numerous studies undertaken by the National Academy of Sciences and the Committee on National Statistics (Bradburn & Mackie, 2000). Last but not least, there are huge challenges posed by the collection, indexing, archiving, curation, and preservation of the new types of data that can be collected. In other words, realizing the remarkable potential of data requires not only that they be preserved, but also that they be discoverable by others (using various search tools) and available in a usable format, including essential metadata describing the nature, quality, and history of the data.

2.2.3 Funding and staff

The role of costs and benefits or future costs and future benefits (MacKenzie & Wajcman, 1999) certainly exerts an important influence on the shape and success of an innovation in market economies. Costs of development, market introduction, and production, return on investment, expected sales price compared to older technologies and competing solutions are all economic categories which influence the decision of the involved groups in an innovation project. For instance, Law and Callon (1992) describe nicely how the high – and over the project duration continuously increasing – expected total development and production costs of a new military aircraft, the TSR2, raised substantial opposition among different actors in British government. In the end, economic reasons like the high costs, failure of securing overseas markets, and the availability of a cheaper alternative contributed together with other arguments to the cancellation of the project.

The users of e-Infrastructures are often confronted with high learning and installation costs for new computer applications and unclear returns on making these investments; they have multiple needs in regard to computers and their use in their professional communication and cooperation and they have to deal with different communication situations; they work in different organisational settings and financial arrangements; they are subject to pressures and demands from peers (and students) on the channels to be used for communication, endorsed research practices and methods, acceptable data and information sources, etc. In addition, there is likely to be under-investment and under-valuation of the human capital aspects of investment in e-Infrastructure, both because not enough attention is paid to securing continuity of key personnel and because inadequate resources exist to fund the documentation of software and practices for their use that can be used to aid continuity. US and UK scientists have expressed substantial concern about sufficient numbers of trained individuals for the full exploitation and maintenance of e-social science investments.[6] The e-IRG proposes to increase efforts in the training of scientists and computer support personnel on working with grid

[6] Unpublished summary reports NSF/SBE cyberinfrastructure workshops Sept 18, 2004 and Oct 22, 2004; survey results from ESRC review of NCeSS hub, 2005

environments (Leenaars, et al., 2005). Extensive thought needs to go into devising the most effective management for e-Infrastructure projects. A cadre of paraprofessionals may be needed to supplement Ph.D. researchers. It was noted that the actual learning of the new technologies is not time consuming; rather, it is their adaptation for specific uses in the laboratory that requires great amounts of (expensive) principal investigator time.

The producers of e-Infrastructures are particularly affected by standardisation and resulting network economies. There are several examples in the history of computing in which the development of an industry standard either in relation to hardware, e.g. personal computers, microprocessors, or software, e.g. operating systems, human computer interfaces, provided a decisive push in the diffusion (Williams, 1997). An industry standard triggers two attractive consequences for the technology producers: First, the existing users of a technology benefit from additional users because of network externalities and the customer base for this technology grows. Second, a large customer base creates economies of scale and makes mass production possible. Then products and ideas diffuse via social networks through a domino effect. Early adopters ease the adoption for less innovative second movers. This again helps others and the innovation spreads gradually. At a certain point the process tips and the innovation spreads explosively, turns into an “epidemic”. The introduction of mobile phones in the mid 90’s is a good example. More and more people needed to be reachable when away from a fixed line; it became fashionable to communicate through mobile phones; they became the standard communication device in certain contexts.

We examine the role of technology diffusion through social networks, arguing that these reduce learning costs, enhance usability and sustainability and create a social incentive structure. The role of economic incentives in technology adoption has been clear since Griliches’ (1957) analysis of the adoption of hybrid corn in developing countries. However, sociologists have long argued that social networks provide important ways in which technology is diffused, and in the hybrid corn debate, Griliches acknowledged the importance of such networks: “If one broadens my ‘profitablity’ approach to allow for differences in the amount of information available to different individuals, differences in risk preferences, and similar variables, one can bring it as close to the ‘sociological’ approach as one would want to.” (Griliches, 1962, p. 330, cited in Skinner & Staiger, 2006).

Standardisation could also solve a major issue which hampers adoption of new technologies, namely the concern by (potential) users about the sustainability of new tools and the resulting interoperability. This is, of course, a fundamental issue in e-science more broadly. In order for social scientists to invest time and energy in e-social science, they need to be convinced that the tools that they are using will not become rapidly obsolete. For example, in the United Kingdom the very successful initial Pilot Demonstrator Project, SAMD (http://www.sve.man.ac.uk/Research/AtoZ/SAMD), which has been used as a flagship example of the value added of e-social science, is built on a platform that has since become obsolete. The successor project has essentially had to start from scratch because the new platform is not compatible with the earlier one. A related issue, which has also been raised in the United States, is that the successful development of middleware requires a support infrastructure that is beyond that envisaged by initial grants. Of course, hardening and sustaining research products is difficult because products are heterogeneous, the process is costly, and researchers are trained to break new ground, rather than sustain existing projects.

2.2.4 Relationship to institutional practices and disciplinary cultures

Another important group of factors that influence technology development and adoption stem from the routines and practices that have been established over the years in the institutional and field environments. New technologies need to connect

to institutional and field routines, practices, and cultures. They also have to bridge them whenever knowledge of different types needs to be combined and they need to create cross-disciplinary exchange and understanding.

Matching between technical capacities and surrounding conditions. In a recent study Wouters and Beaulieu (2006) argue that e-Infrastructures are not (yet) conceived in a way that permits their integration into the particular culture, habits, customs and organisational setting of fields in the social sciences and humanities. They speak of a "misalignment between the emerging e-science community and other scholarly communities" (ibid., p. 62) and exemplify this by comparing the research practices and social relations in a particular social science field (women's studies) with the current offerings of e-science. They conclude that e-science initiatives are still too much driven by computational research and the production of infrastructures for large-scale data and computation, and that a different turn to e-science should be considered: starting at the analysis of different research fields, with particular research practices, communication and collaboration relations, and a specific social organisation to find out how their differing needs can be supported by new ICTs.

This work is in the tradition of earlier work that stresses the influence of the cultural particularities of a field on how the internet is used. The importance of differing work organizations and social structures as well as the external relations determine in Walsh and Bayma's (1996) study how the internet is used by mathematicians, chemists, experimental biologists and physicists. Kling and McKim (2000) show that field-specific constructions of trust and of legitimate communication influence whether and in what particular way e-publishing has become part of the communicative forum: Whereas high-energy physicists quickly adopted the arxiv.org e-print server as a central communication channel, some fields in computer science have established pure electronic journals, and molecular biologists rely on digital databases and shared digital libraries (like PubMed Central). Taking the case of a humanity field, namely corpus-based linguistics, Fry (2004) has highlighted that cultural elements exert a strong influence on the uptake and use of ICTs.

Political considerations. Winner (1999) provides several examples for technical solutions that are not primarily shaped by a technological paradigm or efficiency considerations, but consciously by political goals or subconsciously by a lack of consideration or awareness: the low height of bridges in New York intended to keep public transport and thus poor people and minorities out of certain areas; inefficient moulding machines that had the only advantage that they could be run by unskilled labour were used to destroy the union influence in a firm; the 1970s movement of handicapped people made society aware of the design deficiencies of many technologies for handicapped people and the resulting social exclusions.[7]

Political shaping in this sense means that arrangements and considerations of authority and power influence the form that a technology takes. Concerning e-Infrastructures in particular political considerations of different players in science policy like universities, sponsors of research and research infrastructure (like science foundations, research ministries and the European Commission), publishers, scholarly societies and others should be taken into account. Past initiatives at national level on promoting e-Infrastructures in the social sciences and humanities in the US and the UK certainly contribute to the fact that both countries are currently at the forefront of the discussion on e-Infrastructures. Publicly sponsored actions, like the building of demonstrators and prototyping of ways of

[7] However, Winner (1999) makes clear that technologies can also induce certain social conditions; for instance, nuclear power plants require a hierarchical management and control system, due to their health and security risks.

making e-Infrastructures more usable and deployable contributes to their spread in the UK. Because the evaluation and maintenance of data tools and products are both costly and not a natural part of research culture, they are unlikely to happen without a coordinated strategy to develop a critical mass of resources and appropriate incentive systems. The principal near-term opportunity is to survey existing mechanisms of hardening and sustaining e-Infrastructure at various levels and test the most promising approaches. Possible examples of successful hardening might be found in the US Digital Government program (see Burton & Lane, 2005, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5459).

Academic production function. In terms of the basic unit of analysis, we think of each individual academic as operating like a firm that tries to maximize individual academic profits. This is a classic constrained optimization problem in which output is a function of inputs such as time, labour resources, and computational resources, and the cost constraint is described by prices of each input. In this very oversimplified framework, academic ability is the capacity to convert these inputs into outputs, where again, in simplified terms, output is the standard academic currency: the quality of refereed academic publications (as measured by a variety of factors, including citations) and academic grants. However, the broader societal problem faced by the European Commission is that each individual researcher is operating within a local, but not a global, optimum. The new capacities of e-Infrastructure offer the potential to fundamentally advance academic knowledge by generating new knowledge by means of creating new data, and new methods to analyse data. The challenge for the European Commission is to identify the factors that are needed to catalyse the adoption and use of e-science, broadly defined, and to change, in some ways, the nature of the academic production function. In this framework, we particularly focus on identifying the benefits to individuals, narrowly defined, and society, broadly defined, associated with social scientists adopting and using e-Infrastructure.

Assigning scientific credit and ownership rights. In addition, an important social aspect is that there is inadequate scientific credit for dissemination of existing research datasets or code, and this results in disincentives to sharing both. Barriers to wide data sharing result from their character as research resource: the production of empirical databases is costly; ownership and access to databases constitutes an important resource and input to empirical research. Hence, scientists might be unwilling to share these resources as long as they haven't drawn all the benefits from them. Or they might not want or be able to provide sufficient information for other scientists to use the available data with confidence. As Woolgar and Coopmans (2006) argue, the sharing of raw data might not be fully realised and hindered by practices that are not in line with the idealistic and mostly discarded Mertonian norm of communalism. Until issues of intellectual property rights are worked out, individual scientists and private firms may be reluctant to participate in shared developments. In other words, there is substantial misalignment both in assignment of ownership rights and in how academic credit is granted. Ownership rights in data generated in a collaborative project are difficult to assign, yet the data themselves may have substantial financial value. Likewise, some social science communities and departments do not have a tradition of granting academic credit to tool builders or researchers who share their data widely.

Cross-disciplinary communication and collaboration. A final issue relates to the problems of reaching an accommodation of research agendas where computer scientists and researchers from the user disciplines are collaborating in e-Infrastructure development projects. The problem seems to be that these agendas are difficult to reconcile: the computer scientists wish to push the state of the art in their field, whereas the researchers wish to see progress in delivering solutions (Lawrence, 2006). In the social sciences, models of collaborative basic research and publishing are less developed and there is little history of academic credit

accruing to developers of collaborative tools and disseminators of data; and compared to other sciences, there are no established protocols for allocating credit among, e.g., researchers in the social sciences and tool developers (perhaps from other disciplines) (Burton & Lane, 2005).

3. Stock-taking of e-Infrastructures in the social sciences and humanities

The work in this chapter responds to the first set of requirements from the tender specifications, namely:

1. To provide a stock-taking of e-social science initiatives in four fields in the social sciences and humanities in Europe and beyond
2. To provide a selected list of initiatives that support virtual research organisations and services for researchers as well as training opportunities for (post graduate) students in the social sciences and humanities
3. To produce a classification scheme for these initiatives

The approach taken by the team was to contact the 'early adopters' of e-Infrastructure in the social sciences and humanities. We administered an email survey (reproduced in the appendix) which asked these key informants to provide their insights with respect to these three key issues.

In what follows, we begin by describing the empirical approach. This is followed by a description of the characteristics of the sample and of the types of projects that are underway. We then describe the barriers and catalysts to e-Infrastructure adoption as identified by respondents to the survey, and their report on the lessons learned. The list of initiatives is provided separately.

3.1 Explanation of the empirical approach

The team determined that the best way to do a stock-taking of the emerging field of e-Infrastructure was to directly survey the e-Infrastructure community. A major challenge with developing an empirical approach was determining the appropriate unit of analysis. One methodology would have used the research organization as the unit of analysis. This would involve identifying the major research institutions in Europe, UK, US, Oceania and Asia, identifying the key informants in each social science department, and surveying them. Although this approach had the advantage of potentially having a clearly defined frame, it was dismissed as impractical for a number of reasons. First, there is no list of major institutions in Europe and Asia. Second, there is no list of social science departments for each discipline, and hence identifying the key informant would be impossible. Finally, the time frame for the study precluded such a time and resource intensive approach.

The second methodology was to use the individual researcher as the unit of analysis. This had the disadvantage of the lack of a clearly defined population frame from which to draw a sample of key informants. This challenge is mitigated, however, by the fact that the very nature of the e-Infrastructure community requires that researchers be visible in some way – by attending conferences, publishing research, or having a well-known website. The second disadvantage is that multiple researchers could come from the same institution or project, which might mean that the outcomes of one heavily staffed project might disproportionately influence the results. There are several factors mitigating this disadvantage as well. First, since the very nature of the community is collaborative, multiple researchers work on multiple projects, and it is likely to be structurally impossible to create a one respondent/one project dichotomy. Second, since heavily staffed projects are likely to be the ones in which major investments have been made, it makes sense to have a greater weight on the experiences of such projects.

The second major challenge with developing the empirical approach was whether to survey a handful of key leaders in the field, or whether to cast a very wide net. As a result of much discussion, the team decided to go with a broad-ranging approach: namely contacting everyone who could be identified as even having

been tangentially involved with some aspect of e-Infrastructure. The basis for this decision was the focus of the study, which was to generate a stock-taking of different aspects of e-Infrastructure, rather than a scientific analysis of technology adoption. As a result, generating the maximum number of responses was judged to be much more important than maximizing response rates.

With this in mind, the team developed an initial list of email addresses from the following sources:

- A list of participants in NCeSS nodes and small grants as well as ESRC pilot demonstrator projects
- A list of participants in e-social science events, such as workshops and conferences at NCeSS, and recipients of NCeSS' monthly newsletter
- A list of participants in the US National Science Foundations/SBE workshops as well as cyberinfrastructure awards made by NSF
- The participants in ESFR roadmap social sciences and humanities working group
- Internet searches on programme, project and conference pages

A total sample of more than 1900 mail addresses in 45 countries and 5 institutional TLD (.edu, .com, .org, .net, .gov) was obtained in the process and addressed in the survey.

The survey was developed by the team and had five main sections. The first section, Section A, gathered background information on the respondent, the respondent's organization, and the respondent's experience with e-Infrastructure. The second section, Section B, gathered additional information on the respondent's current or most recent e-Infrastructure project. The third section, Section C, provided more background about the funding and results of the respondent's e-Infrastructure project(s). The final two sections, D and E, asked the respondent to identify potential catalysts and barriers to the development and implementation of e-Infrastructure projects, as well as further e-Infrastructure projects and people which could provide interesting information for the study.

The draft questionnaire was first circulated within the team, then tested on a number of other researchers, including staff at the Oxford Internet Institute, NSF, and the European Commission. Their input was used to further refine the questionnaire.

The initial email (reproduced in the appendix) was sent to the potential respondents on 20th February, with a reminder on 8th March, 2007. More than 560 responses were returned for a response rate of 27.6%. Of these responses 448 (23.4%) were valid and included in the subsequent analyses. The low response rate is an expected outcome of the sampling strategy described above: corroborating this view is the fact that many of the respondents who received the email sent responses back saying that they felt that they were out of scope for the survey. The distribution of the responses and the total sample can be seen in table 3.1.[8] Clearly, in the sample as well as among the responses the UK and the US (most of the responses from the TLDs .edu, .com, .org, and .gov) are the most important countries, each contributing about one third of the responses. Another country with notable share is Germany, other countries are only in the range of 0-2%.

[8] Several countries with less than three responses (Belgium, Denmark, Japan, Philippines, Czech Republic, Israel, India, Kyrgyzstan, Lebanon, Lithuania, Mexico, Poland, Russia) and countries with no response were excluded from this table.

Table 3.1: Country distribution of the sample and the responses

Country	Sample			Responses in the dataset		
	TLD*	No.	%	No.	%	RR in %*
UK	ac.uk, co.uk, gov.uk, nhs.uk	501	26.1%	182	32.4%	35.7%
Educational	edu	587	30.6%	135	24.1%	23.0%
Germany	de	276	14.4%	69	12.3%	25.0%
Commercial	com	100	5.2%	23	4.1%	23.0%
Organisation	org	84	4.4%	19	3.4%	22.6%
Netherlands	nl	39	2.0%	15	2.7%	38.5%
Australia	au	38	2.0%	14	2.5%	36.8%
Canada	ca	20	1.0%	12	2.1%	60.0%
France	fr	26	1.4%	10	1.8%	38.5%
Italy	it	22	1.1%	10	1.8%	45.5%
Switzerland	ch	11	0.6%	8	1.4%	72.7%
New Zealand	nz	13	0.7%	7	1.2%	54%
Austria	at	16	0.8%	6	1.1%	38%
Governmental	gov	31	1.6%	6	1.1%	19%
Greece	gr	7	0.4%	5	0.9%	71%
Sweden	se	20	1.0%	5	0.9%	24%
Spain	es	8	0.4%	4	0.7%	50%
Norway	no	8	0.4%	4	0.7%	50%
Slovenia	si	4	0.2%	4	0.7%	100%
Hungary	hu	3	0.2%	3	0.5%	100%
Ireland	ie	8	0.4%	3	0.5%	38%
Portugal	pt	11	0.6%	3	0.5%	27%

* TLD: Top level domain of the email address; RR: response rate in %.
Source: AVROSS WP2.

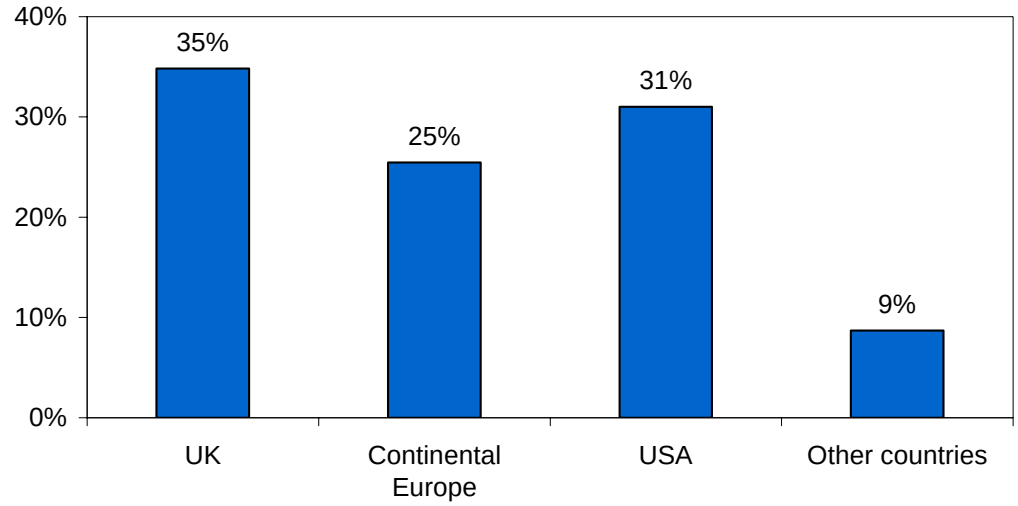
3.2 Background information on respondents

The first section on the survey results describes and groups the respondents in regard to their location, activity profile in regard to time use, location of their collaborators, involvement and experience with e-Infrastructure.

3.2.1 Differences in origin

As expected, the bulk of the responses came from three regions: the UK (156), Europe (120), and the USA/Canada (149). Eight responded from Oceania, one from Asia (Japan) and 4 from other countries (Mexico, Israel, Lebanon and Iran) (QA1). Since there are substantial regional differences in the e-Infrastructure environment, we examined the regional variation in responses across four regions with very different institutional structures: UK, continental Europe, USA and other countries. UK and USA contribute around one third, continental Europe one fourth and other countries less than ten percent of the valid responses (see Figure 3.1).

Figure 3.1: Origin of the e-Infrastructure users



Based on question A1 in the questionnaire. Number of valid cases N = 448.
Source: AVROSS WP2 survey.

Table 3.2: Main location of collaborators across regions (in %)

Main location of collaborators	UK	Continental Europe	USA	Other countries
Own university	36%	38%	38%	34%
Other organization close by city / area	14%	15%	11%	17%
Organization elsewhere in the country	26%	20%	33%	25%
Organization in other country	24%	28%	18%	24%
Cases	N=110	N=81	N=118	N=31

The figures indicate a level of cooperation derived from question A3b in the questionnaire.[9]
Source: AVROSS WP2 survey.

A brief review of the data revealed that there were no substantive differences in the work allocation of the respondents: the typical respondent from a given region spent as much time on teaching, researching, and administration as his or her colleagues form other regions. In addition, an examination of Table 3.2 shows that the distribution of collaborator locations does not differ enormously among the regions. Not surprisingly, given the size of the U.S. the number of US interviewees collaborating with organizations in other countries is the smallest compared to the other regions. Continental European respondents are more likely to collaborate with other countries: while this might be due to the size of the countries, it might also be a consequence of the sponsorship policy of the EU.

The majority of respondents (322) also worked for a university or technical university (QA2). Fifty five were affiliated with a non-university research institute, three for a polytechnic/university of applied sciences, eleven for a research council or science foundation, and fifty seven for "other" organisations (see annex I.4, p. 181).

[9] The characteristic of the answer-scale was: "none", "less than a third", "between a third and two thirds" and "more than two thirds". To code the answers we substituted every value with the middle of the represented range. i.e. "none" = 0, "less than a third2 = 16.5 and so on. Than we have added this values for each respondent and standardized it to 100%.

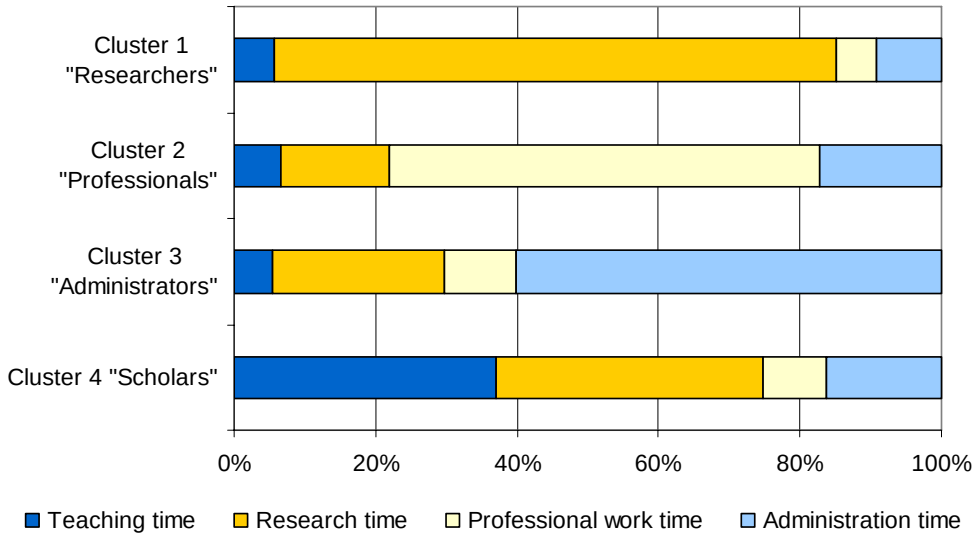
3.2.2 Activity profiles of time use

The questionnaire included a question (QA3a) on the percentage of the annual working time spent on teaching, research, other professional work (professional practice, third mission, patent and license work etc.) and administration and unallocable time.

These percentages varied considerably by respondent, as a cluster analysis of the responses showed.[10] However, an indepth analysis of the data revealed that there were four different clusters of respondents (see Figure 3.2):

- Cluster 1: A large cluster of 141 respondents, “Researchers”, use 80% of their working time for research and the rest more or less equally for teaching, administration and professional work.
- Cluster 2: The smallest cluster with just 47 persons, “Professionals”, consists of respondents who use 60% of their time for professional work around 15% for each research and administration and a little rest for teaching.
- Cluster 3 is again a rather small cluster of 65 respondents, “Administrators”, use 60% of their time for administration. They seem to be mostly research administrators, as another 25% of the working time is used for research and teaching is of little importance.
- Cluster 4: The 164 respondents grouped in cluster 4 form the largest group, “Scholars. Their time use pattern reflects the typical pattern of scholars who have to reserve a considerable share of their time to teaching – the cluster average is 37% – and about the same amount of time to research. Administration takes up around 15% and professional work 10% of the working time in this group.

Figure 3.2: Clusters of respondents according to time use pattern (“activity profiles”)



Data for this figure in annex I.3, table A.1.
Source: AVROSS WP2 survey.

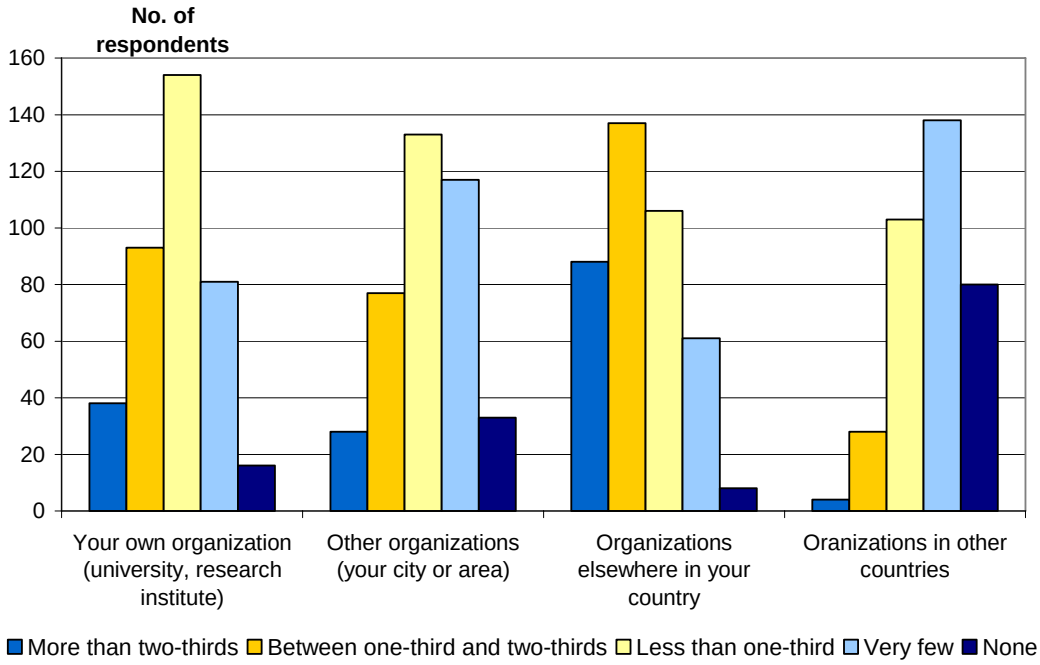
[10] The data of the 4 time use variables was processed in a Hierarchical Cluster Analysis using the squared Euclidic distance as the distance measure and the Ward algorithm to group the cases. The 4-case solution appeared to be the most appropriate solution. The initial clustering was revised in a cluster centre analysis with the cluster centres from the hierarchical analysis as the initial input values. 34 cases were re-grouped in this analysis.

The interesting question is to be investigated in section 3.4 of the report is whether the involvement with e-Infrastructure differs across these four groups of researchers, administrators, professionals and scholars.

3.2.3 Collaborators

Figure 3.3 shows the distribution of respondents' collaborators (response to QA3b), and the importance of geographical (or linguistic) proximity. Almost all respondents reported having collaborators in their own organisation – albeit most say that less than one third of their collaborators are co-located with them. Similarly, almost all report having collaborators within their city or country – many reporting that this accounts for one-third or more of their collaborators. Very few report having collaborators in other countries. Since part of our interest is in describing the geographic dispersion of collaboration, in our following discussion, we classify respondents as working in their "local" arena if more than two thirds of their collaborators are in either their local institutions or in their city/area, or if more than one third of their collaborators are in their local institution and a further one third are in their local city/area.

Figure 3.3: Location of respondents' collaborators



Source: AVROSS WP2 survey.

3.2.4 Respondents' involvement and experience with e-Infrastructure

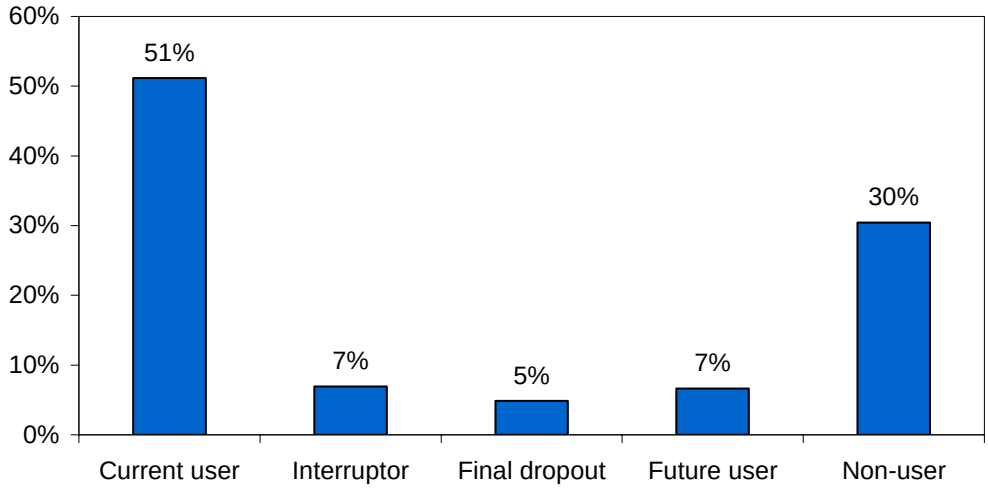
User status

The questionnaire included a set of questions on the respondents' past, current and future involvement in projects using e-Infrastructure (questions QA4-QA6). The following figure 3.4 shows the distribution of respondents by different groups: current users; interrupters,[11] drop-outs,[12] future users,[13] and non users. Current

[11] Respondents that stopped using e-Infrastructure but are considering starting a new project in 2007.

users are the largest group with more than half of the respondents. Interrupters, drop-outs and future users are of about the same size and non-users add up to 30%.

Figure 3.4: Allocation of the status of the users



Number of valid cases N = 391, missing values = 57
Source: AVROSS WP2 survey.

There are no clear differences in the current involvement of the survey participants with e-Infrastructure by their country of origin.[14] The involvement in the fields of interest, linguistics, sociology, geography, and archaeology, is above average; while economics is slightly lower it is still above the average of all respondents.

Table 3.3: Current involvement with e-Infrastructure by field of project[a]

	Archae-ology	Economics and business	Socio-logy	Social geography, regional science	Linguistics	All cases[b]
Current user	84.0%	77.3%	85.9%	85.2%	88.9%	72.9%
Interrupter	4.0%	9.1%	4.2%	3.3%	6.7%	9.8%
Final dropout	4.0%	2.3%	4.2%	4.9%	2.2%	7.6%
Future User	8.0%	11.4%	5.6%	6.6%	2.2%	9.8%
Cases N	25	44	71	61	45	225

a QA4-QA6 by QB11.

b Fields don't add up to all cases, as multiple responses for the fields were possible and only selected fields are shown. No answer on the field question for non-users.
Source: AVROSS WP2 survey.

Another issue that can be investigated with the data is whether the proportion of active users differs across type of user: administrators, researchers, professionals and scholars. An examination of Figure 3.5 reveals that the highest share of current users can be found among professionals and the lowest among scholars. People who dropped out are most frequently found among the administrators and scholars. The administrators are unusual in that there is a relatively high proportion of respondents who intend to use e-Infrastructure in the future and the lowest proportion of non-users. The proportion of non users is much higher – around one

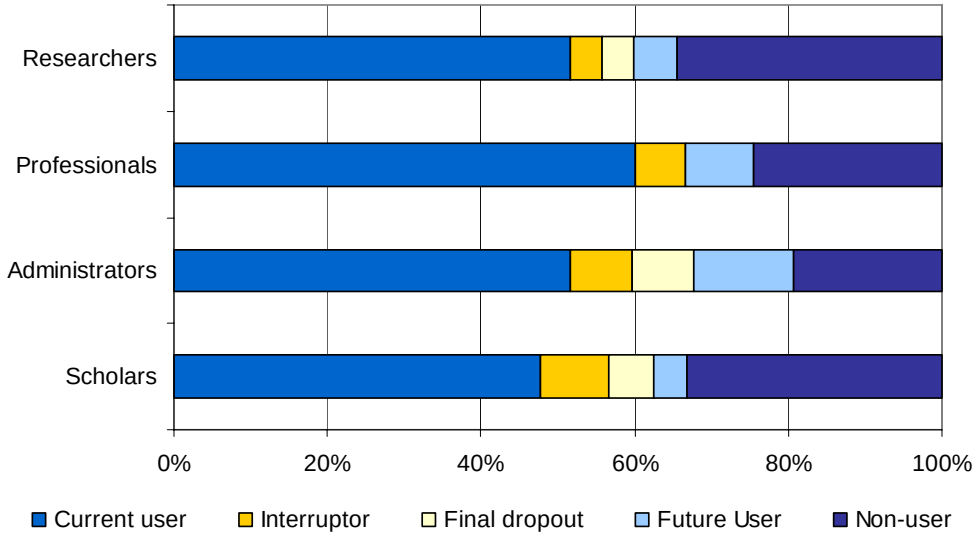
12 Respondents who stopped using e-Infrastructure and who have no plan to start again in 2007.

13 People who have not yet been involved in an e-Infrastructure project but plan to become involved in 2007.

14 The source table is provided in annex I.3, table A.2.

third of the respondents – among researchers and scholars. Of course, since the survey targeted e-Infrastructure researchers, this result should not be seen as generalizable to the use of e-Infrastructure among social scientists and humanities researchers more broadly.

Figure 3.5: Current involvement with e-Infrastructure by activity profiles



Data for this figure in annex I.3, table A.3.
Source: AVROSS WP2 survey.

Reasons for interruption or dropout

Interrupters and drop-outs were directly asked why they stopped or interrupted their involvement with e-Infrastructure. As table 3.4 reveals, the most cited reasons included lack of funding and lack of staff.

Table 3.4: Importance of reasons for interrupting or ending participation in humanities or social science e-Infrastructure projects

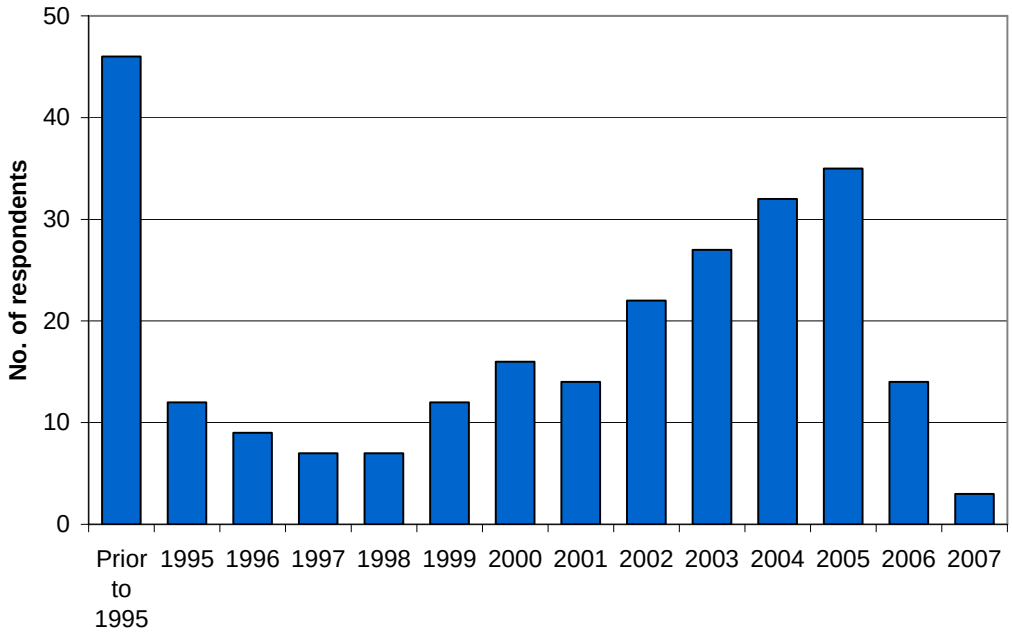
	Very im-portant	Somewhat Important	Neutral	Somewhat unimportant	Not at all Important	All valid N
Lack of sustainability of funding	32.5%	37.5%	15.0%	2.5%	12.5%	38
Lack of staff available to help with development and deployment	21.1%	39.5%	21.1%	2.6%	15.8%	38
Not enough scientific pay-off	13.5%	21.6%	29.7%	16.2%	18.9%	37
Technology was not mature enough	11.1%	22.2%	30.6%	16.7%	19.4%	36
Other reasons	60.0%	20.0%	10.0%	0.0%	10.0%	10

Please note that the number of responses to question QA7 (drop-outs) is only N=12 and to QA8 N=26 (interrupters), so the overall N=38 for this table.
Source: AVROSS WP2 survey.

Experience with e-Infrastructure

Many of the respondents were relatively new to e-Infrastructure (QA9), as indicated by Figure 3.6, although a substantial fraction – about 10% – had been involved in e-Infrastructure for at least a dozen years. Again, because we are also interested in distinguishing between early and late adopters of e-Infrastructure, we classify respondents as early adopters if they began working in e-Infrastructure prior to 2000.

Figure 3.6: Year of respondents' initial involvement in e-Infrastructure



Source: AVROSS WP2 survey.

The diversity of experiences, i.e. the number of e-Infrastructure projects in which the respondents had been involved (QA9), was quite remarkable: 72 had been involved in just one project, 51 in two, 32 in three, 18 in four, 5 in five, and 66 in more than five such projects.[15]

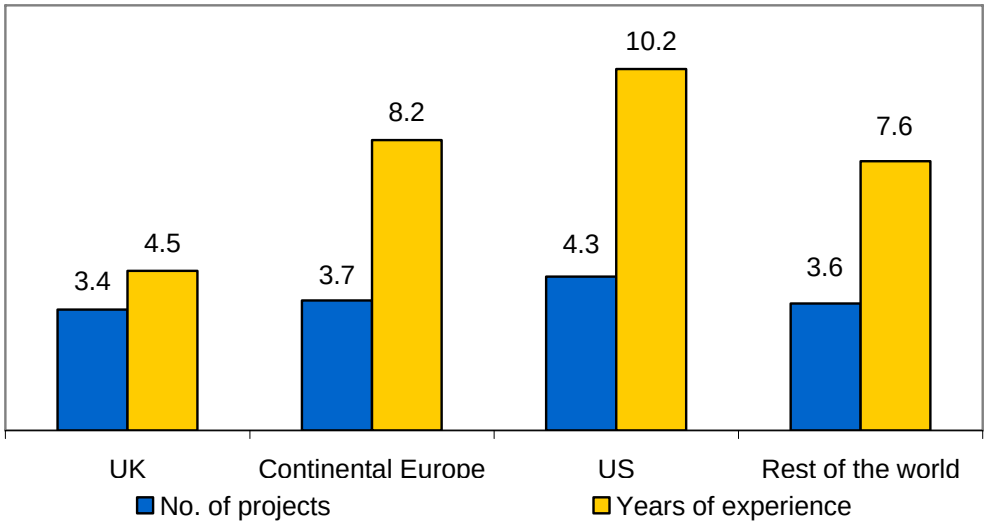
There are some regional differences in respondents' experiences with e-Infrastructure projects as evidenced by Figure 3.7. Most strikingly, US participants are more experienced than their colleagues from other regions, with more than 10 years experience in e-Infrastructure, and experience with an average of over 4 projects. Despite the fact that there are currently numerous e-Infrastructure projects in the UK, the relatively recent nature of this phenomenon is evidence by the fact that the typical respondent has a relatively short experience with e-Infrastructure, and has worked on relatively few projects.

Last but not least there are also some variations regarding the experience with e-Infrastructure by field. The median respondent involved in a project with archaeology as a discipline started with e-Infrastructure in 1998, and in linguistics in 2000. The median respondent in the other disciplines, economics, sociology, and social geography started in 2002. Not only are those involved with archaeology projects more experienced than the average respondent in terms of the date of

[15] Very few responded to our probe on whether they intended to be involved in the future (197), and only 56 indicated that they would be involved.

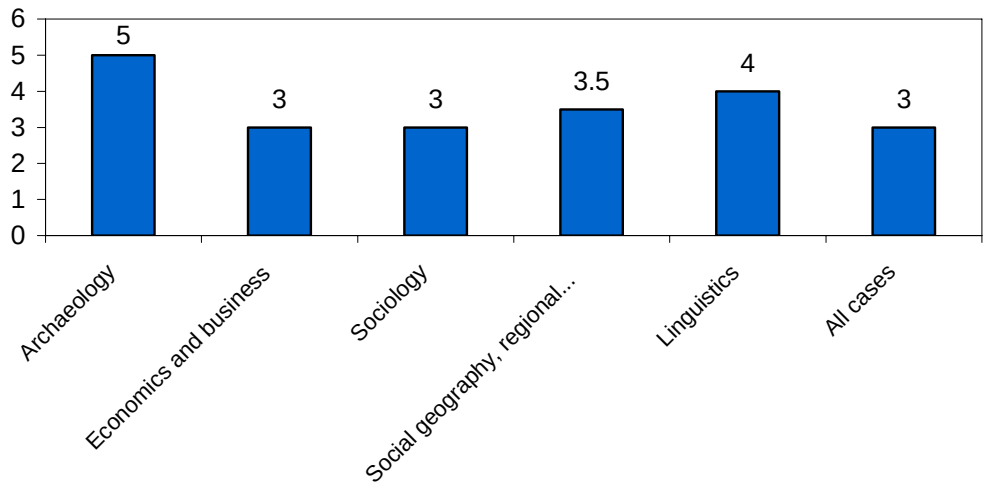
adoption, but also in terms of the number of projects with which they have been involved (c.f. Figure 3.8). Notably, they have been involved in about five projects, compared with between 3 and 4 for respondents in the other disciplines.

Figure 3.7: Experience in e-Infrastructure projects by region of the respondent (arithmetic means)



Responses to QA9 and QA10
Source: AVROSS WP2 survey.

Figure 3.8: Median number of e-Infrastructure projects of the respondents by field of their project



Response to QA10 by QB11.
Source: AVROSS WP2 survey.

The material in this section documented the differences in the respondents in terms of their discipline, location, their activity profile, the geographic dispersion of their collaborators, their involvement and their experience. These differences are further explored in the next sections which examine differences in e-Infrastructure projects and e-Infrastructure adoption.

3.3 Background information on projects

One of the core sections of the questionnaire asked a set of questions about one completed, ongoing, or future e-Infrastructure project in which the respondents have been or will be involved (sections B and C of the questionnaire). A broad range of issues was examined: the technological items used in the project, the main sources of information that led to the project conception, as well as what organizations were involved. Additional questions included requests for information about the project funders, as well as project outcomes, and the existence and types of user constituencies.

As a start to this questionnaire section, the respondents were asked to provide some general information about their project so that the team could review the sites, as well as provide a brief description (QB1-QB2).

3.3.1 Disciplines represented

The respondents were asked what domain areas were represented by the projects (QB11). Many of the projects were interdisciplinary: only 36 respondents reported that their project had only one discipline, 47 reported 2 disciplines, 32 reported 3 disciplines, 36 reported 4 disciplines, and 67 reported 5 or more disciplines. The diversity of coverage is partially summarized in Table 3.5 in two columns. The first column reports how often the discipline was mentioned as part of a project; the second column weights the discipline proportionately to the number of other disciplines reported in the project (see annotation to the table 3.5).

Table 3.5: Discipline groups represented by projects (as defined by OECD Frascati classification)

Discipline	Unweighted		Weighted[a]
	Cases	in % of all 218 projects	Cases
Agricultural Sciences	12	5.5%	2
Engineering and Technology	28	12.8%	7
Electrical engineering, electronic engineering, information engineering (hardware)	*17*	*7.8%*	*4*
Engineering & technology (civil, mechanical, chemical, materials, environmental or medical engineering, bio- or nanotechnology, others)	*19*	*8.7%*	*3*
Humanities	109	50.0%	54
Archaeology	*26*	*11.9%*	*8*
Art (arts, history of arts, performing arts, music)	*42*	*19.3%*	*8*
History	*46*	*21.1%*	*11*
Languages and literature (excluding linguistics)	*35*	*16.1%*	*7*
Linguistics (including computational linguistics)	*45*	*20.6%*	*11*
Other Humanities	*39*	*17.9%*	*6*
Philosophy, ethics, religion	*16*	*7.3%*	*2*
Medical and Health Sciences	29	13.3%	8
Natural Sciences	142	65.1%	50
Natural sciences (mathematics, physical, chemical, biological sciences, earth & environmental sciences, other natural sciences	*45*	*20.6%*	*11*
Computer and information sciences (software)	*135*	*61.9%*	*39*

contiued

Continuation table 3.5

Discipline	Unweighted		Weighted[a]
	Cases	in % of all 218 projects	Cases
Social Sciences	153	70.2%	95
Economics and business	*45*	*20.6%*	*26*
Educational sciences	*54*	*24.8%*	*13*
Political science	*37*	*17.0%*	*8*
Psychology	*30*	*13.8%*	*6*
Social and economic geography, regional science	*64*	*29.4%*	*20*
Sociology	*72*	*33.0%*	*20*
Law	*18*	*8.3%*	*3*
Other	45	20.6%	16

a Proportionate weighting by to the number of disciplines reported in a project. If, for example, a project reports six disciplines, each discipline is weighted by 1/6.
Source: AVROSS WP2 survey.

While, as expected, the dominant discipline represented is computer and information sciences, there was substantial representation of the four fields identified by the team a priori. Economics was represented in 45 of the projects identified by respondents; sociology in 72; geography and regional science in 64; linguistics in 45 and archaeology in 26.[16]

3.3.2 Project funding and size

The funding source for the projects is dominated by research councils and foundations (QC1): 124 respondents cited that as their main source of funding, 27 cited the European Union, 48 national and state research or education ministries, 80 cited their home institution and 29 cited private foundations; the “other” category was quite varied (see annex I.4, p. 189). 118 respondents provided information on their total budget; 71 on their annual budget (QC3). The median project was initially funded at just under 335,000 Euros; the median annual budget was just over 122,000 Euros. Although the average project was funded for 36 months (QC4), the length of the projects varied substantially. About 26% of projects lasted less than 18 months, 52% between 19 and 36 months, and 23% more than 36 months.

The typical project has quite a substantial staff of about 14 individuals, of whom 5 are scientists, 3 are graduate students and 6 are other, technical and administrative and supporting staff.

Funding/staff and geographical location of the project

There were substantial differences across regions in the average amount of initial funding differs to a large amount (QC10). The respondents from continental Europe reported the largest initial budgets, followed by the US, the UK and then the other countries (c.f. Figure 3.9).[17] The scheduled funding period also differed among the regions, with continental European projects lasting the longest at an average of 37 months, compared with 34 months in the USA, 26 months in the UK, and 30 months in the rest of the world.

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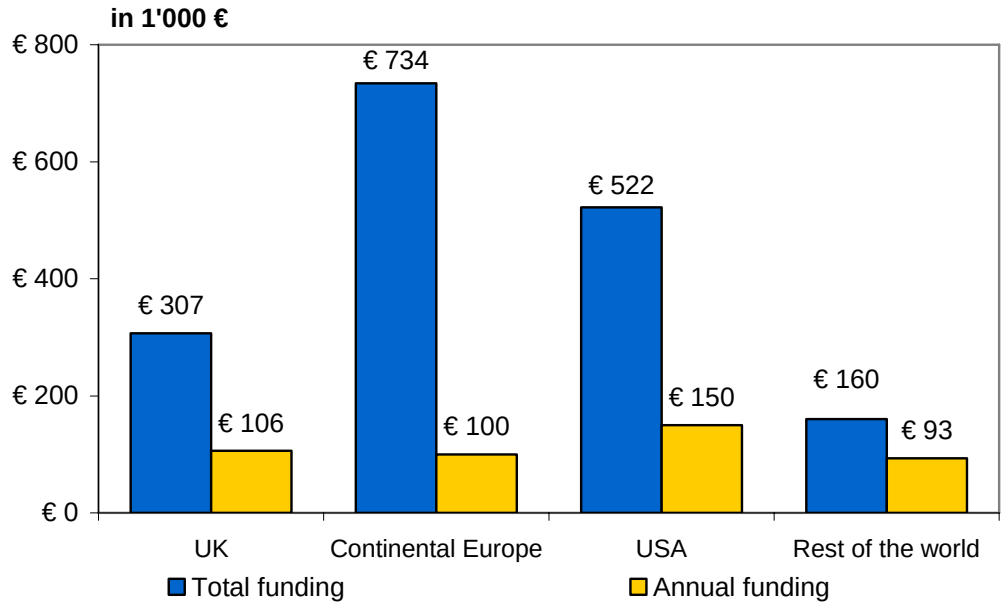
16 Note that because there can be multiple respondents per project, this does not denote unique projects.

17 To calculate the budgets we used the exchange rate from January, 1st 2007 as published on http://www.oanda.com.

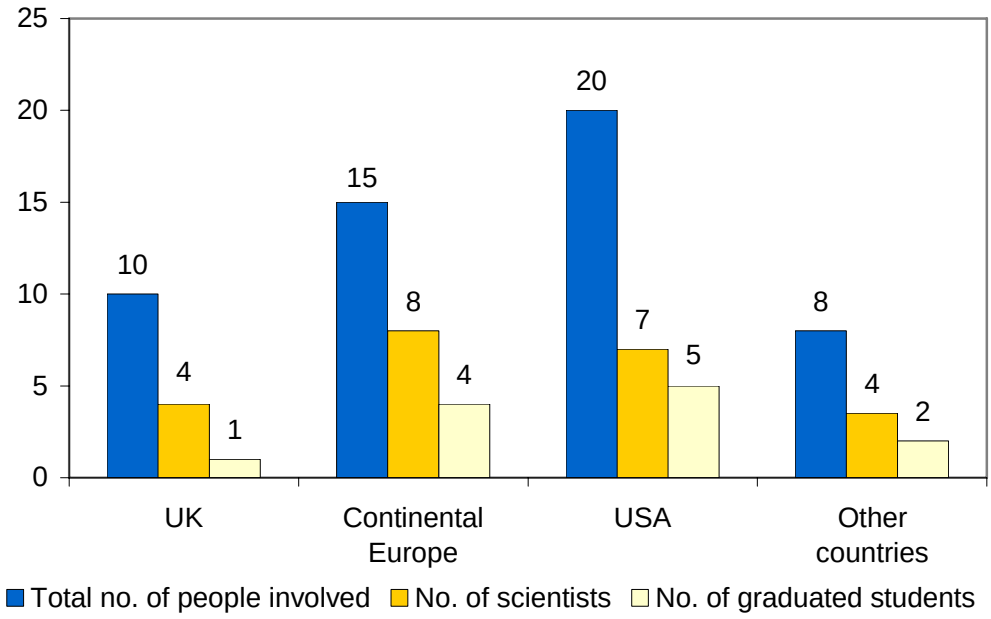
Figure 3.9: Initial funding of the projects in Euro (median values)



Source: AVROSS WP2 survey.

Respondents also provided information about the number of people working on their projects, and this differed by region of the respondent (QB12). US projects tended to be quite large (see Figure 3.10): 20 people on average, with typically 7 scientists and 5 graduate students and a substantially larger number of non scientific staff than their European counterparts; UK projects were quite small, averaging around 10 staff, with 4 scientists and just 1 graduate student. The continental European respondents reported average staff sizes – typically 15 staff members including 8 scientists and 4 graduate students.

Figure 3.10: Size of the projects grouped by regions (median personnel data)



Source: AVROSS WP2 survey.

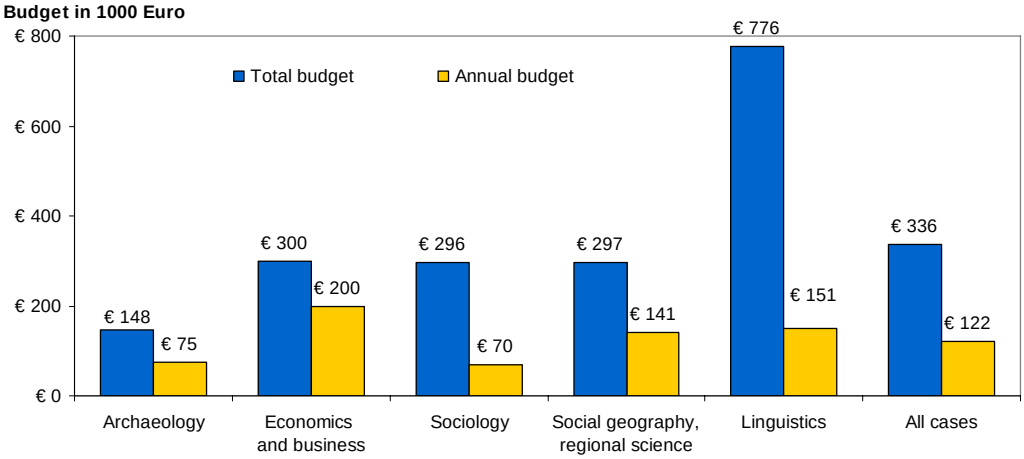
There were also regional differences in numbers of domains involved in projects. The US respondents reported the most inter-disciplinary projects, with 4.6

disciplines being represented on average, followed by 4.1 disciplines per project in the rest of the work, 3.5 in continental Europe and 2.5 in the U.K.

Funding, staff and field of the project

If we differentiate the projects' funding by the included fields, we see that linguists' projects were by far the largest with a total budget of nearly 800'000 € (see Figure 3.11). The large budget of linguistic projects is at least partially due to their long duration of 36 months (see Figure 3.12) but also to their size (see Figure 3.13 on the staff below). Most other fields, namely economics, sociology and geography projects were close to the overall average of roundabout 300'000 €. Archaeology projects just reached about half the average.

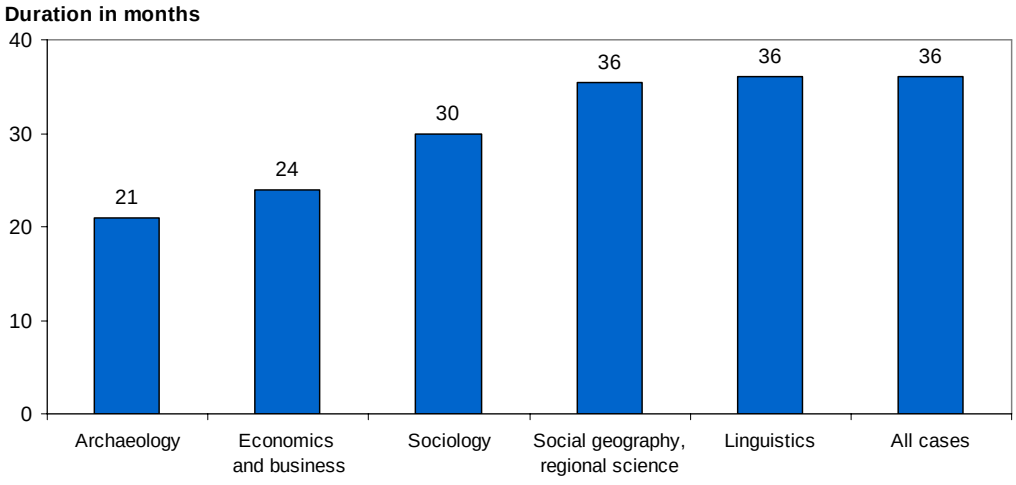
Figure 3.11: Average total and annual project budgets in 1000 Euro by field



Source: AVROSS WP2 survey.

The annualised data produce a slightly different picture: economics & business administration projects are now the largest with 200'000 € per year, and archaeology and sociology projects are smaller than the average. Archaeology projects are also those with the shortest duration of just around one year and a half (see Figure 3.12).

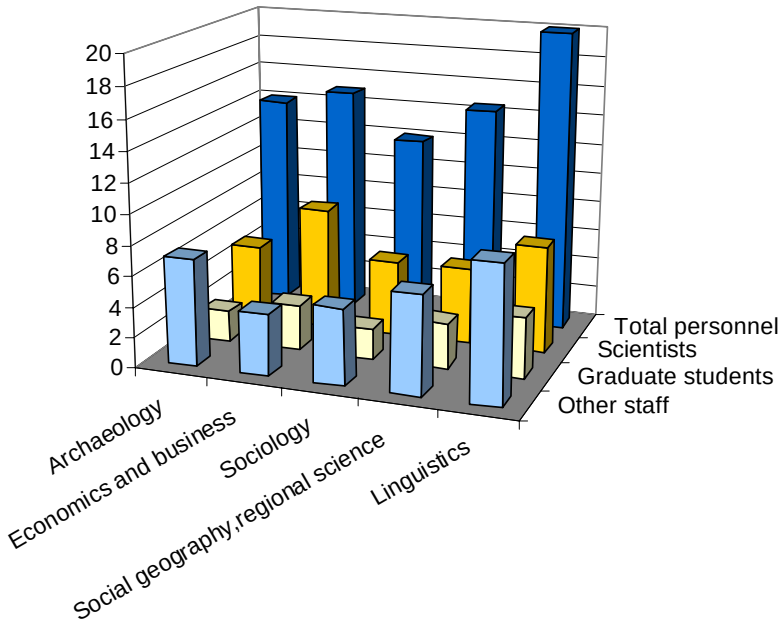
Figure 3.12: Average project duration in months by field (median)



Source: AVROSS WP2 survey.

Linguists' projects had by far the largest number of staff with on average (median) 20 total personnel (see Figure 3.13). Archaeology, economics & business and geography projects had just about average size, whereas sociology projects were somewhat smaller.

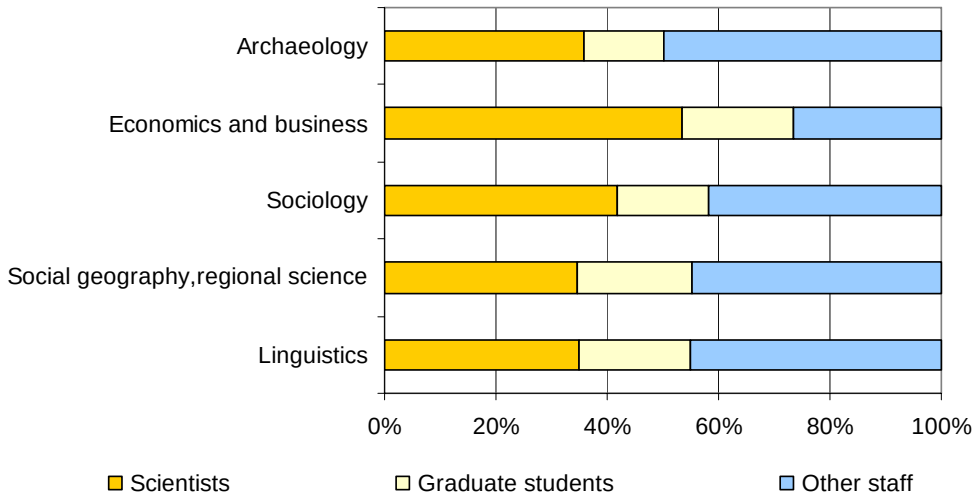
Figure 3.13: Average project size (median personnel) by field



Data for this figure in appendix I.3, table A.4.
Source: AVROSS WP2 survey.

The research intensity, i.e. the percentage of staff with a scientific objective, also varies between the fields as shown in Figure 3.14: in economics & business projects more than half of the personnel were scientists. The share is notably lower in all the other fields. The role of graduate students is similar in the fields and other staff is most important in archaeology and least important in economics & business projects.

Figure 3.14: Percentages of different personnel categories by field

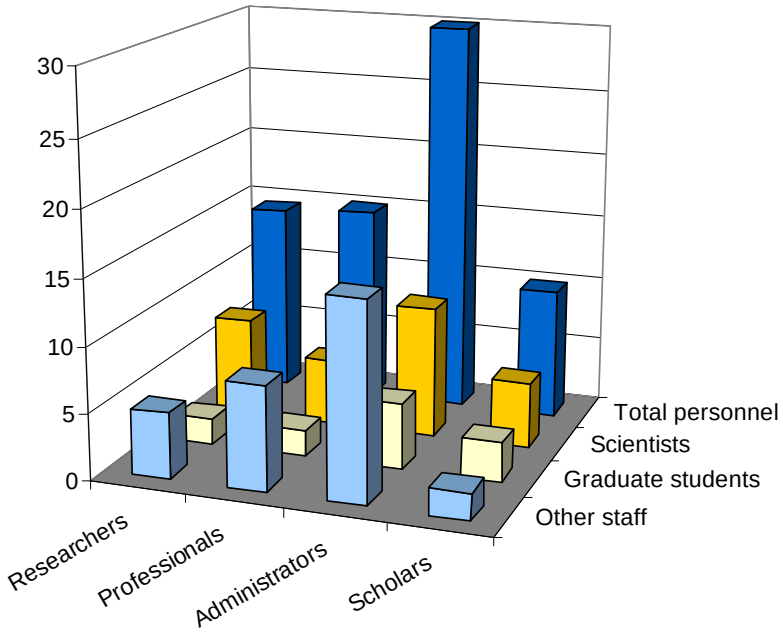


Data for this figure are available in appendix I.3, table A.4.
Source: AVROSS WP2 survey.

Staff and activity profile of the respondents

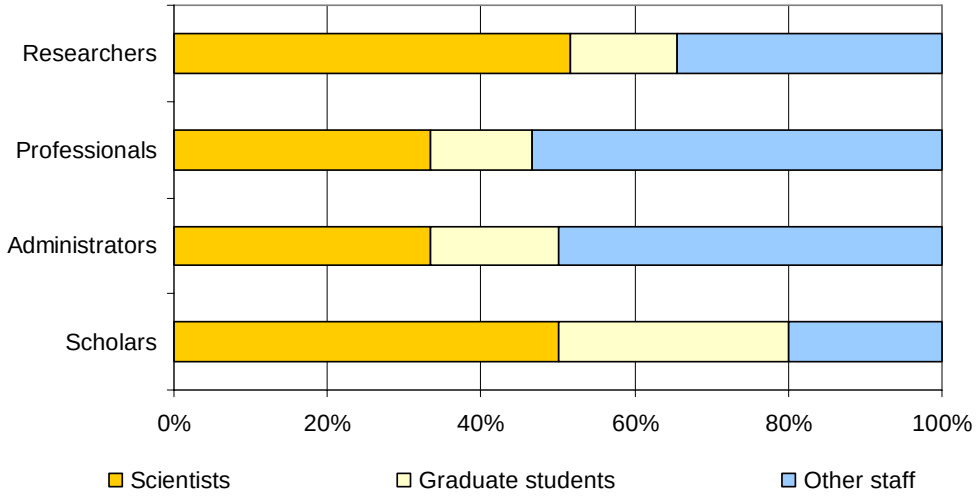
It is also interesting to examine how the type of respondent (results from the activity profile analysis, see section 3.2.2 above) differed by type of project. Not surprisingly, administrators tended to be reporting on the largest projects (see Figure 3.15). The average size of such projects was about 30 people – twice as many as in projects which were described by the other three groups (researchers, professionals, and scholars).

Figure 3.15: Average project size (median personnel) by activity profiles



Data for this figure in appendix I.3, table A.5.
Source: AVROSS WP2 survey.

Figure 3.16: Percentages of different personnel categories by activity profiles



Data for this figure in appendix I.3, table A.5.
Source: AVROSS WP2 survey.

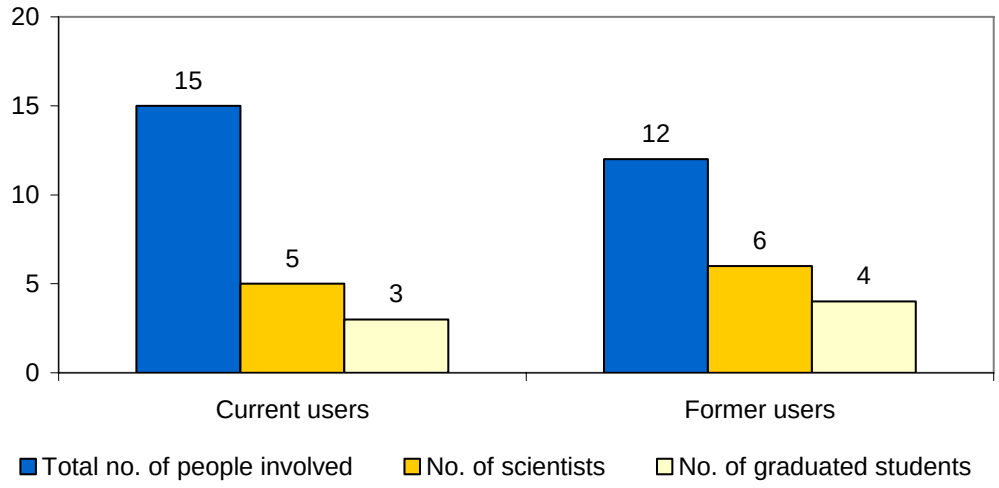
The research intensity in the different projects varies substantially: only one third of the people working on the project were classified as scientists in projects described by “administrator” respondents, whereas “researchers” and “scholars” reported that

scientists represented about half of the staff. In the same vein, graduate student involvement was proportionally larger in projects described by scholars than in projects described by researchers, administrators or professionals (see Figure 3.16).

Funding/staff and user status of the respondent

Next, we contrasted the size of the projects by the user status, differentiating between current and former e-Infrastructure users. Projects of former users had more non-scientific staff than those of current users (see Figure 3.17). This might indicate that either the e-Infrastructure technology has become easier to use or the responding skills of the users have become better.

Figure 3.17: Average number of people involved in the project by user status of the respondent (median values)



Current users N=136, former users N=25.
Source: AVROSS WP2 survey.

Projects from former users were also larger in terms of the initial budget, at a median level of €470,000, compared with €373,000 for current users.[18] Not surprisingly, larger budgets and larger staff are closely related.

3.3.3 Technological features of the projects

Technological features

The respondents were also asked to provide a summary of the features used in their projects, and this summary is provided in Table 3.6. The results are again consistent with both the brief descriptions provided in the responses to QB2 and with the prior expectations of the team, based on their experience with both NSF and NCeSS. The most frequently cited features of the projects included communication and collaboration tools, as well as distributed data, and required high band width. The high performance computing, which is a feature of other sciences, was not as important, nor were the innovative data collection methods.

[18] Note, however, that there were only 106 respondents to this question; 93 respondents were current users and 13 were former users

Table 3.6: Technological features used in the project

	N (total 217)	Percentage
High performance computing	77	35.5%
High performance communication	101	46.5%
High bandwidth	133	61.3%
Distributed data, data repository	167	77.0%
Collaboration tools/systems	173	79.7%
Learning environments	84	38.7%
Grid-enabled videoconferencing	64	29.5%
Virtual/3D environments	34	15.7%
Innovative data collection methods	55	25.4%

Source: AVROSS WP2 survey.

The most widely used e-Infrastructure items are data repositories and collaboration tools. There is one set of items that was routinely reported as being used together, namely: high performance communication, high band width, data repository and collaboration tools. 52 of the 217 respondents responded that they use all four of them, and an additional 67 use at least three of the items.[19]

There were some interesting differences in the use of technology by project length. An examination of Table 3.7 suggests that short-term projects are more likely to be associated with distributed data and collaboration tools, but much less likely to use virtual environments, which only appear in one sixth of such projects. Medium-term projects also often deal with distributed data – in nine out of ten cases – and nearly as often with collaboration tools. High-performance computing and communication and high bandwidth are also comparatively more important than in the short-term projects. Last but not least, the long-term projects lasting for five years and more are very likely to use high bandwidth and high-performance communication. Learning environments are also particularly frequent among the longer projects.

Table 3.7: Use of e-Infrastructure items in projects of different length

	Short-term projects (0-18 months)		Medium-term projects (19-36 months)		Long-term projects (>36 months)	
	N	In %	N	In %	N	In %
High performance computing	10	27.0%	31	44.3%	14	46.7%
High performance communication	13	38.2%	35	50.7%	23	71.9%
High band width	19	50.0%	45	63.4%	23	76.7%
Distributed data, data repository	28	75.7%	68	89.5%	24	77.4%
Collaboration tools/systems	28	75.7%	69	86.3%	28	82.4%
Learning environments	14	40.0%	29	40.8%	15	51.7%
Grid-enabled videoconferencing	12	35.3%	24	35.8%	8	27.6%
Virtual/3D environments	5	14.7%	12	19.0%	5	17.2%
Innovative data collection methods	12	50.0%	27	55.1%	6	33.3%

Source: AVROSS WP2 survey.

[19] Of course, this may be due to an unclear discrimination between these items. For instance it is conceivable that some respondents tick high performance communication, high bandwidth and collaboration tools by meaning simply one item.

Technological features and fields of the project

There are some notable variations between the use of e-Infrastructure items and the fields on which the study focuses (Table 3.8). In particular, we see:

- Archaeology: 84% of the projects with archaeologists use high bandwidth and 42% use virtual/3D environments; also the use of data collection methods is particularly important and present in nearly seven out of ten projects in this field.
- Economics and business: Projects with economists participating do only slightly differ from the overall portfolio. One specific feature is the frequent use of high performance computing.
- Sociology: Projects with sociologists use nearly all technological items less often than projects in other fields. Only data collection methods are more frequently used.
- Social geography, regional science: Particular features of projects in this field are also difficult to discern. Grid-based video conferencing sticks out as does the more frequent use of high performance computing.
- Linguistics: In this field projects are also characterised by a rather low variety of e-Infrastructure items.

Table 3.8: Use of e-Infrastructure items in projects with different fields

	Archaeo-logy	Economics and business	Sociology	Social geogra-phy, regional science	Linguistics	All projects
High performance comp.	45.5%	57.1%	37.3%	48.1%	40.0%	35.5%
High performance comm..	54.2%	57.1%	47.5%	51.9%	44.7%	46.5%
High bandwidth	84.0%	73.2%	57.8%	66.7%	71.8%	61.3%
Distributed data, data repository	87.5%	88.1%	77.3%	84.5%	82.1%	77.0%
Collaboration tools/sys.	76.0%	86.0%	83.3%	86.0%	86.4%	79.7%
Learning environments	45.5%	41.0%	41.5%	45.5%	41.0%	38.7%
Grid-enabled videoconferencing	34.8%	42.1%	32.8%	43.1%	30.6%	29.5%
Virtual/3D environments	41.7%	16.7%	11.3%	19.2%	21.9%	15.7%
Innovative data collection methods	68.8%	50.0%	48.9%	38.2%	48.3%	25.3%

Source: AVROSS WP2 survey.

Technological features and location of the project

In a next step we have grouped the respondents by their origin (see section 3.2.1). The following Table 3.9 shows the use of e-Infrastructure items in the four different regions. The variations are notable, but somewhat difficult to interpret: learning environments and virtual/3D environments play a larger role in US-based projects. Continental European projects more often contain data repositories, whereas videoconferencing is relatively unimportant – it is used more than twice as often in UK-based projects.

Table 3.9: Use of e-Infrastructure items grouped by countries

	UK		Continental Europe		USA		Other countries	
	N	In %	N	In %	N	In %	N	In %
High performance computing	23	39%	18	38%	30	45%	6	38%
High performance communication	27	46%	22	45%	40	62%	12	71%
High bandwidth	32	53%	40	77%	50	76%	11	65%
Distributed data, data repository	54	82%	50	93%	49	75%	14	82%
Collaboration tools/systems	51	77%	47	84%	59	83%	16	89%
Learning environments	22	36%	23	45%	34	53%	5	31%
Grid-enabled videoconferencing	24	44%	10	21%	23	37%	7	44%
Virtual/3D environments	9	18%	8	18%	15	24%	2	13%
Innovative data collection methods	14	39%	15	43%	18	45%	8	53%

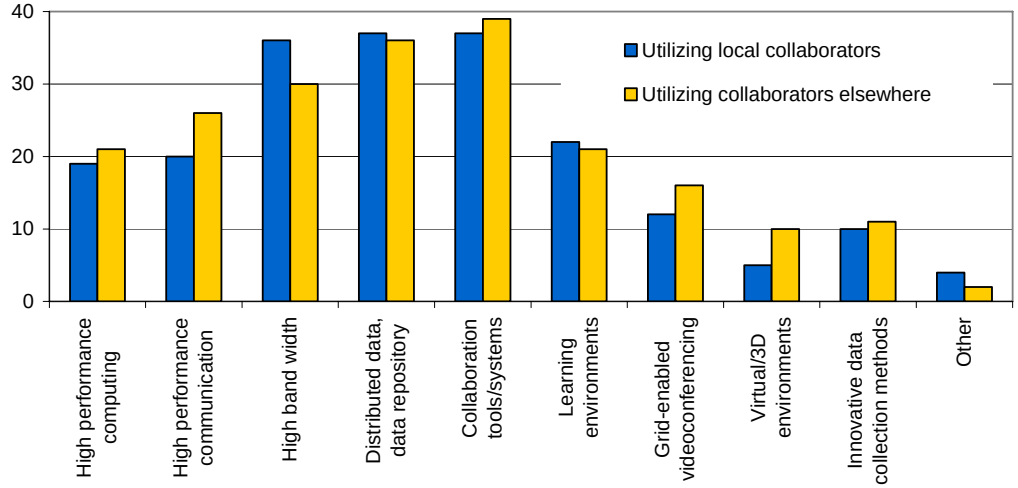
Source: AVROSS WP2 survey.

We generated a simple index that counted the number of e-Infrastructure items used per project. The users with the broadest portfolio of items are from the other country category. They use 4.7 items on average. They are followed by the US respondents with 4.5 items. On the bottom of the scale are the European respondents (4.1) and those from the UK. The latter use 3.7 items on average, almost one item less than the users from the other countries.

Technological features and location of collaborators

Since some of these items offer the potential to work with geographically dispersed collaborators, we tabulated how the use of different technologies varied by whether the respondent had a lot of local collaborators.[20] The results, reported in Figure 3.18, did not seem to suggest that there were substantial differences in the usage of items by the types of collaborators.

Figure 3.18: Technological features by location of collaborators (no. of positive responses)



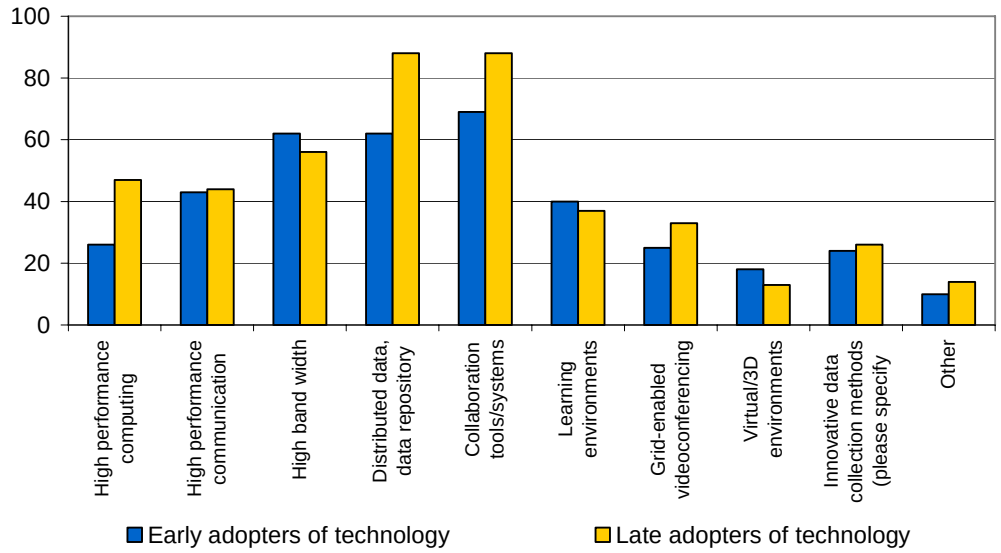
Source: AVROSS WP2 survey.

[20] We categorized respondents as being predominantly local if they reported that at least two-thirds of the collaborators were at the same institution or local area, or at least one-third were at the same institution and one-third were in the local area.

Technological features and user experience

Similarly, since some of the distance technologies might take some experience to adopt, we also tabulated the results by whether the respondents were early or late adopters of e-Infrastructure.[21] The results are reported below in Figure 3.19 and suggest that newcomers to e-Infrastructure seem to be much more likely to use distributed data repositories, collaboration tools or systems, and high performance computing.

Figure 3.19: Technological features by experience (no. of positive responses)



Source: AVROSS WP2 survey.

Based on the previous finding we would also expect some differences between the user status (current versus former users) and the items in a project. However, there is no difference in the use of e-Infrastructure items among current and former users of e-Infrastructure. Both use the same items to the same extent, and the degree of variation is very similar.

3.3.4 Project outcomes and user constituency

The respondents were also asked about the main outcomes of the project (QC5). Most identified publications (148), new methods (129), new data (114), follow-on collaborations (143) and new tools (143) as key outcomes. In response to the open part of the question (the "other" category), many more outcomes were identified (see annex I.4, p. 190). The questionnaire also probed for a discussion of what type of data had been produced: 80 respondents identified numerical data, 75 verbal/textual data, 67 visual data, and 22 identified other data types (see annex I.4, p. 191).

We have asked in more detail about new methods and tools developed in the projects. Unfortunately it turned out, that it was not possible to differentiate between methods and tools. Both are mutually dependent. To categorize the methods and tools respectively we have looked at their purpose. Obviously the categorization corresponds to two further questions: the technological features used (QB4, see chapter 3.3.3) and the type of data produced (QC6b). We could differentiate

[21] We categorized respondents as early adopters if their first involvement in e-Infrastructure was before 2000.

between eight different functions of new methods and tools which are distributed as shown in table 3.10.

Table 3.10: Function of new methods and tools

Function	Frequency	In %
Generation or analysis of qualitative data	83	57.2%
Generation or analysis of quantitative data	83	57.2%
Visualisations	73	50.3%
Building a database (including data grids, data management systems, ontologies, digital libraries, data curation, data repositories, etc.)	38	26.2%
Simulation	14	9.7%
GIS	9	6.2%
Expert-knowledge systems	6	4.1%
No category/other/unclear (e.g. specialized search engine, e-learning tools)	5	3.4%
Communication	3	2.1%
Total responses	145*	100%

* Multiple functions per response are possible.
Source AVROSS WP2 survey

The assignment of the method to one or more of the categories has not been clear in some cases. Hence the figures have to be treated cautiously.

The generation or analysis of data is the most important purpose of the newly developed methods. Many of the methods are designed for both, quantitative and qualitative data. This holds for 51 (35.2%) of the projects. Fairly common are also visualisations which were included in around half of the responses that answered the questions on new tools or new methods.

As different disciplines have different demands on their methodological toolboxes we expect some differences between the humanities, social sciences and sciences. Percentages in table 3.11 correspond to all projects in the particular discipline having developed new methods or tools. The number of cases in each cell is relatively small. Hence differences between percentages may be stochastic. However, there are a few obvious things to claim. Researchers of the different fields struggle with different problems. Particularly they treat different kinds of data and have different necessities to represent them. The need for tools or methods to analyze or generate quantitative data is less frequent in the humanities compared to other disciplines. However, researchers from the humanities prefer visualisations more than their colleagues from other disciplines.

Table 3.11: Function of new methods and tools by discipline included in the project[a]

Function	Humanities		Social Sciences		Natural Sciences	
	Freq.	In %	Freq.	In %	Freq.	In %
Generation or analysis of qualitative data	21	63.6%	35	49.2%	12	52.2%
Generation or analysis of quantitative data	13	39.4%	37	62.7%	11	47.8%
Visualisations	21	63.6%	29	49.2%	8	34.8%
Building a database	13	39.4%	12	20.3%	5	21.7%
Simulation	2	6.1%	6	10.2%	1	4.3%
GIS	2	6.1%	6	10.2%	1	4.3%
Expert-knowledge systems	1	3%	2	3.4%	0	0.0%
no category / other / unclear	1	3%	2	3.4%	1	4.3%
Communication	1	3%	0	0.0%	2	8.7%

a Smaller frequencies compared to the previous table are due to missing discipline variables.
Source AVROSS WP2 survey

Outcomes, user constituencies and country of the project

The different output categories do not vary too much by country/region of the respondent. Publications and new methods resulted less often from the projects in the other countries (Canada, Australia, New Zealand etc.) and new data and collaborations less often in the UK (see Table 3.12).

Table 3.12: Project outcomes by country of the project

Outcomes	UK		Continental Europe		USA		Other countries	
	N	% of valid N	N	% of valid N	N	% of valid N	N	% of valid N
Publications	47	84%	43	92%	48	85%	10	77%
Patent applications	1	0%	0	4%	1	3%	0	0%
New methods	47	82%	37	82%	36	89%	9	75%
New data	41	71%	32	81%	30	82%	11	92%
New tools	47	91%	41	85%	39	82%	16	94%
Follow-on collaborations	51	81%	39	88%	37	91%	16	94%
Others	10	44%	4	58%	7	71%	1	100%

Question C5 by country of the respondent.
Source: AVROSS WP2 survey.

We also attempted to use the response to this question to approximate the outcome of a project more generally by counting how many items were identified as outputs. Although this is a relatively weak indicator of depth, since, for example, one publication is valued as much as many, it is an indicator of the breadth, and hence possibly the maturity, of the project. Overall the 220 respondents which provided information on projects listed an average output of 4.2 out of the 7 different types provided in question C7. Our analysis suggested that projects from the other countries are the ones with the broadest array of outcomes, averaging 4.7 per project. This is followed by the US (4.5), continental Europe (4.1) and the UK (3.7).

About 180 respondents answered the questions dealing with their user constituency: 129 said there was a constituency for their work, 58 did not. The list of the domains of their constituency is provided in Table 3.13 (see also question QC8) – again, the four fields of interest to the project appear to be well represented. It is worth noting, however, that a number of additional constituencies were identified, including statistics, geospatial analysis, tourism classics, law enforcement institutions, anthropology, government departments and agencies, art history, government and industrial planners, ethnography anthropology, indigenous users, general public teaching, community non-profit groups, people with disabilities, government policy analysts, public media studies, natural resource management, policy-making, and decision support.

Table 3.13: User constituency

Domain areas for constituency of users	Constituency applies	Proportion of projects with this domain as a constituency
Agricultural Sciences	9	7.0%
Engineering & technology	16	12.4%
Electrical engineering, electronic engineering, information engineering (hardware)	*8*	*6.2%*
Engineering & technology (civil, mechanical, chemical, materials, environmental or medical engineering, bio- or nanotechnology, others)	*14*	*10.9%*
Humanities	69	53.5%
Archaeology	*18*	*14.0%*
Art (arts, history of arts, performing arts, music)	*34*	*26.4%*
History	*33*	*25.6%*
Languages and literature (excluding linguistics)	*27*	*20.9%*
Linguistics (including computational linguistics)	*27*	*20.9%*
Other Humanities	*29*	*22.5%*
Philosophy, ethics, religion	*9*	*7.0%*
Medical and Health sciences	22	17.1%
Natural sciences	55	42.6%
Natural sciences (mathematics, physical, chemical, biological sciences, earth & environmental sciences, other natural sciences	*31*	*24.0%*
Computer and information sciences (software)	*38*	*29.5%*
Social sciences	92	71.3%
Economics and business	*20*	*15.5%*
Educational sciences	*45*	*34.9%*
Law	*15*	*11.6%*
Political science	*25*	*19.4%*
Psychology	*26*	*20.2%*
Social and economic geography, regional science	*43*	*33.3%*
Sociology	*47*	*36.4%*
Others	21	16.3%

Source: AVROSS WP2 survey.

The breadth of this user constituency, i.e. the number of different fields listed among it, shows again substantial variation by region of the project. The average US project has users from 4.8 academic domains. In contrast, the average continental European and UK project has users from 3.8 academic domains.

Surprisingly the breadth of the user constituency, as measured by the number of disciplines represented, decreases with the length of the project duration. Short-term projects have users from 4 fields, medium-term projects from 3.4 and long-term projects from 2.6 fields.

Outcomes, user constituencies and discipline of the project

Although one might expect there to be substantial variation in outcomes across discipline, this is not the case. As table 3.14 shows, projects that had a user constituency in the social sciences were more likely to mention tools as an important outcome; this result holds even when weighted by the number of times an outcome was mentioned.

Table 3.14: Outcomes by major discipline of the user constituency
(% of all responses in the discipline listing an output for a project)

	Humanities	Social Sciences	Neither humanities nor social sciences
Publications	85.2%	89.4%	86.5%
Patent applications	6.3%	3.8%	2.1%
New methods	88.9%	88.4%	83.8%
New data	75.0%	77.5%	79.2%
New tools	84.6%	94.1%	86.7%
Follow-on collaborations	99.9%	81.3%	87.7%
Others	42.9%	84.6%	61.1%

Source: AVROSS WP2 survey.

There are other measures of project depth and breadth. One measure is to calculate, for each project, whether a discipline represented within a project has developed a user constituency within that same discipline. The proportion of such projects is reported in the middle column in Table 3.15, and ranges from about half (in education, languages and natural sciences) to under a quarter (in computer and information sciences). The last statistic is to be expected, given the fact that computer and information sciences are typically engaged in providing e-Infrastructure to other disciplines rather than their own. Turning the question around, we also calculated, for each user constituency that was identified, whether or not that discipline was represented in the project. This set of results is reported in the second column of the table, and the range is much higher. Almost all disciplinary constituencies that are reached are reached by a project that includes a researcher with the same discipline as the user constituency. There are a number of possible interpretations of this intriguing result. It could be that projects are developed by researchers in given disciplines because they have specific disciplinary needs in mind. It could also be that researchers in a project already have a dissemination network in place that is discipline specific, and that knowledge about the project is transmitted through such disciplinary networks. These different possibilities have useful, but differing, implications for the structure of funding and should be explored in a broader scientific study.

Table 3.15: The interaction between project disciplines and the disciplines of user constituencies

	Proportion of identified project disciplines with constituency in same discipline[a]	*Proportion of constituencies identified with the same discipline as the project*[b]
Agricultural Sciences	58.3%	77.8%
Engineering and Technology	46.4%	81.3%
Electrical engineering, electronic engineering, information engineering (hardware)	*35.3%*	*75.0%*
Engineering & technology (civil, mechanical, chemical, materials, environmental or medical engineering, bio- or nanotechnology, others)	*47.4%*	*64.3%*
Humanities	50.5%	79.7%
Archaeology	*50.0%*	*72.2%*
Art (arts, history of arts, performing arts, music)	*57.1%*	*70.6%*
History	*47.8%*	*66.7%*
Languages and literature (excluding linguistics)	*54.3%*	*70.4%*
Linguistics (including computational linguistics)	*44.4%*	*74.1%*
Other Humanities	*38.5%*	*51.7%*
Philosophy, ethics, religion	*31.3%*	*55.6%*
Medical and Health sciences	27.6%	36.4%
Natural sciences	35.2%	90.9%
Natural sciences (mathematics, physical, chemical, biological sciences, earth & environmental sciences, other natural sciences)	*51.1%*	*74.2%*
Computer and information sciences (software)	*24.4%*	*86.8%*
Social sciences	50.3%	83.7%
Economics and business	*31.1%*	*70.0%*
Educational sciences	*50.0%*	*60.0%*
Law	*33.3%*	*40.0%*
Political science	*35.1%*	*52.0%*
Psychology	*40.0%*	*46.2%*
Social and economic geography, regional science	*48.4%*	*72.1%*
Sociology	*45.8%*	*70.2%*
Others	28.9%	61.9%

a Read as follows: 58.3% of the projects with agricultural scientists on the team had also agricultural science as user constituency.

b Read as follows: 77.8% of the projects with agricultural science as the user constituency also had agricultural scientists on the team.

Source: AVROSS WP2 survey.

Looking again at the fields highlighted in this work-package we see only little differences in the extent to which they produce the most frequent outcome, publications (see Table 3.16). Some differences appear for new methods which result less often in any of the five fields, and clearly less often in projects with economics & business participation. New tools and follow-on collaborations, on the other hand, result less often from archaeology projects.

Table 3.16: Outcomes of e-Infrastructure projects by fields targeted by the project

	Archaeo-logy	Economics and business	Sociology	Social geogra-phy, regional science	Linguistics	All projects
Publications	82.4%	81.1%	84.7%	80.0%	81.1%	86.5%
Patent applications	6.7%	4.8%	2.8%	2.9%	0.0%	2.1%
New methods	75.0%	66.7%	72.2%	82.6%	77.1%	83.8%
New data	78.9%	79.3%	80.0%	73.5%	84.8%	79.2%
New tools	73.7%	88.6%	80.0%	87.8%	86.5%	86.7%
Follow-on collaborations	78.9%	84.8%	86.2%	83.7%	86.1%	87.7%
Others	40.0%	69.2%	50.0%	66.7%	72.7%	61.1%

Source: AVROSS WP2 survey.

Roundabout three quarters of projects with archaeologists and linguists had a user constituency; in sociology and geography/regional science this percentage went down to two-thirds and in economics to only 55%.

Outcomes, user constituencies and duration of the project

As might be expected, the number of results reported for a project increases the longer the project lasts, as is evident from an examination of Table 3.17. There are, however, two exceptions: some long-term projects of more than three years have not produced any publications and new data is even less often an outcome in mid-term and long-term projects than in short-term projects. Hence, the generation of new data obviously does not need a long-term arrangement.

Table 3.17: Outcome by project duration

	Short-term (up to 18 months)	Medium-term (19-36 months)	Long-term (more than 36 months)	Valid N
Publications	69.7%	94.5%	83.9%	137
Patent applications	0.0%	2.4%	5.6%	83
New methods	78.1%	83.3%	90.0%	128
New data	81.3%	77.8%	68.0%	120
New tools	81.8%	87.5%	93.9%	138
Follow-on collaborations	81.8%	88.4%	93.3%	132

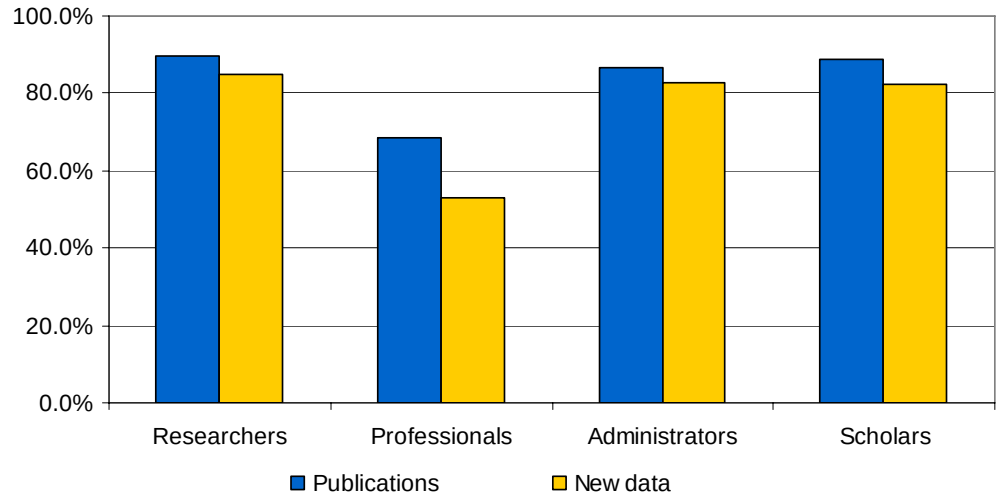
Source: AVROSS WP2 survey.

The relationship between project duration and the existence of a user constituency is difficult to interpret: seven out of ten short-term projects reported such a constituency, compared with six out of ten for medium-term projects and eight out of ten for long-term projects. It would be interesting to probe the reasons for this non-monotonicity in a broader reaching study.

Outcomes, user constituencies and activity profile of the respondent

Respondents with different activity profiles reported working on projects with very different outcomes (see section 3.2.2). Those respondents whose time allocation fit a professional's activity profiles were engaged in projects that produced fewer results than projects of the other respondent categories. In particular, these projects produced less often publications (only 70% of the projects compared to 90% for the other respondents) and new data (50% compared to 80% for the other respondents, see Figure 3.20).

Figure 3.20: Percentages of projects producing publications and new data by activity profiles



Data for this figure in annex I.3, table A.6.
Source: AVROSS WP2 survey.

There are also substantial differences in whether the respondent's project has developed a user constituency. Indeed, "only" two thirds of the scholars and researchers were working on projects that had developed such a constituency, compared with three quarters of the professionals and administrators. This may, of course, reflect a project's life cycle, where young projects are more likely to engage researchers, and more mature projects, which have developed a constituency, need administrators and professionals

Table 3.18: Percentages of projects with a user constituency by activity profiles

	User constituency
Researchers (n=51)	66.7%
Professionals (n=21)	76.2%
Administrators (n=35)	74.3%
Scholars (n=78)	65.4%
All respondents (n=158)	68.6%

Source: AVROSS WP2 survey.

In sum, the projects which were described by the professionals are more likely to be application-oriented, whereas projects described by researchers and scholars are stronger in the science dimension. The administrators' projects seem to incorporate both a scientific orientation and user focus.

3.4 e-Infrastructure adoption

In addition to project-related information, the survey also collected, in particular in its question B5 and section D, information on the factors influencing the adoption of e-Infrastructure technologies.

3.4.1 Sources of information contributing to e-Infrastructure use

Some insight into the factors contributing to the decision of researchers to use e-Infrastructure is provided by their responses to Question B5 on the sources of information and know-how. Not surprisingly, most cited the importance of human interaction: other scientists, colleagues or collaborators were very important or important sources of information for almost 9 out of 10 respondents (see table 3.19). Infrastructure and administration people from other organizations (e.g. research networks, ministries, funding bodies, etc.) were also important for roundabout 80%. The own infrastructure and administration support staff and meetings and workshops were still important for 60% of the respondents. A minor role was attributed to journals and other printed information. As noted in earlier questions, there is substantial heterogeneity in the verbatims (see annex I.4, p. 188).

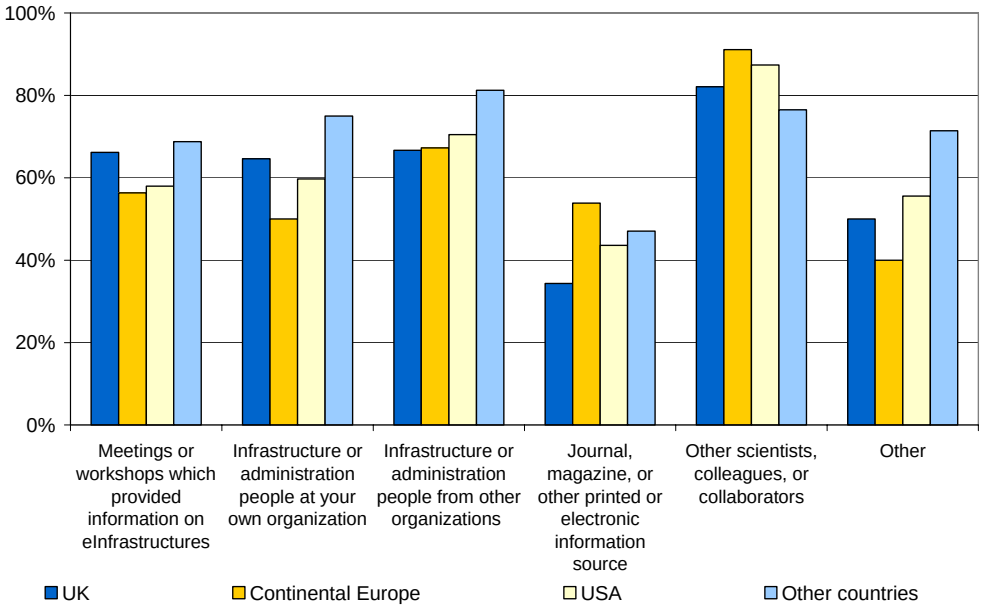
Table 3.19: Sources of information about e-Infrastructure (in % of responses)

Source	Very important	Somewhat important	Neutral	Somewhat unimportant	Not at all important
Meetings or workshops which provided information on e-Infrastructure	29.0%	29.0%	20.8%	9.7%	11.6%
Infrastructure or administration people at your own org.	31.6%	28.2%	13.6%	11.2%	15.5%
Infrastructure or administration people from other org.	32.4%	38.1%	17.1%	4.3%	8.1%
Journal, magazine, or other printed or electronic information source	13.2%	30.4%	26.5%	12.7%	17.2%
Other scientists, colleagues, or collaborators	54.5%	32.9%	9.4%	1.9%	1.4%
Other (see annex I.4)	52.8%	2.8%	30.6%	0.0%	13.9%

Source: AVROSS WP2 survey.

Though the rating of the information sources shows some similarities there are also some differences between the regions of the respondents (see Figure 3.21): the influence of infrastructure people is higher in the other countries category, as is the importance of meetings and workshops. Infrastructure and administration people at the respondents' organizations were less often important in continental Europe than in the UK or the US – printed information, however, was slightly more often important. This could indicate less interaction between computer infrastructure services and scientists in the continental European research environment.

Figure 3.21: Percentage of respondents assessing the following sources of information as very or somewhat important by region



See table A.7 in annex I.3 on the data.

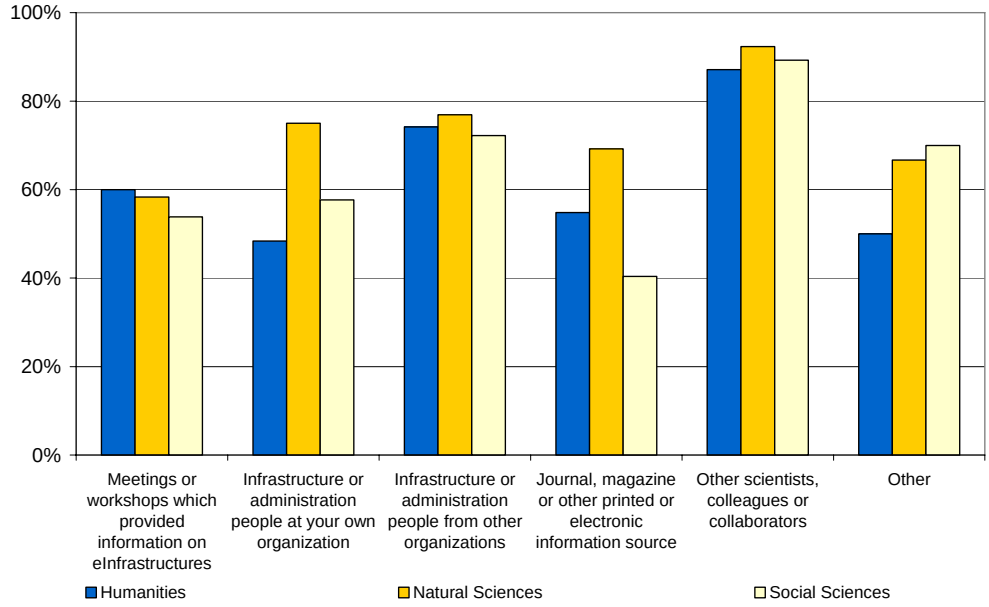
Source: AVROSS WP2 survey.

Disciplinary differences in the sources of information

One of the questions (Question B5) probed what sources of information and know-how were important in the respondent's decision to begin using e-Infrastructure. Though the rating of information sources is generally quite similar across projects in the humanities, social sciences and natural sciences, there are some notable variations (see Figure 3.22):[22] It is particularly interesting that infrastructure people from the respondents' own organizations are less influential for social scientists and humanities researchers than for natural scientists. The same applies to printed information.

[22] We subsumed a project to a research field division according to the Frascati classification only if the majority of the involved domain areas belonged to the division.

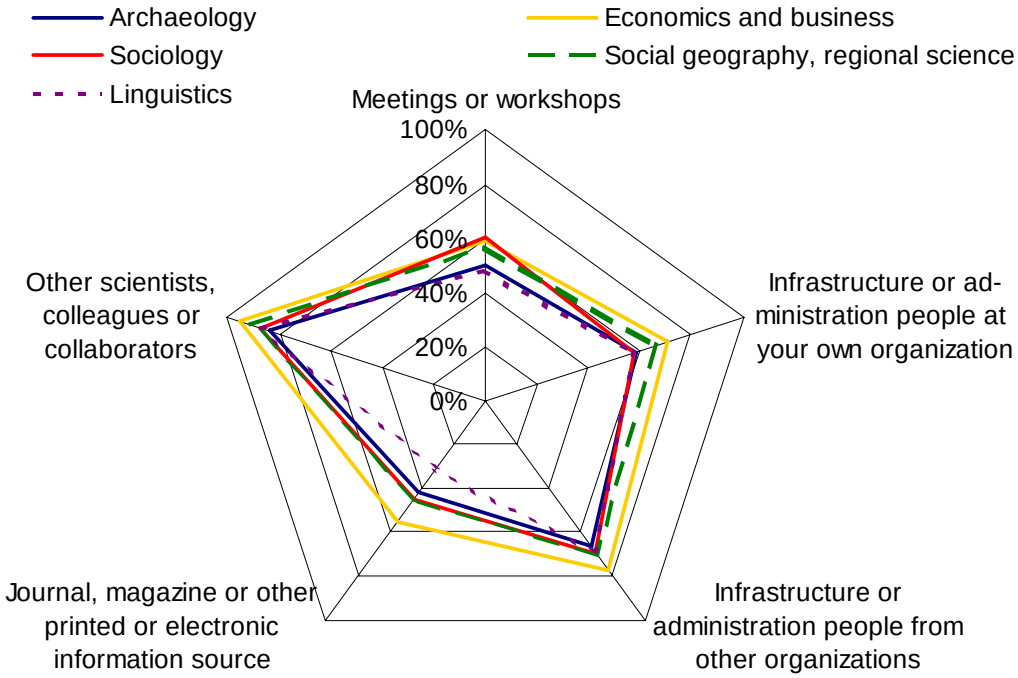
Figure 3.22: Percentage of respondents assessing the following sources of information as very or somewhat important classified by discipline



See table A.8 in annex I.3 on the data.

Source: AVROSS WP2 survey.

Figure 3.23: Source of information on e-Infrastructure by field of the project (% of respondents who considered a source as very or somewhat important)



See table A.9 in annex I.3 on the data.

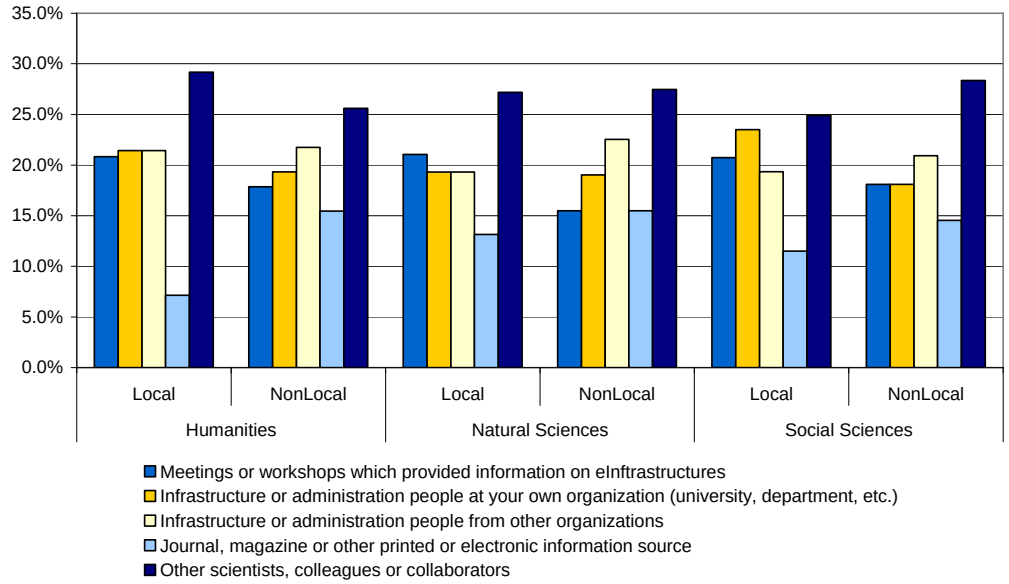
Source: AVROSS WP2 survey.

Figure 3.23 provides another way of comparing the importance of different information sources in different fields of research. In particular, respondents in projects with economists and business administrators rate all the information sources as more important than respondents from the other fields. The humanities projects, in particular linguists but also archaeologists, consider meetings and workshops as well as journals and other printed information to be less important.

Location of collaborators and sources of information

As with all the rest of the responses, there is some heterogeneity both by discipline and by whether the respondents collaborators are essentially local or non-local. The importance of other scientists in spreading information about e-Infrastructure is important in all projects (see Figure 3.24). The role of journals, magazines and other printed sources is more important for respondents having predominantly non-local collaborators than for those having local collaborators, whereas meetings or workshops are of less importance (the other information sources are more or less of similar importance). For instance, only 7% of the respondents with local collaborators in humanities projects consider printed material to be important, compared with 15% of the respondents. This could indicate that printed information on e-Infrastructure are more important for those who are less integrated in their local communities. These people can be reached with printed information on e-Infrastructure, though they also generally depend more on human interaction.

Figure 3.24: Source of information by discipline and location of collaborators (% of respondents who considered a source as very or somewhat important)



See table A.10 in annex I.3 on the data.

Source: AVROSS WP2 survey.

e-Infrastructure adoption and sources of information

There are no clear differences between current and former users regarding the sources of information (c.f. table 3.20). Current users attribute even less importance than do former users to written information in journals.

Table 3.20: Source of information of current and former users

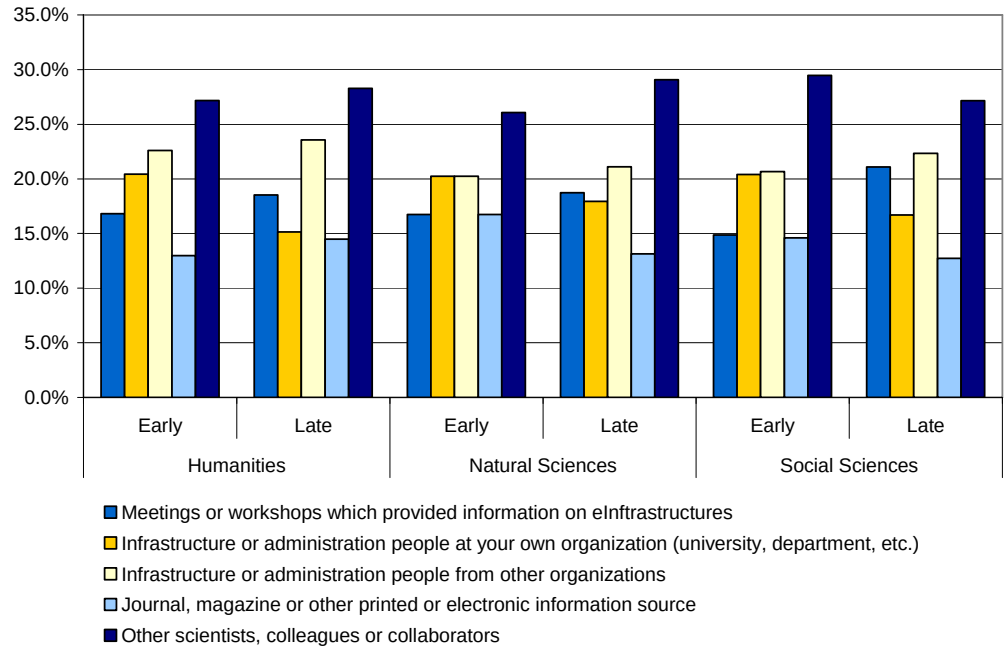
	Current users		Former users	
	N	Mean*	N	Mean*
Meetings or workshops which provided information on e-infra.	156	2.3	31	2.5
Infrastructure or administration people at your own org.	157	2.3	29	2.2
Infrastructure or administration people from other org.	158	2.1	32	1.9
Journal, magazine or other printed or electronic inf. source	154	2.7	31	2.4
Other scientists, colleagues or collaborators	160	1.6	32	1.7

* Arithmetic means of responses on the scale from 1 = very important to 5 = very unimportant.

Source: AVROSS WP2 survey.

It is also interesting to compare the differences in information sources between early and late adopters.[23] In the projects which involve disciplines from the social sciences, meetings and workshops as well as other organizations are much more frequently mentioned for late adopters than for early adopters (see Figure 3.25). The role of the written word, notably journals, seems to be much less important – possibly because of the associated time lag.

Figure 3.25: Source of information by discipline and adoption date
(% of respondents who considered a source as very or somewhat important)



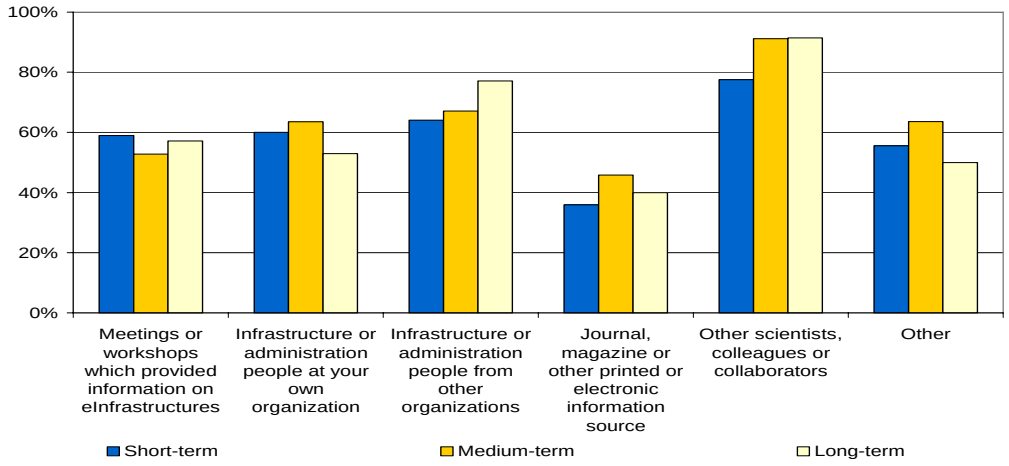
See table A.11 in annex I.3 on the data.

Source: AVROSS WP2 survey.

There appear to be very little differences in the assessment of the importance of different sources of information by length of project (see Figure 3.26). Indeed, for all project lengths, the most important source is the peer group of the scientists: other scientists, colleagues or collaborators.

[23] See adopters section on pp. 24f.

Figure 3.26: Source of information by length of the current project
(% of respondents who considered a source as very or somewhat important)



See table A.12 in annex I.3 on the data.
Source: AVROSS WP2 survey.

3.4.2 Potential catalysts in the adoption of e-Infrastructure technology

The respondents were also asked to identify the important factors that were particularly important in their development of or work with e-Infrastructure, and the results are reported in Table 3.19 (see QD1 in the annexed questionnaire). Not surprisingly, given our earlier review of the literature, the overwhelming view of the respondents was that three factors were of critical importance: seed funding, collaboration, and the possibility of doing interesting research. Interestingly, given the regional differences in funding levels observed in the previous section, there were no regional differences in this view. Respondents from all regions felt that seed funding from an outside agency, collaboration and expected contribution to interesting research were the most important factors driving adoption.

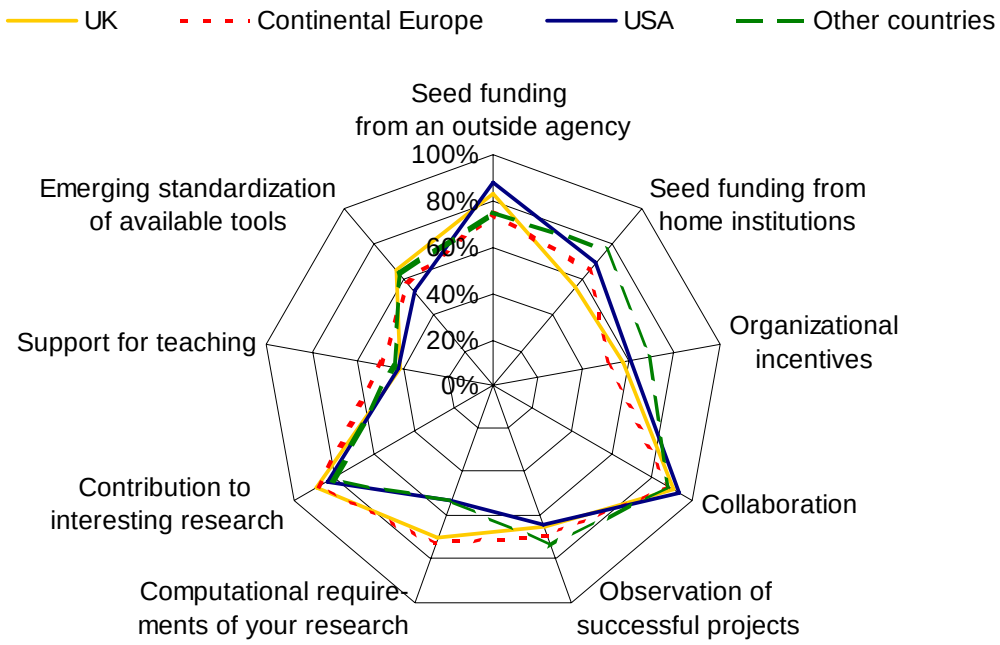
Table 3.21: Catalysts for e-Infrastructure (in % of valid responses)

Catalyst	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Seed funding from an outside agency	57.8%	23.1%	9.2%	2.9%	6.9%
Seed funding from home institutions	34.5%	30.4%	15.2%	9.4%	10.5%
Organizational incentives within your institution	26.2%	31.5%	22.6%	6.5%	13.1%
Collaboration	65.4%	25.1%	7.8%	1.7%	0.0%
Observation of successful projects in other areas	25.1%	41.9%	22.2%	6.6%	4.2%
The computational requirements of your research	31.8%	31.8%	22.4%	6.5%	7.6%
Contribution to interesting research expected	54.3%	31.2%	12.7%	0.0%	1.7%
Support for teaching activities	15.2%	28.7%	24.6%	17.0%	14.6%
Emerging standardization of available tools	23.2%	35.7%	19.6%	13.1%	8.3%

Source: AVROSS WP2 survey.

There appear to be few regional differences in catalysts, with two notable exceptions (see Figure 3.27). Respondents from the USA were more likely than those from the European continent to point to the beneficial character of external seed funding and/or seed funding from the home institutions. And European respondents, both from the UK and continental Europe, highlighted the computational requirements of their research as a catalyst for e-Infrastructure adoption.

Figure 3.27: Catalysts for e-Infrastructure adoption by country of the respondent (% of respondents who considered this catalyst as very or somewhat important)



See table A.13 in annex I.3 on the data.

Source: AVROSS WP2 survey.

Disciplinary differences between catalysts

There was not much variation by major discipline. As is evident from table 3.22, respondents involved in projects from the humanities, natural sciences and social sciences alike pointed to the importance of collaborators, seed funding from outside agencies and contributions to existing research as their top three catalysts.

When we break out the results by whether the scientists are local or non-local in their research collaborations, however, table 3.23 reveals a striking difference among the social sciences: Those that are locally oriented emphasise the role of collaboration; those with a more widespread base of collaborators emphasise seed funding, interesting research and observation of successful projects.

Table 3.22: Catalysts for work with e-Infrastructure by discipline
(responses who considered a catalyst as important in % of all responses)

Catalyst	Humanities	Social Sciences	Neither humanities nor social scienc
Seed funding from an outside agency	62.0%	76.9%	81.6%
Seed funding from home institutions	78.9%	42.3%	64.9%
Organizational incentives within your institution	63.2%	45.8%	57.7%
Collaboration	97.3%	81.5%	90.5%
Observation of successful projects in other areas	63.2%	54.2%	67.1%
The computational requirements of your research	50.0%	45.8%	63.5%
Contribution to interesting research expected	86.5%	73.1%	85.5%
Support for teaching activities	51.4%	48.1%	43.9%
Emerging standardization of available tools	60.5%	56.0%	58.9%

Source: AVROSS WP2 survey.

Table 3.23: Catalysts for e-Infrastructure adoption by discipline in the project and location of the collaborators of the respondent
(respondents who considered this catalyst as important in % of all respondents)

	Humanities		Social Sciences		Neither humanities nor social sciences	
Catalysts	Local	Non-local	Local	Non-local	Local	Non-local
Seed funding from an outside agency	100%	84.4%	66.7%	78.3%	86.7%	84.7%
Seed funding from home inst.	75%	78.8%	66.7%	39.1%	58.3%	65.5%
Organizational incentives within your institution	50%	63.6%	66.7%	42.9%	50.0%	60.3%
Collaboration	75%	100%	66.7%	83.3%	92.8%	93.4%
Observation of successful projects in other areas	75%	60.6%	0%	61.9%	72.7%	67.9%
The computational requirements of your research	25%	53.1%	66.7%	42.9%	60.0%	75.4%
Contribution to interesting research expected	100%	84.8%	66.7%	73.9%	100.0%	93.0%
Support for teaching activities	75%	46.9%	33.3%	50.0%	30.8%	42.9%
Emerging standardization of available tools	100%	54.5%	33.3%	59.1%	61.5%	58.9%

Source: AVROSS WP2 survey.

We can also examine the views of respondents about key catalysts by whether they adopted e-Infrastructure technologies before or after 2000 (early or late adopters). We report the results in Table 3.24. The results do not vary systematically by date of adoption or by discipline. Both early and late adopters report that collaboration is an important catalyst, regardless of their discipline, and identify initial seed funding as important.

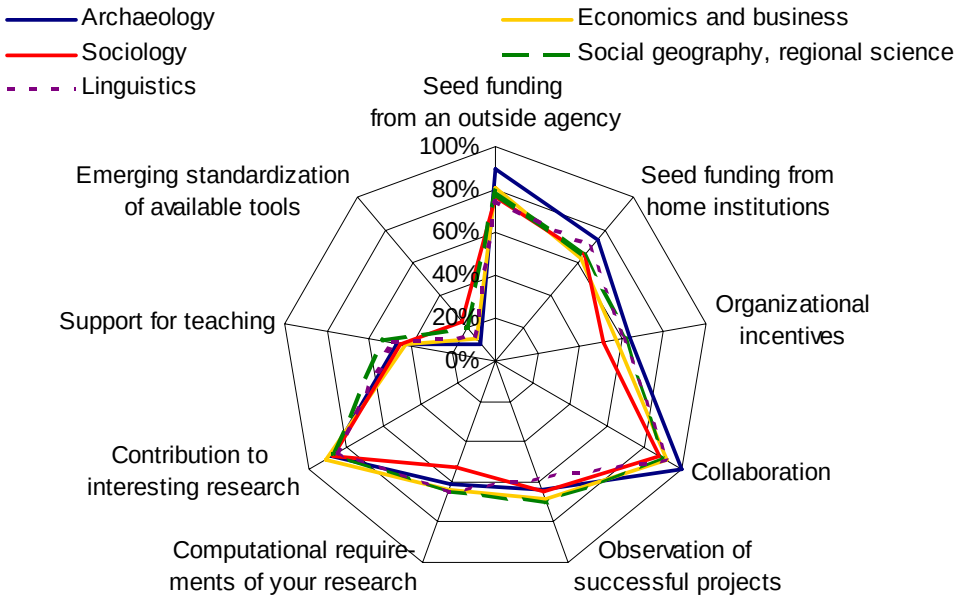
Table 3.24: Catalysts for e-Infrastructure adoption by discipline in the project and year of e-Infrastructure adoption of the respondent
(respondents who considered this catalyst as important in % of all respondents)

	Humanities		Social Sciences		Neither humanities nor social sciences	
Catalysts	Early	Late	Early	Late	Early	Late
Seed funding from an outside agency	82.4%	81.8%	100.0%	53.8%	88.9%	86.5%
Seed funding from home institutions	88.9%	75.0%	50.0%	16.7%	69.2%	61.1%
Organizational incentives within your institution	61.1%	66.7%	33.3%	41.7%	59.3%	60.0%
Collaboration	100.0%	90.9%	100.0%	69.2%	96.6%	89.2%
Observation of successful projects in other areas	72.2%	66.7%	42.9%	63.6%	75.0%	58.8%
The computational requirements of your research	52.9%	50.0%	42.9%	45.5%	57.7%	77.8%
Contribution to interesting research expected	94.4%	83.3%	75.0%	66.7%	92.3%	94.4%
Support for teaching activities	61.1%	36.4%	50.0%	46.2%	34.6%	51.5%
Emerging standardization of available tools	55.6%	58.3%	75.0%	54.5%	63.0%	59.4%

Source: AVROSS WP2 survey.

Focussing on the five fields of interest, as reported in Figure 3.28, it is clear that there are not large differences across fields. Indeed, the percentage of respondents who ranked a catalyst as important are more or less the same. Seed funding from an outside agency or the home institution was a little bit more important for projects with archaeologists; the result is similar for collaboration. Factors such as organisational incentives and the computational requirements of the research seem to be lower for projects with sociologists.

Figure 3.28: Catalysts for work with e-Infrastructure in five fields
(% of responses who considered a catalyst as important)

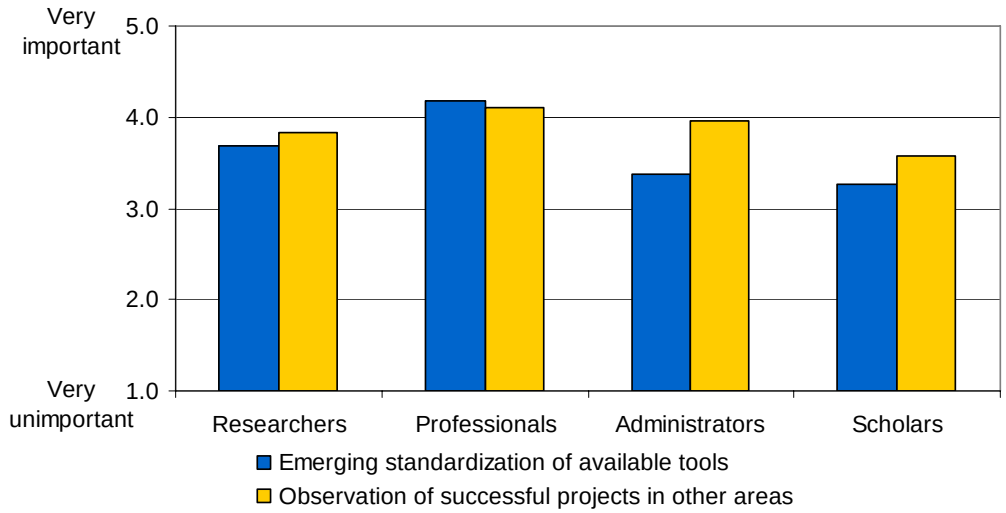


Data for this figure in annex I.3, table A.14.
Source: AVROSS WP2 survey.

Catalysts and activity profiles

The catalysts to e-Infrastructure involvement can also be differentiated between the four groups of activity profiles. The groups differ only for two of the listed catalysts (see Figure 3.29 and table A.15 in the annex I.3). In particular, professionals rate the emerging standardization of available tools to be more important than do the other groups of researchers, scholars and administrators. Professionals were more likely to respond that the observation of successful projects in other areas was an important catalyst, in contrast to the responses by scholars.

Figure 3.29: Catalysts for work with e-Infrastructure by activity profiles (arithmetic mean of the responses from 1=very unimportant to 5=very important)



Data for this figure in annex I.3, table A.15.
Source: AVROSS WP2 survey.

There are not strong differences between the way in which former and current e-Infrastructure users view the different catalysts. Both groups rate collaboration as the most important catalyst, followed by expected contribution to interesting research and seed funding of an outside agency.

3.4.3 Potential barriers in the adoption of e-Infrastructure technology

In addition to catalysts, the barriers to e-Infrastructure involvement were assessed in a separate question of the questionnaire (question D2 in the questionnaire).

Table 3.25 reports the respondents' views about key barriers to e-Infrastructure adoption. Although respondents' thought all factors were important, lack of funding, costs, and lack of qualified staff were most frequently identified. The verbatims were also eloquent (see annex I.4, p. 191). Again respondents from all regions, UK, continental Europe, USA, and beyond, agree on the importance. The lack of funding and the costs associated with e-Infrastructure were assessed as most important.

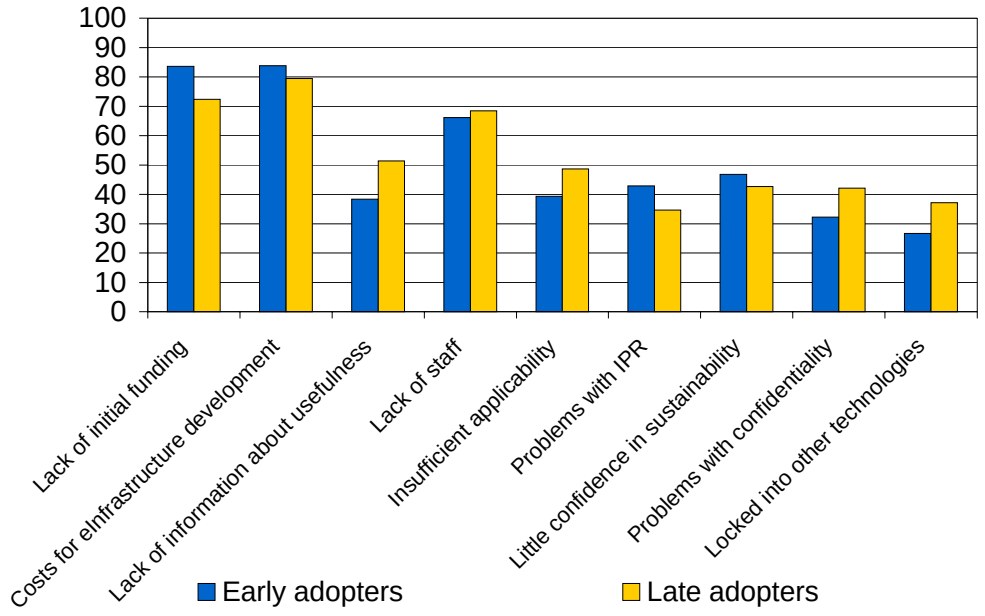
Table 3.25: Barriers to e-Infrastructure development (in % of valid N)

Barrier	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Lack of initial funding	45.3%	32.4%	9.4%	7.1%	5.9%
Costs associated with e-Infrastructure development	38.4%	40.7%	12.8%	4.7%	3.5%
Lack of information about usefulness	19.0%	28.8%	23.9%	14.1%	14.1%
Lack of staff available to help with development	33.5%	35.3%	15.3%	8.8%	7.1%
Insufficient applicability of existing technology to social science research problems	21.0%	26.9%	21.6%	14.4%	16.2%
Problems with intellectual property rights	10.1%	30.8%	24.3%	18.3%	16.6%
Lack of trust in sustainability	16.2%	29.9%	22.8%	13.2%	18.0%
Problems with protecting confidentiality of data	13.0%	27.8%	25.4%	16.0%	17.8%
Locked into other technologies	8.9%	22.2%	32.3%	16.5%	20.3%
Other	45.3%	32.4%	9.4%	7.1%	5.9%

Source: AVROSS WP2 survey.

The barriers are mostly similar for early and late adopters of e-Infrastructure (see Figure 3.30). However, three barriers seem to have increased in importance over time – more important for late than for early adopters: the lack of information on usefulness and the insufficient applicability to research problems might be a reflection of the fact, that more scientists got exposed to e-Infrastructures without having developed a need of their own in the first place. The higher importance of data confidentiality for late adopters probably reflects an increasing awareness.

Figure 3.30: Barriers to e-Infrastructure development by adoption year (responses who considered a barrier as important in % of all responses)



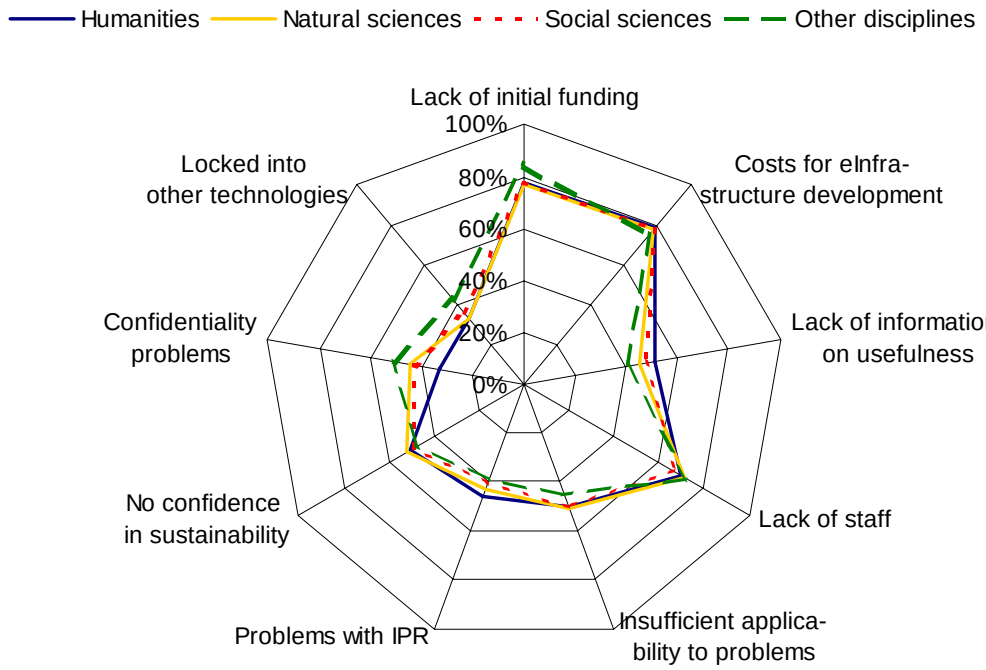
Source: AVROSS WP2 survey.

Respondents from all regions (continental Europe, UK, USA, other countries) agree on the importance of the same barriers. The lack of funding and the costs associated with e-Infrastructure were assessed as most important (see annex I.3, Table A.16). There are no noteworthy differences in regard to how the barriers are judged by current e-Infrastructure users compared to former users, interrupters or drop-outs either.

Disciplinary differences between barriers

Although disciplinary differences are of interest, one major challenge is that many projects are interdisciplinary, making them difficult to classify. Figure 3.31 reports the barriers by discipline without regard to how many disciplines were identified as key to the project. All disciplines attributed the highest importance to a lack of funding and a lack of staff. Researchers in humanities projects were more bothered by the lack of information on the usefulness of the technology and considerably less by confidentiality problems – IPR issues are only slightly more problematic for them (see Kaur-Pedersen & Kladakis, 2006).

Figure 3.31: Barriers for e-Infrastructure adoption by discipline in the project (% of respondents who considered this barrier as very or somewhat important)

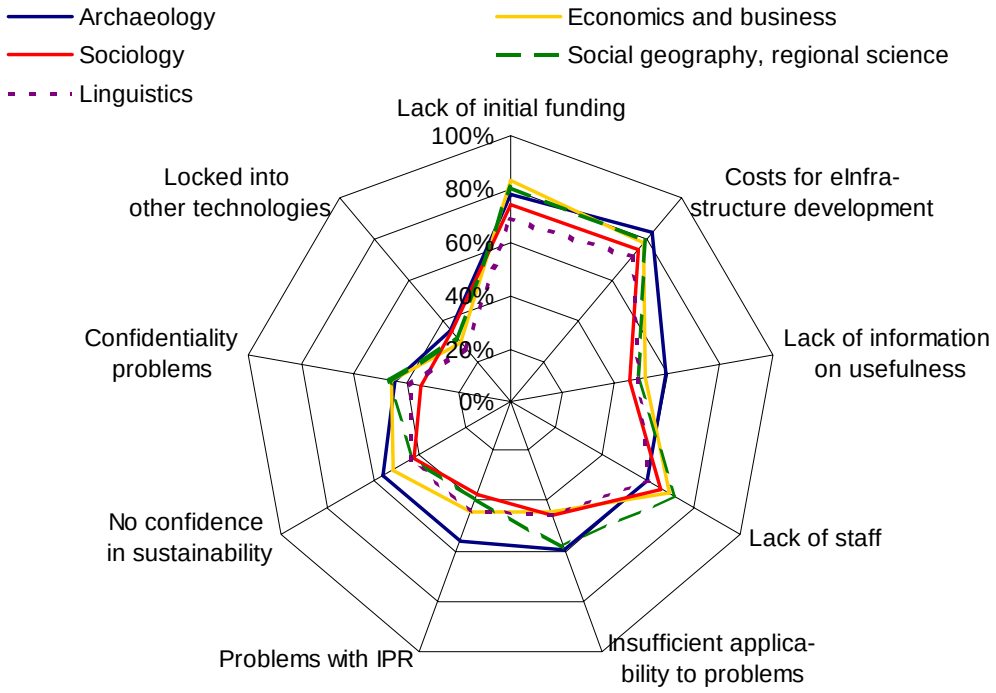


See table A.17 in the annex I.3 on the data.

Source: AVROSS WP2 survey.

The variation within broad categories is very evident in the next figure, which reports for the fields of our investigation, what respondents felt were the major challenges faced by their project, though the most important barriers of funding and costs were in all fields highly rated. Projects which had archaeology represented were clearly much more concerned about applicability, problems with IPR, and sustainability than those projects which did not; moreover, they more often lamented a lack of information on the usefulness of e-Infrastructure. Projects with geographers and regional scientists more often refer to a lack of staff to help with development and deployment as well as insufficient applicability and projects with economists rate lacking confidence in sustainability also higher than the other projects. One possible question that might thus be investigated in a further study would be the interdisciplinary heterogeneity of project challenges.

Figure 3.32. Barriers for e-Infrastructure adoption by field in the project
(% of respondents who considered this barrier as very or somewhat important)

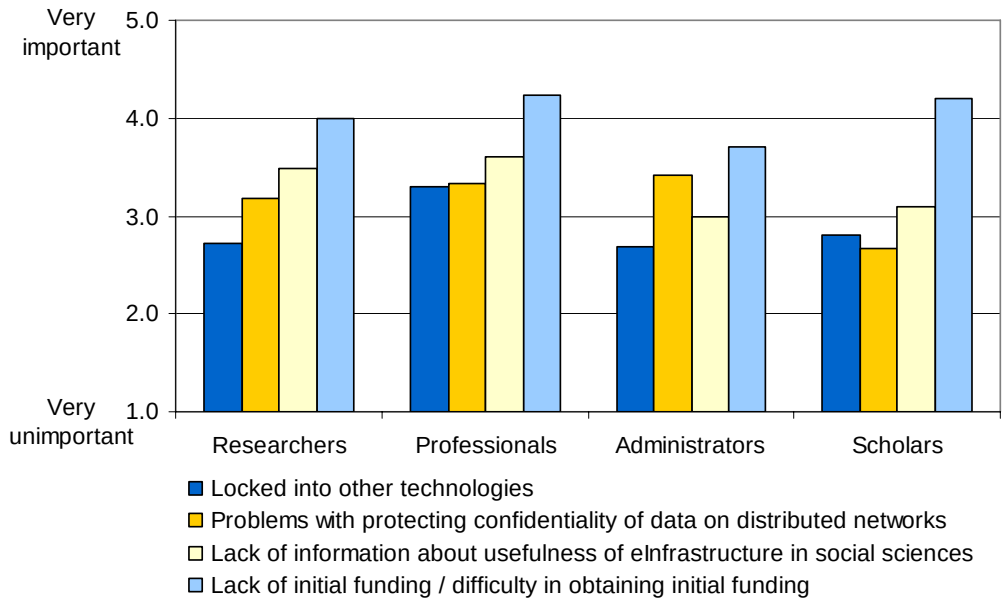


Data for this figure in annex I.3, table A.18.
Source: AVROSS WP2 survey.

Barriers and activity profiles

Differentiating the barriers by the main activities of the respondent also provides some interesting insights. The lack of initial funding is found less restricting by the administrators among the respondents (see Figure 3.33). The latter are also less burdened by the lack of information about the usefulness of e-Infrastructure in the social sciences and a lock-in into other technologies; both issues are found more important by professionals. Scholars state less problems with protecting the confidentiality of data on distributed networks than the other respondent groups – possibly because they deal more in a learning and teaching environment than the other respondents, which is less sensitive to this problem than the research environment.

Figure 3.33: Barriers for work with e-Infrastructure by activity profiles
(arithmetic mean of the responses from 1=very unimportant to 5=very important)



Data for this figure in annex I.3, table A.19.
Source: AVROSS WP2 survey.

3.5 Positive and negative lessons learned during the realisation of an e-Infrastructure project

3.5.1 Responses on positive and negative lessons learned

The questionnaire included questions on positive and negative lessons learned during the realisation of an e-Infrastructure project. The distinction between positive and negative was made, to make respondents aware of both sides of the medal. Up to 3 positive and 3 negative lessons could be listed. The questions were located close to the end of the online questionnaire. This probably explains why only 127 respondents or 28.3% of the total of 448 respondents undertook the effort to provide either positive or negative lessons or both.

Based on around one third of the responses a code system was developed by a senior researcher and then implemented for the remainder of the responses by a research assistant. The codes, code labels and selected examples of the corresponding responses are shown in annex I.5 (see pp. 192ff.). In the coding each non-empty response received at least one code. Complex responses may have received up to five different codes for each, positive and negative lessons. The respondents did not clearly distinguish between positive and negative lessons and partially included similar issues with different wording under both headings. Each code is given only once per respondent.

Table 3.26 shows the frequencies of the responses. We can see that a broad range of positive and negative issues was listed: users' perspectives and needs were addressed in many different responses (1, 13, 18 and 23); other lessons which resulted from the realisation of e-Infrastructure projects cover aspects of collaboration and communication (6, 8, 16 and 34), staff and funding (4, 33 and 5), technological (9, 11, 14, 29 and 32), institutional (3), legal (21), and management (22) issues. A couple of key issues need to be discussed in more detail.

Table 3.26: Responses on positive and negative lessons (QD3 and QD4)

No.	Response	Frequency	In %
1	Consider user and other participants perspectives and needs	46	36.2%
2	Other lessons (not e-Infrastructure related)	40	31.5%
3	Positive and negative influences of the field and institutional environment on e-Infrastructure are important	39	30.7%
4	Importance of human factor, problems with finding good staff and skills	35	27.6%
5	Importance of funding, problems with funding, cost issues	31	24.4%
6	Problems of collaboration and communication	26	20.5%
7	Supporting interdisciplinarity for e-Infrastructure	24	18.9%
8	Collaboration works and pays	22	17.3%
9	Technological limitations of e-Infrastructure	22	17.3%
10	Other lessons (e-Infrastructure related)	19	15.0%
11	Software & middleware elements and technological configuration of e-Infrastructure are important	18	14.2%
12	Connect to other projects, exemplars, frameworks, peers	17	13.4%
13	Problems of establishing and managing interdisciplinarity	14	11.0%
14	Solving issues of data/metadata	14	11.0%
15	Issues of timing	14	11.0%
16	Benefits of e-Infrastructure for communication and collaboration	13	10.2%
17	Research-related benefits of e-Infrastructure	13	10.2%
18	Proactiveness, bringing new tools to users a.s.a.p. brings success	13	10.2%
19	General positive effects of e-Infrastructure	12	9.4%
20	Positive contribution of e-Infrastructure to scholarship, teaching and learning	10	7.9%
21	Problems with legal issues and finding solutions	10	7.9%
22	Importance of project design & management	10	7.9%
23	Engage in community-building	10	7.9%
24	Care for sustainability after project completion	9	7.1%
25	Don’t place too high expectations on e-Infrastructure	9	7.1%
26	Problems of tool development	6	4.7%
27	Importance of flexibility	6	4.7%
28	Benefits of e-Infrastructure regarding data	6	4.7%
29	Advantages of standards and open source	6	4.7%
30	Hardware issues	5	3.9%
31	Disadvantages of standards	4	3.1%
32	General negative effects of e-Infrastructure	3	2.4%
33	Composition of the research & project team	3	2.4%
34	Disadvantages of e-Infrastructure for communication and collaboration	2	1.6%

Source: AVROSS WP2 survey.

1. *Interaction with users and other stakeholders.* Forty-six out of the 127 respondents mentioned the necessity and benefits of taking users' and other stakeholders' perspectives and needs into account. Adding the 14 responses that mention problems of interdisciplinarity (no. 13) (which frequently also evolve from the cooperation of computer scientists and lead users), those that stress the necessity of community building (no. 23) and early user feedback (no. 18), we obtain more than half of the respondents stressing the key role of the users in e-Infrastructure development and deployment. The following quotes from the responses illustrate this:

> *"Keep users involved in all stages and find 'champions' among domain scientists"*
>
> *"Leadership must come from members of the domain community (e.g., a humanities or social science faculty member) -- and not from a computer or computational scientist. Relying on CI centers (e.g., NCSA or SDSC) only engenders "learned helplessness." It is better to adopt less ambitious technology that can be controlled/customized by humanities/social scientist users then to depend on the latest thing from the centers (which produces a state of dependency)."*
>
> *"Keep it practical and applied. Developing a tool is applied work for the community, it is NOT your ticket to a long ride on the academic granting gravy train. People who use these programs to advance their academic career rather than produce robust tools in a timely manner are destroying some schemes. Equally, technologists who have little idea about what researchers need are responsible for many expensive projects which are never used."*
>
> *"Don't wait for the tool to be "perfect" - get using it for research as soon as possible because the development of the tool should obviously be in the context of particular research projects. The tool is useless if it isn't being used to generate research outcomes that are being published in respected social science journals."*

Second in frequency are responses who mention general positive or negative issues which are not e-Infrastructure-related (see annex I.5 for examples).

2. *Influences of the institutional and scientific environment.* Around 30 percent of the respondents who answered the lessons questions highlighted the contribution of their environment to realising e-Infrastructure projects. This environment consists of the local institution and the services that it provides, but also of the research field that supports or discourages R&D on e-Infrastructure and funding agencies who accept or reject project proposals. Some quotes may again illustrate this issue:

> *"Tool development is not particularly well-regarded within the social sciences - embarking on tool development is a risky career move, but I expect (and hope) that it can payoff bigtime if the tools become widely used. But a safer career move for a social scientist who can code is probably to just use the code purely to support his/her own research activities and write papers. A further problem with tool development in the social sciences (if you are also pursuing an academic career) is that you can be pigeon-holed as a "technician" or technical support officer for your non-technical social science colleagues who are going to be using the tools. …"*
>
> *"Senior leaders in most fields tend to look backward and value the modes of inquiry that shaped their own thinking while in graduate school."*
>
> *"Working in relative isolation on national scale. This technology is still perceived as "futuristic" and "putting new barriers (meta data) between*

> *researchers and their data"- No joke- almost verbatim quote of leading decision makers is social science infrastructure questions."*
>
> *"Keep the work secret from local IT staff and institution administration, especially IP services. They will obstruct."*
>
> *"Lack of interest in developing humanities based digital projects on the part of administrators and colleagues at my home institution."*

3. *Issues of staff and funding.* These were also given high priority. One respondent, for instance, formulated an appeal for the funding of staff:

> *"Fund staff!! Applied projects which succeed best have paid committed staff. In Social Sciences, there are many social and methodological issues which are barriers to using even the current data networking technologies for research. We need recurrent funding for research assistants to engage with the research community and foster new ideas. We also need recurrent funding for archivists to help researchers use the technology. Equipment without the staff and expertise to run it is wasted."*

Others stressed the importance of leadership, of being able to bridge the differences between computer science and domain sciences through multidisciplinary individuals or teams, and the necessity of being patient to allow for training and capacity-building of scientists. Budgetary issues referred to problems of obtaining long-term funding, inflexibility in managing funds and larger development costs than expected among others.

4. *Cross-disciplinary collaboration and communication.* Around 20% of the respondents who answered the questions on lessons learned reported positive effects of an interdisciplinary approach (no. 7 in the table) and12% stated problems in this regard (no. 13). In most cases the statements refer to the collaboration and communication between computer scientists and domain scientists, exemplified by the following two quotes:

> *"Collaboration between social and computer scientists IS possible. Communication barriers can be overcome."*
>
> *"Communication barriers between social and computer scientists are very high. Significant amount of time is needed to get to a common understanding of the issues."*

In the same vein, problems of managing collaboration in general were mentioned by many of the respondents. A recent case study on a meteorological e-Infrastructure project in the US shows that divergent agendas, multiple needs, interinstitutional and interdisciplinary communication problems and tensions are not specific to collaborations between social scientists and computer scientists, but rather a general feature in e-Infrastructure development (Lawrence, 2006).

Some, however, stressed explicitly the potentials of e-Infrastructures to make collaborations work:

> *"Collaboration is enhanced by eInfrastructure and better collaboration produces better scholarship."*
>
> *"Data storage and repositories are given disproportionately high attention (e.g., the ACLS report) relative to collaboration tools and e-learning when talking about CI and the humanities/social sciences. The greatest success stories involve tools for communication and collaboration (e.g., email) - and efforts to improve and deploy collaboration tools should not be neglected."*

5. *Technological limitations of e-Infrastructure.* The latter were frequently cited among the negative lessons learned throughout working with e-Infrastructure. They

address the service models of computing services that are not in line with humanities' and social sciences' needs (see quote below) or the reliability and user-friendliness of the technology.

> *"The content disciplines (arts and humanities) have significant high-performance computing needs as we move the evidence we use online. The future is not in grand challenge computing but in content rich computing. Look at Flickr, YouTube, FaceBook ... they don't solve grand challenges, just as most researchers don't think in terms of Big Challenges that can be solved by the 1960s batch processing service model common in most supercomputing outfits. Content scientists work iteratively and need web accessible computing that is much closer to Web 2.0 types of services than the classic supercomputer model."*

Having this in mind, it is logically consistent that several respondents suggest large flexibility of the technical solutions (no. 27), openness to software revisions (no. 11) and that they stress the importance of information exchange across projects, monitoring of the results of pilot projects and information exchange in the peer community of e-Infrastructure (no. 12):

> *"Be open to major revisions in the development approach (e.g. types of software being used) - I shifted from a "proper" desktop environment built using Qt which had nice OpenGL visualisations etc to a web-based application environment (built using PhP etc) and I've never looked back because web-based tools are fantastic for supporting collaboration. It was a lot of work making the shift from Qt to PHP/javascript/AJAX, but worthwhile."*

> *"Use of robust software and standards with multiple implementations versus the latest research code, newly minted standards (while being aware of them...) is critical to avoiding lock-in to specific research projects."*

> *"Attend as many conferences/seminars as possible where tool development is the focus - several of the big developments in the … project came about from hearing about a new piece of software or approach."*

> *"Innovation is not always a completely new idea - it includes taking something from one area to another, or putting two things together in a new way."*

The latter statements reflect the results of a recent NSF workshop on e-Infrastructure. One of this workshop's recommendations to policy makers centre on the comparison and information exchange across projects (and different scientific domains and countries) to enhance technology transfer and linkage of local projects into an interconnected network (Edwards et al., 2007, pp. 39-40).

6. G*eneral issues.* Of interest from a policy perspective are also the responses on the general (no. 19) and research-related (no. 17) benefits of e-Infrastructure, as well as on the contribution of e-Infrastructure to scholarship, teaching and learning (no. 20):

> *"Research in this field "ICT for social science data service" has good impacts on further methodology developments. More research is needed."*

> *"The DBG can help scholars tap into the potential of networked, relational, and object-oriented processes for the generation of new genres of research and expression. Such scholarship has the potential to push the work of humanities beyond the current silos it tends to inhabit, offering up other models of what the scholar is or could be in*

the age of information. The potential of technology for the humanities continues to need illustration to persuade new users."

To our astonishment, rather few responses addressed some of the other issues that have a high priority on the policy agenda, such as the development of standards, open source (no. 29), sustainability (no. 24) and IPR and other legal issues (no. 21).

Comparing the frequencies of these lessons learned across different types of respondents is useful to find out whether certain problems appear more often for certain types of users – if so, this might be a starting point for policy intervention. Hence, we distinguish respondents by their

- Country of origin,
- Activity profile (researcher, scholar, administrator, professional),
- Involvement in e-Infrastructure projects (current user, interrupter/drop-out, future user),
- Year of first use of e-Infrastructure.

3.5.2 Lessons learned by characteristics of respondents

We first differentiated the lessons learned by the country of the respondent, grouping countries into the four groups shown in table 3.27. As the "other countries" category is only represented with 15 responses we will not interpret the results. For continental Europe we see three notable variations compared to UK and US:

- Issues related to project members and staff were more often mentioned than in the UK and US. They cover knowledge gaps on technology, high value of enthusiasm and motivation for success, and – in few cases – the problem of finding adequate staff.
- Second, continental European respondents particularly often remark on the value of connecting to peers, taking the outcome of pilot projects into account, engaging in some sort of information exchange across projects; respondents from the US hardly ever comment on this.
- Last but not least, respondents from continental Europe also strikingly often put up the warning of "Be patient and don't expect too much".

The responses obtained from the UK show two differences compared to the rest: First, funding and cost issues are less often mentioned and therefore possibly less problematic than in all the other regions. This is indeed in line with the barriers to e-Infrastructure adoption as identified in the previous deliverable: a lack of funding and problems in obtaining it is slightly less often considered very or somewhat important in the UK than in continental Europe and the US (see annex I.3, table A.16). Second, technological limitations of e-Infrastructure are more often brought up: 11 out of 48 respondents from the UK mentioned them compared to only 9 out of 77 respondents from outside of the UK.

Table 3.27: Positive and negative lessons by country of respondent

	UK	Continental Europe	USA	Other countries
Consider user and other participants perspectives and needs	35.4%	37.5%	36.8%	33.3%
Other lessons (not e-Infrastructure related)	25.0%	45.8%	26.3%	40.0%
Positive and negative influences of the field and institutional environment on e-Infrastructure are important	27.1%	25.0%	34.2%	46.7%
Importance of human factor, problems with finding good staff and skills	18.8%	45.8%	26.3%	20.0%
Importance of funding, problems with funding, costs	14.6%	29.2%	31.6%	33.3%
Problems of collaboration and communication	18.8%	29.2%	21.1%	13.3%
Supporting interdisciplinarity for e-Infrastructure	18.8%	16.7%	18.4%	26.7%
Collaboration works and pays	14.6%	16.7%	23.7%	6.7%
Technological limitations of e-Infrastructure	22.9%	8.3%	10.5%	20.0%
Other lessons (e-Infrastructure related)	18.8%	4.2%	13.2%	26.7%
Software & middleware elements and technological configuration of e-Infrastructure are important	16.7%	8.3%	13.2%	13.3%
Connect to other projects, exemplars, frameworks, peers	10.4%	25.0%	2.6%	33.3%
Solving issues of data/metadata	14.6%	4.2%	10.5%	13.3%
Problems of establishing and managing interdiscipl.	6.3%	8.3%	13.2%	26.7%
Research-related benefits of e-Infrastructure	12.5%	12.5%	10.5%	0.0%
Proactiveness, bringing new tools to users a.s.a.p. brings success	6.3%	8.3%	13.2%	20.0%
Issues of timing	12.5%	4.2%	10.5%	13.3%
Benefits of e-Infrastructure for comm. and collab.	6.3%	4.2%	10.5%	26.7%
General positive effects of e-Infrastructure	12.5%	4.2%	10.5%	6.7%
Positive contribution of e-Infrastructure to scholarship, teaching and learning	6.3%	0.0%	10.5%	20.0%
Problems with legal issues and finding solutions	4.2%	12.5%	13.2%	0.0%
Importance of project design & management	6.3%	16.7%	7.9%	0.0%
Engage in community-building	2.1%	8.3%	13.2%	6.7%
Care for sustainability after project completion	10.4%	4.2%	7.9%	0.0%
Don't place too high expectations on e-Infrastructure	2.1%	20.8%	5.3%	6.7%
Benefits of e-Infrastructure regarding data	6.3%	4.2%	2.6%	6.7%
Problems of tool development	2.1%	0.0%	7.9%	13.3%
Advantages of standards or open source	6.3%	0.0%	7.9%	0.0%
Importance of flexibility	4.2%	0.0%	7.9%	6.7%
Hardware issues	4.2%	0.0%	7.9%	0.0%
Disadvantages of standards	2.1%	8.3%	2.6%	0.0%
General negative effects of e-Infrastructure	2.1%	0.0%	5.3%	0.0%
Composition of the research & project team	0.0%	4.2%	2.6%	6.7%
Disadvantages of e-Infrastructure for communication and collaboration	2.1%	0.0%	0.0%	6.7%
Total respondents	48	24	38	15

Source: AVROSS WP2 survey.

Another distinctive characteristic of the respondents is their activity profile, i.e. whether they are mainly doing research ("Researchers"), are engaged in professional work ("Professionals"), mainly administrate ("Administrators") or are more or less to the same extent involved in research and teaching ("Scholars"). Again, we note some particularities for each group (except for professionals due to the small number of cases).

- Probably because of their position in the hierarchy researchers are less often affected by funding and staff issues and they mention rarely benefits of e-Infrastructure for communication and collaboration (see table 3.28).
- Administrators on the other hand pointed more often to the latter benefits. They also mentioned more frequently the necessity and benefits of involving users and problems of solving issues of metadata and data. They less often wrote about the benefits or weaknesses of interdisciplinary work and they raise less often technical issues (technical limitations, software, standards, tool development etc.).
- Among the responses from scholars we see a smaller orientation towards the e-Infrastructure users (see also the low percentage of scholars' projects with a user constituency in table 3.18, p. 43). In contrast, scholars show more consideration for their research team and personnel.

The distribution of respondents on user groups is unfortunately not very even and we have only 15 interrupters/drop-outs and 10 future users of e-Infrastructure in the dataset who provided an answer on these questions on lessons learned (see table 3.29). It is not intuitive to add up the data for these two user groups either, hence we will make cautious interpretations of the most striking differences only.

A large majority of the respondents are current users. Two differences to the other two groups appear:

- First, the benefits of collaborating and communicating are stressed, and interdisciplinary work with scientists in other fields is not considered as particularly problematic.
- Second, benefits of e-Infrastructure for collaboration are not stated very often.

One of the notable differences between current users and interrupters and drop-outs is that the latter mentioned less often problems of costs and funding, though a lack of sustainable funding was actually the most important reason for stopping the participation in humanities or social science e-Infrastructure projects (see table 3.4, p. 23). However, as we had expected, drop-outs more often mentioned problems (e.g. technological limitations and of collaboration) and less often benefits of e-Infrastructure (e.g. for research and scholarship).

Future users should not have any experiences with e-Infrastructure and we presume that the 10 respondents of this category actually wrote about their expectations for the future rather than their past experiences. Hence, we see that they might underestimate the problems of collaboration and communication which are more often addressed by more experienced e-Infrastructure users. In addition, they see particular contributions to scholarship, teaching and learning.

Table 3.28: Positive and negative lessons by activity profile of respondent

	Research-ers	Profes-sionals	Adminis-trators	Schol-ars
Consider user and other participants perspectives and needs	32.4%	64.3%	45.8%	23.5%
Other lessons (not e-Infrastructure related)	29.4%	35.7%	25.0%	35.3%
Positive and negative influences of the field and institutional environment on e-Infrastructure are important	35.3%	14.3%	37.5%	27.5%
Importance of human factor, problems with finding good staff and skills	20.6%	42.9%	20.8%	29.4%
Importance of funding, problems with funding, costs	14.7%	35.7%	29.2%	27.5%
Problems of collaboration and communication	23.5%	21.4%	20.8%	19.6%
Supporting interdisciplinarity for e-Infrastructure	20.6%	28.6%	12.5%	19.6%
Collaboration works and pays	20.6%	21.4%	12.5%	13.7%
Technological limitations of e-Infrastructure	20.6%	14.3%	12.5%	13.7%
Other lessons (e-Infrastructure related)	23.5%	21.4%	16.7%	7.8%
Software & middleware elements and technological configuration of e-Infrastructure are important	20.6%	14.3%	12.5%	9.8%
Connect to other projects, exemplars, frameworks, peers	17.6%	21.4%	12.5%	5.9%
Solving issues of data/metadata	8.8%	21.4%	20.8%	5.9%
Problems of establishing and managing interdiscipl.	17.6%	14.3%	8.3%	7.8%
Research-related benefits of e-Infrastructure	11.8%	0.0%	16.7%	9.8%
Proactiveness, bringing new tools to users a.s.a.p. brings success	8.8%	7.1%	8.3%	13.7%
Issues of timing	11.8%	7.1%	12.5%	9.8%
Benefits of e-Infrastructure for comm. and collab.	2.9%	7.1%	16.7%	11.8%
General positive effects of e-Infrastructure	11.8%	0.0%	12.5%	9.8%
Positive contribution of e-Infrastructure to scholarship, teaching and learning	11.8%	0.0%	12.5%	5.9%
Problems with legal issues and finding solutions	5.9%	7.1%	4.2%	11.8%
Importance of project design & management	2.9%	7.1%	8.3%	9.8%
Engage in community-building	2.9%	21.4%	12.5%	3.9%
Care for sustainability after project completion	5.9%	7.1%	4.2%	9.8%
Don’t place too high expectations on e-Infrastructure	5.9%	7.1%	8.3%	5.9%
Benefits of e-Infrastructure regarding data	5.9%	14.3%	4.2%	2.0%
Problems of tool development	5.9%	0.0%	0.0%	7.8%
Advantages of standards or open source	5.9%	7.1%	0.0%	5.9%
Importance of flexibility	5.9%	0.0%	8.3%	3.9%
Hardware issues	5.9%	0.0%	0.0%	5.9%
Disadvantages of standards	2.9%	0.0%	4.2%	3.9%
General negative effects of e-Infrastructure	0.0%	0.0%	4.2%	3.9%
Composition of the research & project team	0.0%	0.0%	0.0%	5.9%
Disadvantages of e-Infrastructure for communication and collaboration	0.0%	0.0%	0.0%	3.9%
Total respondents	34	14	24	51

Source: AVROSS WP2 survey.

Table 3.29: Positive and negative lessons by involvement with e-Infrastructure projects of respondent

	Current user	Interrupter/ drop-out	Future User
Consider user and other participants perspectives and needs	36.4%	33.3%	40.0%
Other lessons (not e-Infrastructure related)	29.3%	33.3%	40.0%
Positive and negative influences of the field and institutional environment on e-Infrastructure are important	32.3%	33.3%	20.0%
Importance of human factor, problems with finding good staff and skills	25.3%	26.7%	40.0%
Importance of funding, problems with funding, costs	27.3%	6.7%	30.0%
Problems of collaboration and communication	22.2%	26.7%	0.0%
Supporting interdisciplinarity for e-Infrastructure	18.2%	26.7%	20.0%
Collaboration works and pays	20.2%	0.0%	10.0%
Technological limitations of e-Infrastructure	15.2%	26.7%	10.0%
Other lessons (e-Infrastructure related)	16.2%	6.7%	20.0%
Software & middleware elements and technological configuration of e-Infrastructure are important	13.1%	20.0%	10.0%
Connect to other projects, exemplars, frameworks, peers	14.1%	13.3%	10.0%
Solving issues of data/metadata	12.1%	6.7%	10.0%
Problems of establishing and managing interdisciplinarity	9.1%	20.0%	20.0%
Research-related benefits of e-Infrastructure	12.1%	0.0%	10.0%
Proactiveness, bringing new tools to users a.s.a.p. brings success	11.1%	0.0%	20.0%
Issues of timing	11.1%	6.7%	10.0%
Benefits of e-Infrastructure for comm. and collaboration	7.1%	20.0%	20.0%
General positive effects of e-Infrastructure	11.1%	6.7%	0.0%
Positive contribution of e-Infrastructure to scholarship, teaching and learning	6.1%	0.0%	40.0%
Problems with legal issues and finding solutions	8.1%	13.3%	0.0%
Importance of project design & management	7.1%	6.7%	20.0%
Engage in community-building	7.1%	13.3%	0.0%
Care for sustainability after project completion	7.1%	6.7%	10.0%
Don’t place too high expectations on e-Infrastructure	7.1%	6.7%	10.0%
Benefits of e-Infrastructure regarding data	5.1%	0.0%	10.0%
Problems of tool development	2.0%	20.0%	10.0%
Advantages of standards or open source	5.1%	0.0%	10.0%
Importance of flexibility	4.0%	13.3%	0.0%
Hardware issues	3.0%	6.7%	10.0%
Disadvantages of standards	2.0%	13.3%	0.0%
General negative effects of e-Infrastructure	2.0%	6.7%	0.0%
Composition of the research & project team	1.0%	13.3%	0.0%
Disadvantages of e-Infrastructure for comm. and collaboration	2.0%	0.0%	0.0%
Total respondents	100	15	10

Source: AVROSS WP2 survey.

A final distinction that can be made based on the information collected in the survey is the distinction between adopters of e-Infrastructure before 2000, between 2001 and 2003 and 2004 or later. The importance of most of the lessons learned differs between these three groups across which the respondents are more or less evenly distributed. We just point out the most notable differences (see table 3.30).

Table 3.30: Positive and negative lessons by period of first e-Infrastructure use

	Before 2000	2000-2003	2004 and later
Consider user and other participants perspectives and needs	41.9%	27.5%	37.1%
Other lessons (not e-Infrastructure related)	34.9%	30.0%	28.6%
Positive and negative influences of the field and institutional environment on e-Infrastructure are important	32.6%	30.0%	28.6%
Importance of human factor, problems with finding good staff and skills	25.6%	27.5%	25.7%
Importance of funding, problems with funding, costs	25.6%	30.0%	17.1%
Problems of collaboration and communication	20.9%	27.5%	17.1%
Supporting interdisciplinarity for e-Infrastructure	20.9%	15.0%	25.7%
Collaboration works and pays	16.3%	12.5%	22.9%
Technological limitations of e-Infrastructure	4.7%	27.5%	14.3%
Other lessons (e-Infrastructure related)	14.0%	12.5%	22.9%
Software & middleware elements and technological configuration of e-Infrastructure are important	14.0%	15.0%	11.4%
Connect to other projects, exemplars, frameworks, peers	9.3%	12.5%	20.0%
Solving issues of data/metadata	7.0%	20.0%	8.6%
Problems of establishing and managing interdisciplinarity	16.3%	7.5%	8.6%
Research-related benefits of e-Infrastructure	11.6%	12.5%	8.6%
Proactiveness, bringing new tools to users a.s.a.p. brings success	9.3%	15.0%	5.7%
Issues of timing	7.0%	7.5%	20.0%
Benefits of e-Infrastructure for communication and collaboration	4.7%	15.0%	8.6%
General positive effects of e-Infrastructure	7.0%	12.5%	8.6%
Positive contribution of e-Infrastructure to scholarship, teaching and learning	2.3%	12.5%	8.6%
Problems with legal issues and finding solutions	7.0%	7.5%	11.4%
Importance of project design & management	14.0%	5.0%	5.7%
Engage in community-building	14.0%	5.0%	0.0%
Care for sustainability after project completion	4.7%	7.5%	11.4%
Don't place too high expectations on e-Infrastructure	11.6%	5.0%	5.7%
Benefits of e-Infrastructure regarding data	7.0%	5.0%	2.9%
Problems of tool development	7.0%	5.0%	0.0%
Advantages of standards or open source	4.7%	2.5%	5.7%
Importance of flexibility	9.3%	2.5%	2.9%
Hardware issues	2.3%	7.5%	2.9%
Disadvantages of standards	0.0%	5.0%	2.9%
General negative effects of e-Infrastructure	2.3%	0.0%	5.7%
Composition of the research & project team	4.7%	0.0%	2.9%
Disadvantages of e-Infrastructure for communication and collab.	2.3%	0.0%	2.9%
Total respondents	43	40	35

Source: AVROSS WP2 survey.

Respondents who first started using e-Infrastructures in the middle period, 2000-2003, attribute somewhat less importance to the interaction with users. These respondents are more concerned of the technological limitations of e-Infrastructures and solving issues of data and metadata than the pre-2000 adopters. The latter are more concerned than the other respondents with interdisciplinarity, project design and management and community-building. Adopters from the last period 2004-2007 are less troubled by funding and cost issues, but they stress the connection to peers and other e-Infrastructure projects and more problems with development times.

> *"Need to build on existing exemplar work in community through awareness-raising, collaboration, training"*
>
> *"Many technology solutions are already available. It is important to look for existing solutions before to redesign and implement what is needed to satisfy a specific requirement"*

3.6 Summary

The aim of this work-package was to provide a stocktaking of e-Infrastructure in the social sciences and humanities and in particular in the fields of archaeology, social and economic research, social geography and regional science and computational linguistics. We addressed this by surveying early adopters of e-Infrastructure and asking them to describe the types of projects that are currently in existence, in terms of a variety of factors: their size, composition, use of different e-Infrastructure features and outputs. We also asked them to identify what they considered to be barriers and catalysts to e-Infrastructure adoption.

In describing the results we summarized the core findings, and then examined the degree to which they differed by region, by discipline, by whether the respondents were primarily working with local collaborators (in these projects and beyond), by the activity profiles of the respondents, and whether the respondent was an early or late adopter of e-Infrastructure. We found substantial heterogeneity in all of these dimensions and there are several striking findings. *First*, although there is clearly heterogeneity across projects in terms of country of origin, size, discipline, project structure and staffing, and outcomes, there appears to be consensus about the key catalysts and key barriers to e-Infrastructure adoption. The key barriers are consistently identified as lack of funding, costs, and lack of qualified staff. The key catalysts are clearly seed funding, collaboration, and interesting research. *Second*, the ability of a project to connect to a user community appears to be easier when that discipline is also represented in a project. This is consistent with the focus by funding agencies on fostering interdisciplinary projects. *Third*, the respondents clearly identified the influence of other scientists as an information source – suggesting that getting highly visible scientists to adopt e-Infrastructure will be an important mechanism in generating widespread adoption.

Some further details on the e-Infrastructure projects, adoption in general and lessons learned are worth noting.

3.6.1 e-Infrastructure projects

We found that research foundations and councils were the dominant source of funding across the board. The median project was initially funded at just over 335,000 Euros; the median annual budget was just over 122,000 Euros. The projects in continental Europe and the USA are larger than projects in the UK, both with respect to funding and staff. Scholars were more likely to be involved with small projects; these are also the ones with the proportionally highest scientific personnel input. Professionals appear to more involved with application-oriented projects, whereas projects described by researchers and scholars are stronger in

the science dimension. The administrators' projects seem to integrate both, science orientation and user focus.

The most frequently used e-Infrastructure items included communication and collaboration tools, as well as distributed data, and required high band width. High performance computing, which is a feature of other sciences, was not as important, nor were the innovative data collection methods. Some level of variation was visible by country of the project: learning environments and virtual/3D environments play a larger role in US-based projects. Continental European projects more often contain data repositories, whereas videoconferencing is relatively unimportant – it is used more than twice as often in UK-based projects. The items varied also by project length: virtual/3D environments were of notably higher relevance in long-term projects, lasting for three years or longer. This is consistent with a view that the provision of interfaces for learning and practice becomes more important when the development phase is completed and the actual user involvement gets more and more critical.

Respondents reported a variety of outcomes from their projects, including publications, new methods, new data, follow-on collaborations, and new tools. They also reported a very broad user constituency ranging from 3.8 – 4.8 academic domains. Interestingly, almost all disciplinary constituencies that are reached are reached by a project that includes participants on the team with the same discipline as the user constituency. There are a number of possible interpretations of this intriguing result. It could be that projects are developed by researchers in given disciplines because they have specific disciplinary needs in mind. It could also be that researchers in a project already have a dissemination network in place that is discipline specific, and that knowledge about the project is transmitted through such disciplinary networks. These different possibilities have useful, but differing, implications for the structure of funding and should be explored in a broader scientific study.

With regard to the fields which were one of the specific focuses of the survey, archaeology, economics & business, sociology, social and economic geography/regional science, and linguistics, we find a couple of remarkable characteristics:

- *Archaeology.* Projects with archaeology participation are very small in terms of budget (150'000 €) and personnel (14 people) and with the shortest duration. They also need much non-scientific staff. However, they are still output oriented, with three quarters of the projects indicating the existence of a user constituency and the production of publications, new methods, new data, new tools, or follow-on collaborations. When it comes to their technological profile, archaeology projects show some very specific features: high bandwidth, frequent use of virtual/3D environments and innovative data collection methods distinguish these projects from the others.
- *Economics and business.* The high scientific component – nearly three quarters of the involved personnel are scientists or graduate students – contributes to an average project size of projects with economics and business participation, though the projects are of relatively short duration. Neither the technological profile nor the outcomes of these projects differ in any way remarkably from the overall dataset. However, the respondents stated notably less often that the project already had identified a user constituency.
- *Sociology.* Sociology projects have larger budgets than archaeology projects, but they also last longer and their annual budget is therefore just about as large as in the latter field. In regard to personnel they are the smallest ones (12 people on average). They use all technological items except for data collection methods less often than projects in other fields.

- *Social & economic geography, regional science.* Projects in this field are of average size and duration. Particular technological features are difficult to discern. Grid-based video conferencing sticks out as does the more frequent use of high performance computing.
- *Linguistics.* Projects in these fields are the largest in regard to budget and personnel among the fields considered. They are also the ones with the longest duration. These are their most remarkable features. Neither their technological portfolio nor the outcomes that they produce show any additional patterns. Only – like the considerably smaller archaeology projects – they also rather often said that they address a specified user constituency.

3.6.2 e-Infrastructure adoption

Survey respondents identified a number of key sources of information about e-Infrastructure, notably the importance of other scientists in spreading information about e-Infrastructure. Printed information is of comparatively little importance. Only for scientists who are predominantly collaborating at the non-local, national and international, levels and – supposedly – less integrated in their local communities printed information on e-Infrastructure plays some role. It might substitute local meetings and workshops from which they less often benefit.

Infrastructure and administration people at the respondents' organizations were less often rated as important in continental Europe than in the UK or the US. Moreover, these services were also less influential for social scientists and humanities researchers than for natural scientists. This could indicate less interaction between infrastructure and administration services and scientists in the continental European research environment and for humanities and social science researchers in general.

The respondents highlighted a number of factors as key catalysts: seed funding, collaboration, interesting research, and collaboration. Only few differences exist between different respondent and project categories. Seed funding is more important in the US and in other countries than in the UK, and least important in continental Europe. The computational requirements of the research, on the other hand, are more important in the latter regions.

Most notable is the difference between projects involving social scientists: those described by respondents with a *local* collaboration pattern in particular stress collaboration as a catalyst; those described by respondents with a *non-local* collaboration pattern (i.e. scientists who also collaborate, but not locally) give a much higher importance to seed funding, the observation of other projects and the prospects of interesting research. How can we interpret this? It seems that e-Infrastructure are more likely to support local than non-local collaboration needs. It is possible that the structure of collaboration differs by whether it is local or non-local: the latter might need a clearer division of labour, and the former might be much more integrated and thus in need of technological support. It is interesting that this particular pattern only manifests itself in projects including social sciences and hence more detailed analyses of the relationship between collaboration and technological support are necessary.

The respondents identified a number of key barriers to e-Infrastructure adoption. Almost uniformly most important, regardless of discipline, length of project, and date of adoption are three factors: lack of funding, costs, and lack of qualified staff. Lacking information on the usefulness of the technology was more often observed by the humanities and confidentiality problems less often.

3.6.3 Positive and negative lessons learned in e-Infrastructure projects

The most important lessons learned that were listed by the early adopters are the following:

- It is necessary and beneficial to take the needs of users and other stakeholders into account in the development of e-Infrastructure for the social sciences and humanities. The early adopters frequently remarked that community-building is an important task in the realization of an e-Infrastructure project. In addition, user feedback should be sought early; actually some commented that tool development should be user-led to secure the uptake of the results.
- Supportive institutional and scientific environments are important assets: local IT staff and university administrations, deans and senior leaders in the home organization as well as in the broader domain environment need to be more responsive to the challenges and possibilities of e-Infrastructure development.
- Staff and funding issues are of key importance. Staff issues include the availability of qualified staff as well as the motivation and enthusiasm for the project. Budgetary issues referred to are for instance problems of obtaining long-term funding, inflexibility in managing funds and larger development costs than expected among others.
- Bridging disciplinary boundaries, above all between computer and domain scientists, is not always easy, but it is necessary and possible for advancing e-Infrastructure and beneficial for exploring new areas of knowledge.
- Technological limitations of e-Infrastructure tend to develop around deficient service models of computing services as well as the reliability and user-friendliness of the technology.
- Flexibility of the technical solutions, openness to software revisions and information exchange and mutual learning across e-Infrastructure projects are important.
- Rather few responses addressed some of the issues that have high priority on the policy agenda, such as the development of standards, open source, sustainability and IPR and other legal issues.

Taking a closer look at some of the respondents' characteristics and their responses on these lessons learned may reveal whether some problems appear under specific circumstances or in a specific situation. The picture remains somewhat fuzzy and there are only few issues that seem to be robust:

- There is a notable difference between European and US American responses in regard to the value of connecting to peers, taking the outcome of pilot projects into account, and engaging in some sort of information exchange across projects. In this context it is important to recall, that US respondents have more experience both in years of involvement as in number of e-Infrastructure projects than continental European respondents (see p. 24). This gives room to a number of interpretations: continental Europeans might need some further support in the exchange across projects, as there are more barriers than for their US and UK colleagues, such as differing languages and fewer opportunities for information exchange because of fractionated, inward-oriented science systems. However, it might also be that Europeans are more aware of the work that has been done by previous projects because they are essentially latecomers in this business (and we see, that late adopters stressed this connection to peers and pilot projects more often than very early adopters).
- The responses obtained from the UK show two differences compared to the rest: First, funding and cost issues are less often mentioned and therefore

possibly less problematic than in all the other regions. Second, technological limitations of e-Infrastructure are more often brought up.

- Among the responses from scholars we see a smaller orientation towards the e-Infrastructure users (see also the low percentage of scholars' projects with a user constituency, table 3.18 on p. 43). In contrast, scholars show more consideration for their research team and personnel.

4. Promising approaches to using e-Infrastructures in the social sciences and humanities

The work in WP 3 responded to the first set of requirements from the tender specifications, namely:

1. To describe the challenges, opportunities and barriers for a large scale uptake of e-Infrastructures in the social sciences and humanities
2. To define the requirements and options for a large scale development, implementation and uptake of broadband technologies and applications supporting virtual R&D organisations in the social sciences and humanities
3. To analyse the challenges for Computer Supported Collaborative Learning (CSCL) environments with demanding visual interactions

The main measure in order to accomplish these requirements in WP3 was the "analysis of the 8 most promising approaches to using e-Infrastructures in terms of a comprehensive description of the challenges, opportunities but also barriers for a large scale uptake", as stated in the second requirement B of the tender specifications. The identification of these eight approaches was based on:

- The list of projects from the WP2 stock-taking survey
- Additional desk research
- Interaction with e-science experts worldwide (see appendix II.3)
- Identifying indicators for a typology
- Creating a rating scheme based on this typology

This section of the report first presents in a methodological section how the eight approaches were selected. Then it documents the common framework that was created for conducting the case studies, i.e. methodology, interview guidelines and interview logistics which were applied by each AVROSS consortium member in order to obtain comparable case descriptions. A second section then reports on the results and provides a set of case descriptions which are compared in the final section.

4.1 Case study approach

4.1.1 Identification of the eight most promising approaches

The identification of the eight most promising approaches started from a list of potential projects and initiatives provided by WP2, as well as the identified approaches from desk research and the interaction with e-science experts worldwide (see appendix II.3). This produced a total of 178 projects and initiatives from 18 different countries (Australia, Austria, Canada, Denmark, France, Germany, Greece, India, Italy, Lithuania, The Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Switzerland, UK, USA).

The second step in the selection was the creation of a typology which was then converted into a standardised rating scheme. The scheme consisted of four groups of factors (see appendix II.1 on the rating scheme in detail):

1. Technology (Weight: 30%): Innovativeness of the technology, relevance for social sciences and humanities, and replicability (Can the technology/tool be transferred to another setting?)
2. Success (Weight: 30%): Long-term sustainability (Has it achieved an organizational status beyond the project level, secured an institutional affiliation?), constituency of users involved and size of the current user community, outcomes (publications, patent applications, new methods, new data, new tools, follow-on collaborations)
3. Size (Weight: 20%): Large or small potential user constituency, broadness versus depth (i.e. domain-wide initiatives versus projects creating one specific source or solving one specific problem in a field), countries included (multinational versus national or even local projects)
4. Accessibility (Weight: 20%): Timeframe, access to members and agency of the initiative (includes pragmatic issues, like willingness to participate).

Out of all the 178 projects 80 projects obtained a rank of 3.0 or higher and were considered as possible candidates for the 8 approaches. From these 80 projects 39 were categorised at a meeting of the project team as interesting or potentially interesting (unknown) in a review that used the following criteria:

- Promising technological substance of the projects (proven tools, innovative combination of existing technologies)
- No projects funded by the EC, as these are already known to the EC and more added value should be derived from unknown projects
- National projects, as multinational projects might be hampered by the problems of international collaboration (and only in secondary ways by specific e-Infrastructure issues)

This list of 39 projects was further condensed in a second discussion which resulted in the following list of 13 projects. From these 13 projects the consortium partners took the required 8 cases for WP3 (“first priority”); the remaining 5 cases were used as fall-back options in case projects were not willing to participate, informants could not be reached or initial investigations showed that the projects were a lot less promising than expected (see table 4.1).

Table 4.1: Case studies selected for further analysis

Project	Country	Responsible in AVROSS
Access Grid Support Centre – AGSC	UK	NCeSS
Modelling and Simulation for e-Social Science – MoSeS	UK	NCeSS
Communication Data ComDAT (pseudonym)	US	NORC
Simulation Portal – SPORT (pseudonym)	US	NORC
Understanding New Forms of Digital Records for e-Social Science – DReSS	UK	empirica
Dokumentation Bedrohter Sprachen – DOBES	NL	empirica
TextGrid	DE	FHNW
FinGrid (pseudonym)	EU country	FHNW

Source: AVROSS.

4.1.2 Case study method and guidelines

The analysis of the cases drew mainly on two different methods of data collection:

1. Semi-structured interviews
2. Archival research

Ad 1) *Semi-structured interviews*: After the identification of the case studies each partner contacted the relevant PI(s) of the projects, according to the following procedure: For the selection of the interviewees, a snowball sampling was used aiming at the following groups: PI(s) [starting from here], researchers, developers, users and (if it made sense and was applicable) involved stakeholders like National Grid Service (UK), JISC, TeraGrid, D-Grid or similar related e-Infrastructure projects or service/technology groups. Per case study several face-to-face or telephone interviews with the main initiators, providers and managers of the projects were deemed necessary. The time per interview was set to approximately one hour (see appendix II.2 on the interview partners).

Solicitation and introduction: At the beginning of the interview the interviewer introduced the investigators and explained the purpose of the study, methods (i.e. in depth interviews from eight case studies in the US and Europe), expected duration of the interview, potential contribution and benefits of the study – such as to the CI/e-Science community, and the direct benefit to the interviewee.

The interviews were conducted as semi-structured interviews in which a smaller body of open-ended questions was combined with questions which were based on probes, follow-ups, and case specific items. The semi-structured interview approach permits exploring the conceptual linkages among the four sources of influence on the shaping of technology, as well as potentially identifying new ones. The constructs can be used by the sponsors of AVROSS to understand how funding is related to mobilization, how e-Infrastructure shapes existing socio-technical practices, and the ways in which this framework has been shaped by existing socio-political institutions, for example.

The interview guideline took the influences on e-Infrastructure development according to the Social Shaping of Technology approaches into account, namely technological frames and user requirements, scientific shaping of technology, economic factors, and political influences (see M1 Framework report pp.10ff for a more detailed description). Additionally, the following points had to be considered:

- Challenges and difficulties the projects had to master in their different phases from the invention to the introduction and dissemination among the user community
- Modifications to the initial approaches, key current applications and benefits to the users and possible future developments which might further increase the usability and benefits
- Possibilities of, or experiences with, transferring the project from the initial work environment and community for which it was made to other environments

An initial interview guideline which are rather long with 103 questions was subsequently slimmed and refined in a next step to make it usable for one hour in average of interview time (see appendix II.4 The interview guideline).

Ad 2) *Archival research:* Archival materials are another central data component of WP3 which complement interviews in order to enable a comprehensive analysis of the cases studies. Ideally, the archival research on a specific case was completed prior to interviews with stakeholders associated with that project, as archival data may directly input to interviews. For instance, archival data was utilized for identifying interviewees or it guided an interviewer to revise or adding questions to

an interview. Contingent on data quality, archival material also served as a unique source for examining additional dimensions of the case studies, such as certain aspects of project impact and outreach.

For the purpose of archival research for WP3, archives were defined as sources of data that are either textual or can be converted to textual representations, and are publicly accessible. Among other sources these data include designated web sites for the selected cases, publications and presentations.

4.2 Case studies on e-Infrastructure initiatives

The following sections present first case descriptions of the 8 cases that were analysed. The case descriptions all follow as much as possible the framework outlined above. The case descriptions are followed by a cross-case comparison which identifies common and divergent challenges and solutions.

4.2.1 Access Grid Support Centre – AGSC

Background

The Access Grid Support Centre (AGSC, http://www.agsc.ja.net/) is part of the Research Computing Services at the University of Manchester. It is one of the services provided by JANET (http://www.ja.net/), an education and research network which is connecting the UK's organisations in these fields to each other. By their own account the network currently serves over 18 million end users. Managed by JANET the funding is procured by the JISC Committee for the Support of Research (JCSR, http://www.jisc.ac.uk/aboutus/committees/sub_committees/jsr/jcsrprogramme.aspx), a national programme established for the needs and the support of the various research communities in the UK. The mission of the Joint Information Systems Committee (JISC) is to fund and manage research and development programmes to provide services, develop infrastructure and applications in terms of innovative use of Information and Communication Technology (ICT) in research and education.[24]

As stated on their website "the aim of the AGSC is to improve the user experience of Access Grid through enhanced quality and robust, resilient services", in the whole UK. The Access Grid (AG) is a videoconference system particularly devised for group-to-group interaction and collaboration through the Grid. Video cameras, audio equipment and large-format displays of two or more locations are thereby interfaced via Grid middleware and controlled by AG software.

The benefits of AG are described as improving the modes of interaction between participants through a more realistic experience of an otherwise virtual meeting of a group of people in different locations. Important features of AG are the more natural sounding audio and the multiple viewpoints achieved by different cameras at one time; the big display with its multiple images enables a better overview of the remote sides, participants and presentations; and collaborative software supports the sharing and interacting with data.

After first coming into contact with the AG technology in the US about 1999 members of the University of Manchester's computer science department who were concerned with the research and evaluation of new ICT had the idea of setting up this technology as well. After a brief span of trying to get the funding (50000 GBP initial costs at that time) the first node in Manchester (and the UK) was established

[24] JISC (http://www.jisc.ac.uk/) works in partnership with Research Councils UK and is funded by a number of high level departments and councils in the UK's further and higher education area.

2001 “to evaluate new technologies” in “the early days of e-science and Grid”. More nodes were set up subsequently and the problem of showing people how to use these and to foster the technology became apparent. The now head of the Access Grid Support Centre then wrote some reports, which for the first time promoted the idea of such a centre and therefore a bid was put in and it was funded. The first AGSC contract started April/May 2004 and lasted until the end of July 2007. Just recently the second phase of funding (the second 3 year contract) began.

The AGSC started with three members, the head and two support officers, shortly thereafter adding a third support officer. Within the first two and a half years more support officers were appointed. Today six persons are working at the AGSC, four support officers, the operational manager and the head of service.

One of the interviewees first belonged to the core group of support officers, before moving on as a developer and researcher for AG, being “slightly detached from the AGSC now”. He still is working in the same open space office and still is considered to be a member of the AGSC team (informally), and through his experience he can contribute even better as a developer and contact person. Another interviewee is the operational manager of the AGSC and works half of his time managing the centre while he is researching AG technology in general in the rest of his time. A third person being interviewed works as support officer, while the fourth interviewee possesses a double role as a long time AG user as well as a researcher in AG related projects from the viewpoint of computer graphics and visualisation. The final interview participant is the Director of the Research Computing Services at the University of Manchester, i.e. a person from the institutional environment of the AGSC. He played a leading role in establishing the first AG node in Manchester and supporting the AG technology and use further. Also he is the only person of the interviewees being involved with AG before the founding of the AGSC in 2004. The operational manager and the support officer are the only other persons having been involved with e-Infrastructure in any way before their engagement with the AGSC, one in the area of network security and the other doing IT support.

The AGSC benefits strongly from AG related projects, especially those where members of the AG support centre are taking part besides their work for the support centre as such. The experiences, knowledge exchange and concrete developments are said to be invaluable for the proper support and further evolvement of the AGSC.

Technology

In an AG videoconferencing session the images are projected against an empty wall on one side of the room, the so called AG node, the conferencing room at the points of use. The huger scale than other video conferencing technologies very early stood out (e.g. to remotely show historical pieces of handwriting which had to be displayed at the same time to compare them). The AG node is equipped with the necessary hardware, i.e. diverse video cameras, microphones, loudspeakers and projectors, including a computer to operate an AG session with the necessary software. Additionally a so called virtual venue server is needed, the AGSC is running a number of such servers. The centre supports the commercial inSORS as well as the Open Source AG Tool Kit software, which applies for the server as well as for the client side. There are two ways of connecting between parties in an AG session, one is called multicast, which is more efficient and allows better quality video and audio connections, but also needs more network resources and a well adjusted system, the other is called unicast connection (with less technical demands, but also producing less quality). Besides connecting a session between two or more AG nodes, i.e. different fully equipped real meeting rooms, the AG also allows two other modes of participation: 1) office nodes, which use multiple monitor displays and microphones and 2) desktop nodes called PIGs (personal interface to the Grid), running on a single computer with client software, webcam and headset.

Another software supported by the AGSC is the Virtual Room Videoconferencing System (VRVS, http://www.vrvs.org; in the future, i.e. next year the next generation system called EVO will be introduced), a type of desktop conferencing system, for example used in the astrophysics community. This system can be connected also to the AG so that sessions in each system can be joined by the other. Therefore both user communities are supported and are able to interact with each other. There are some similar technologies (e.g. Skype or standard video conferencing tools or more similar the development of MS Conference XP) which are not supported but watched carefully in terms of market share and competition but also in order to learn from them, or maybe also include them at some point. The original ideas of AG and for example Skype are completely different, but sometimes people use he AG just for standard video conferencing, whether it is intended to be used as a system that is as close as possible to human interaction where the user also is enabled to manipulate data as he needs it. But a lot of people use AG for simple management meetings – "and for that you can use other technologies".

Concerning development for inSORS as a commercial system it is not easy to develop anything, therefore most of the development happens with the AG Tool Kit. The first thing to develop was some way of sending the screen within AG (for others to see, e.g. a presentation). The Codecs for AG have not been that good at the beginning for sending screens, so this was improved and Codecs have been developed generally as well. In the end in the (now completed) Memetic project (http://www.memetic-vre.net/) this became the tool Screen Streamer and sessions could be recorded and later also annotated with the Compendium tool. This is since then usable as a service and it is used actually. In the succeeding Collaborative Research Events on the Web project (CREW, http://www.crew-vre.net/) these developments are further improved. Another project called Portal Access Grid (PAG, http://www.rcs.manchester.ac.uk/research/PAG, http://www.portal.ac.uk/spp/) tries to make the AG easy usable via a portal in the Web and additionally aims at bridging Access Grid and Skype and maybe even Access Grid and ConferenceXP in the future.

The technological basis of the AG in the beginning had not to do so much with the Grid. With RAT and VIC, the audio and video communication tools mainly video standards have been important from the beginning. In terms of standardisation at least video and audio are still compatible between the commercial and the open source system, "otherwise it would be a big problem".

Development done in funded projects always is open source. Java is the preferred programming language and Flash is an important standardised tool. With the open source community communication mainly takes place via mailing lists. Regular meetings with inSORS take place to talk with them about issues like problems, new software versions or new tools from the AGSC or out of research projects coming up.

A major innovation of AG is to being able to see all the participating sites together, projected to the wall, it makes it easier to orientate and see who is speaking etc. Also lot of little tools and measures being developed over the time make the whole better. For the user the most important improvement in AG is to being able to record sessions now.

E-learning and training

No special e-Learning tools are used, but Wikis are seen as a very good tool to communicate with the developers, "because I can just type in a load of stuff just off the top of my head" and at the same time it functions as a documentation tool. In programming as a way of problem solving there always is a lot of learning involved all the time generally. The notion of learning in doing research is supported by all interviewees.

Training for the team members themselves is considered as a problem, i.e. "*our big problem is time and [personnel] resources*". In team meetings and talks in between learning happens through collaboration. New technology or releases are discussed and tested, "because at the end of the day we are the experts". Also the AG support and development community regularly meets at the annual conferences AG Retreat organised by Argonne Labs and the Workshop on Advanced Collaborative Environments – and also at other conferences which are of interest now and then.

To the outside there are many means of supporting the users. The general support happens via phone and email and in Manchester also locally – but it was also stated that this local support basically could be considered as unfair towards the rest of the users in the UK, who do not have this opportunity. The AGSC website also is an important tool, providing help pages, online training with tutorials and flash movies, FAQ, links to the AG community and general documentation. Additionally there is an incident supporting form and the possibility to register as an AG user in order to use the AG booking service and the AGSC mailing list. Once a week open test sessions are offered over the AG for the whole community to test the AG node or PIG. Training workshops are conducted every 6 months. Furthermore a Quality Assurance (QA) testing programme has been designed to "ensure a high quality of Access Grid facilities at participating sites to overcome problems of poor audio, camera placement, etc. that can detrimentally affect the user experience".

Technological constraints

One big problem has always been networking, i.e. the smooth interaction of different network protocols in using the AG connection (concept of multicast connections). "In order to cope with multi cast problems, what we do is we offer multicast to unicast bridges", i.e. the AG system has a built-in function to overcome such problems. Wrong firewall settings are sometimes hard to overcome, as this lies in the responsibility of the general IT administration of each single institution.

The other problem is audio (audio echo), i.e. as AG is a collaboration system, bad audio at one site (at one node) will have a negative impact on the whole session. Audio is difficult to configure taking into account the hardware, background noise etc. a solution can be the testing of the equipment and settings through the offered QA tests. Most of the users see this quality assurance as something beneficial, but there are still some who do not take part in this, resulting in problems with their sessions.

In connection with that, there are a lot of users the AGSC does not know about, because they are not registered (it is not required to register unless you use services of the AGSC), and if they do not ask for support, they cannot be supported. Such can lead to people or organisations dismissing the use of AG, where it actually could be properly supported.

Some smaller issues include:

- Until the actual AG Tool Kit version came out, there had not been a usable standard for the communication protocols, which made development difficult.
- As the different software platforms are otherwise not compatible this sometimes is difficult to manage.
- Working with the video standard is not as easy as with the audio standard in general, on the other hand video does not cause too much problems.
- Sometimes the stability of the system is an issue, whereas it is also pointed out by one interviewee, that the system ran very stable even at that early stage of AG use. Another interviewee stated: "from about 3 or 4 years ago it was an

okay system", it still needs to be more reliable compared to a "dare I say it, a Microsoft product".

- In general AG is seen as probably a bit too "flaky" for business.

Overall no real technical barriers for development are seen. Sometimes a different programming language has to be used and not the preferred one, but it is emphasized that solving problems is part of this line of work.

Communication: Internal and with stakeholders

Until about six months ago the six members of the AGSC worked in three different offices, which has been a communication barrier for the everyday work. Now all members work in the same open space office, which has improved the overall awareness of what is going on. As an informal seventh team member also the interviewed developer sits in this office and participates in this collaboration. Being used to do telephone support (besides email and sometimes personal support), i.e. working in a rather noisy environment, "there is always this constant feedback between all of the members of the group". This also is understood as a notion of learning through collaboration, experiences and knowledge can be shared in a more direct and faster way. Team meetings still take place regularly for coordination and to discuss issues further. For the Director of the department there are regular meetings and less frequent strategic meetings with the head of the AGSC. In related projects regular meetings take place, also often via the AG itself, and email is more important here. For collaborative software development appropriate tools are used to exchange code. Wikis are important to quickly exchange information and to document the work, also the BSCW is used.

The user pointed out that for him it would be just a three minute stroll to the AGSC office and additionally there is a lot of instant and coffee conversation. Also being on the AGSC mailing list it is easy to keep up-to-date with a few emails everyday. Like the AGSC members he added, that in the projects there are the usual regular meetings and update records.

The AGSC is one of JANET's services, but usually the different services do not collaborate, other than having adopted some measures, strategies or tools in the past from other service groups. One example would be the long time support of the JANET video conferencing service, which experiences and tools have been beneficial for the AGSC and could be adopted, because of some similarities. The JANET AG booking service is basically built on the JANET video conferencing booking service and also a tool to check audio and video quality could be used for AG. This tool (AG check) will be released soon in a better version especially for testing the AG. In general it is seen as very important to adapt the technology in a way it is useful for the AG user community, not vice versa – although sometimes this is not fully possible.

The AGSC is in regular communication with important players like the Argonne National Laboratories ("the guys that created the idea of the AG") as well as with the inSORS people from Chicago. Collaborations with people doing AG research and development have taken place in the past, happen right now and should be even expanded in the future. One example would be the SUMOVER project (http://www.cs.ucl.ac.uk/research/sumover/), which helps to improve the AG audio and video tools. The AGSC got involved because "*first of all we have a lot of expertise we know a lot about our users and second of all because we may be able to influence decisions I mean at the end of the day we kind of lead that big community and we can be important players*". To get involved with other communities (standard video conferencing etc.) is assessed as important to learn from each other and or even collaborate. It is stated that generally the AGSC probably should do more in terms of collaboration.

Community structure and mobilisation

The AGSC supports AG users in the whole UK, who are researchers from different institutions and in different disciplines, including social sciences and humanities[25]. Traditional Grid communities like physicians are said to be not the usual users of AG, as they probably have also a tradition in using other tools for videoconferencing. Most users are believed to be in some way connected to the e-science community through funded projects or collaborations in this area. No other specified communities are known to be really involved.

For users and developers in the environment of the AGSC collaborations take part mainly with other universities through projects, like Memetic, CREW, PAG and others (see above). Another activity starting soon is an Arts & Humanities AHRC funded project.

In the US inSORS have a commercial user base, including for instance an oil rig, from the governmental area also US Army medics, and it was used during the SARS outbreak. In the UK so far AG seems to be used exclusively by higher and further education institutions. Only one defence company is registered (as the only commercial user so far), "*doing defence research for some universities*". The BBC seems to be interested, but so far do not use it.

The first AG node was installed in Manchester in 2001. Academics started to know about AG because of show cases, conferences, workshops and through contact between universities. With the start of the AGSC in 2004 it was planned to reach big audiences foremost via the website, but the main reason for the successful outreach is seen in the following: "*I think it kind of spread because all the academics saw all the potential at conferences and talking to other academics and so on*." So if AG sessions work and users participate in successful sessions this can lead to a snowballing effect.

In the current three year funding period it is planned to revise the strategy for outreach ("we know that while the Access Grid Support Centre has been successful there is room for improvement") and a strategy meeting has been initiated to meet this end. One main goal is to "sell the AGSC better", because one hindrance is seen in people having had bad experiences with AG for different reasons and so not wanting to use it anymore. Making users aware of how the AGSC could help in such cases could lead to users seeing the value of the system and therefore to larger adoption of AG technology. It is pointed out that usually it is more difficult to get aware of the success stories as of the failures, especially when it is the nature of the support centre to help in the latter cases. Part of the new communication strategy will be to show the advantages of using AG and as well the AGSC.

In 2006 and 2007 two user surveys (Daw, 2006; Gomez Alonso, 2007) have been conducted with the intention of reaching as many people as possible (over the website, mailing lists, snowballing). Overall there had been 170 responses from 26 (31 in 2007) different UK institutions. The results corroborate the interview statements in part already described before: The quality of service was assessed as excellent and good, problems have been mostly encountered with network issues (multicast and firewall problems) and improvements were mainly wished for more reliability, greater coverage of AG across organisations that do not currently have it and better quality of audio. The main benefit of the AG has been seen in alleviating the need to travel, whereas facilitating teaching was mentioned only in 6 % of the answers. The benefits of the AGSC have been seen in the general

[25] Prominent examples would be the 'Early Modern Texts & VRE in the History of Political Discourse' project which at the same time is a MA programme (http://www.earlymoderntexts .org/) or the social science 'Using Access Grid Nodes in Field Research and Training' project & other activities of the sociologist Nigel Fielding (http://www.soc.surrey.ac.uk/staff/nfielding/)

support and also to a lesser degree in training. The results have been published on the AGSC website and show the valuable feedback. The problem was, that the results were not easily comparable because the surveys had been designed differently. In the next survey planned for 2008 it will be made sure that the questions are close enough to the one in 2007 and therefore make a comparison and further insights possible. Nevertheless the surveys lead to activities to "*improve the AG experience within our community*", e.g. with the founding of the AGSC UK task force, where users of the AG, the management team of JANET, members of the JANET education and research network and the AGSC are involved and meet regularly. The first issue the task force tackled collaboratively was the improvement of the multicast reliability (i.e. more stable network connections between AG nodes).

For more feedback forms are circulated at the workshops taking place every six months. In general it is pointed out, that the AGSC would be always open for all kinds of comments. The actual support is assessed by the interviewed user along the following lines:

> *"In principle getting things up and running has not been too bad because we've had the experience of lots of different area and coffee conversations. But how often do I phone the support centre, normally now they are quite proactive about, they realise that something is about to go wrong and they contact me which is quite nice".*

As a researcher in the computer graphics and visualisation community the interviewed user stated to have a lot of connections with other universities having an AG node, which would have developed over the years of using AG, e.g. by doing the lecture series.

Adoption

Speaking of numbers of registered users and AG nodes currently there are about 120 room based AG nodes in the UK and over 300 registered users. As the AGSC started in 2004 there had been about 20 AG nodes, constantly growing since then to 40 in 2005 and 80 in 2006.

As the number of official new AG nodes is expected to be still increasing it is argued that for the AGSC it is a matter of playing an important role in this development. This should be achieved in putting forward the AG success stories to sell the AG better against the negative voices which often seem to stand out from what can be heard of experiences with AG. Additionally users with problems who can be identified should be approached and helped to sort those problems out by the AGSC. Generally it is stated that people see the benefits of AG and as the AG spreads there are also more research projects with a lot of participants from different institutions using and exploring he AG, leading to a snowballing effect of AG use and interest. Not having an AG node then can be a disadvantage in working or even applying for a research project.

Additional beneficial factors to foster the use of AG and therefore the AGSC are seen in:

- More ease of use
- The advantages of less travel: it saves time and can also be seen as a green technology
- Open source, open standards and the AG Tool Kit are seen as a big advantage, because in this way functionalities can easily be added to the system and then work basically everywhere (also an advantage looking at commercial systems).

- It is said that when people experience a smoothly running session, they most likely will use AG again and like using it.
- In the beginning AG Grid sessions had an advantage in costs, as conferencing and video conferencing was expensive to do.
- Two interviewees added a additional thought in indicating the importance of laying the focus also on a worldwide outreach, or at least on European bids, meaning, outreach to Europe could be enhanced more with this kind of projects and the help of the AGSC: "*In Europe Access Grid is very early days and there are still problems.*"

The issue of AG nodes where the need of proper set up, support and maintenance is not really seen by the local users or the institution is identified as the main obstacle of adoption. This then causes problems when connecting to such a node within a project etc. And this probably will continue to be the case for some time in the future, until the technology will become more mature and more standard, so that will be effectively supported everywhere.

Also AG can have an initial cost problem, because the hardware for a node is expensive – especially when this is not funded as in universities: this is especially a barrier for the uptake in business and other areas, going along with the low bandwidth outside the university networks. A bottleneck for business communities using AG could be the networks, which have still not the same bandwidth as university networks.

Although mentioned as a beneficial factor for use and uptake, ease of use is also pointed out to be still a problem, open source can also mean that it is not 100% stable: "*That's the hardest part of it I think, getting people to take that on.*" The user furthermore experienced problems with the usability of the interface, especially since two years ago as a lot of new features have been added.

Sometimes there is nobody taking responsibility for maintaining the nodes or trying to do QA tests ("*we are currently trying to work out how to not punish them but enforce it on them*").

The AGSC do not know, who really uses the AG: It is difficult to know

> *"a) which (..) nodes have registered and never been used, b) which ones are used and c) which ones have never registered and put in the system because they don't feel that they need the service or they don't know that we actually provide the service for them".*

Impact

Compared to 2004, when it was a very new technology, there now is a better understanding of and more experience and expertise with the AG in general. Only one person at the time had already had some experience with AG. Furthermore the AGSC team now knows and collaborates with the important players of the community, like the developers at Argonne and the people at inSORS. From the development side of things the introduction of the AG tool kit, especially from version 2 to 3 is seen as the most important change. Additionally there are more servers and a better back-up solution in place. For the user especially the experienced less travel to meetings is seen as very beneficial.

The growing user base is seen as an important measure of success together with the fact, that the number of reported problems has only grown compared to the larger number of users and nodes: "*Which somehow reflects that if we have a lot more users but more or less the same sort of problems report, then that reflects that we are doing our job properly*." The fact that the AGSC now consists of more team members than right at the start is explained by the increase in services now

offered and not because they would have to deal with more problems or support inquiries.

Despite a lot of publications coming out of the projects in the environment of the AGSC, publications are not seen as the right metric to assess success.

The impact of AG and the AGSC in the future is basically seen in constantly improving the system and its use (usability, audio, video, portability, getting the annotations work better) and a constant and wider uptake und broader visibility. Similar commercial systems are seen as a possible threat, one interviewee on the other hand could image the AG itself going into the commercial sector. The developer sees especial a beneficial impact of the currently running CREW project.

Change

Especially during the first three years of funding the AGSC has evolved in a positive way and today more and better services are offered. The whole package is assessed as being better now, due to discussing experiences in the team, using the feedback and also the ideas of the community (from users, developers and researchers). Compared with the initial contract the services done as part of the Support Centre at the end of that contract are said to be completely different. This introduction of new services in the first phase of funding was not planned and came up mainly with the need to support not only inSORS but also AG Tool Kit users. Other small changes were introduced as it was seen that they were needed to support the users:

> *"But as we started doing it, we realised that we needed to change things we needed to offer more things for our community (..). And as an initial idea it was very good and then we needed to change, we needed to develop and come up with new services and change the ones that we were offering already and so."*

Along this notion also the use of the main AG software packages developed. In the beginning only the commercial software was supported (starting in the USA the need for support of inSORS grew due to the massively growing user base, which probably was not expected in that way so fast and also worldwide), but it was found out quickly that a lot of users used the open source software (AG Tool Kit) in the UK, so the initial plan was enhanced "to do something for that very big part of our community". In this sense it is pointed out that constant evolvement is important for the AGSC, also because software changes constantly.

Teaching issues

In Australia and the US there are a lot of people doing developments as part of research degrees, but at the AGSC or in the UK generally that is not the case. In using AG as a tool for teaching it is clearly seen as "one of the things that we had envisaged", particularly to let famous scientists from all over the world give lectures to students. For about a year a scientific lecture series for the computer graphics community has been established, which is very successful and has lecturers from all over the world. Additionally in summer 2007 master students are using a Sony Aibo robot dog as a mobile web cam which can be connected to the AG. Overall it can be stated, that the AGSC itself does not have a formal connection between research or support and teaching, but on the other hand they take part in such activities going on in their immediate environment and benefit from these.

Resources

JANET is funding the AGSC for three more years starting August 2007, with slightly more than 250000 GBP a year. Six months before the end of this contract there will

be negotiations about extending the contract for two more years. Right now there are no considerations about a permanent funding, but the feeling is, that these additional two years most likely can be accomplished, which would extend the time span to 2012. The main costs are salaries, a bit for equipment, travel and conferences. Users are trained in the workshops every six months, which is part of the contract – no service of the AGSC is chargeable for users. Otherwise there is no explicit budget for internal training measures. The setting up of AG nodes is no responsibility of the AGSC in terms of costs.

The research projects running alongside the AGSC are beneficial in terms of development and knowledge transfer, but do not add funds to the AGSC budget in any way. The other way round, to do more than the usual AG support, activities have to be funded from other sources. But overall the funding is seen as sufficient right now. The only thing seen as a slight disappointing is that because of the fixed budget the AGSC has not been able to put money in for more research, development and innovation in the service, e.g. being able to do some experiments about new things and different ways of working besides the research projects already there.

Policy input

The successes are seen in the quality of the fundamental support of the AGSC. Also the current projects running alongside the AGSC and the general strategy are perceived as the right way to enhance the AG with new functionality which is needed, like better recording and annotating.

One challenge in general is seen in the AGSC being a support centre for something called a service which probably was devised more to be a research tool. People in part expect the service to be more mature as it really is right now. And even as the AGSC would do everything to make the system more mature it will take some time to accomplish that.

One the other hand the interviewee coming from the institutional environment of the AGSC perceives the AG as a mature technology and generally as a good idea and that it "*stimulated people to start thinking about it*". He also adds: "*I think the biggest single failure is not being able to get one in research council headquarters, directly nothing to do with us.*" Finally he adds, that he experienced the commercial take up as disappointing and not as high as he would have had hoped.

The user still sees a barrier in administrative support in terms of networking (technically). Otherwise he states to be "really impressed" with the AGSC, because it helps people getting over the barrier of technology use.

Recommendations for policymaking are expressed by three of the five interviewees in different areas.

- Institutions have to understand, that it is not sufficient to just buy equipment, e.g. for an AG node, but also to "*get someone to maintain that equipment and make sure it stays high quality and so on, and if everybody did that the experience would be so much better*."
- The funding cycle is experienced as to short and having that same money for ten years without having to bid every three years is perceived as having been able to do it better.
- It is "*a European version of Access Grid Support Centre or even based on the E-Social Science Software and those areas which I think should be set up.*"

4.2.2 Modelling and Simulation for e-Social Science – MoSeS

Background

The project Modelling and Simulation for e-Social Science (MoSeS, http://www.ncess.ac.uk/research/geographic/moses/) at the University of Leeds is one of the seven research nodes currently funded by the ESRC National Centre for e-Social Science (NCeSS, http://www.ncess.ac.uk). NCeSS itself is an institution funded by the Economic and Social Research Council (ESRC, http://www.esrc.ac.uk/) within the UK e-Science programme and focuses especially on the social science research community. The main question of MoSeS is how to use the massive data resources and computational power of e-science to address important intellectual and applied problems through modelling and simulation.

The three year project started in September 2005. It focuses on creating a micro-simulation model in which the entire UK population with all individuals and households is represented (core component one) and at the same time a demographic model is added that ages the population over the next ca. 25 years (core component two). Together with this so called baseline model several tools are developed to address specific research and policy questions, including a dynamic modelling capability and a Grid-enabled portal for policy analysis. The underlying data used for the projections is the Sample of Anonymised Records (SARs, http://www.ccsr.ac.uk/sars/) from the UK 2001 Census of Population and Households. Different static and dynamic ageing models are used to project the synthetic population forward to the year 2031.

Previous work in the Hydra and Hydra II projects (http://www.ncess.ac.uk/research/pilot_projects/hydra/), two ESRC and NCeSS funded e-science pilot demonstrator projects, provided MoSeS with a spatial decision support system. The projects also have been conducted by the PI of MoSeS. The Hydra demonstrator is a portal build upon a service-based Grid architecture, which provides secure access to a data service, modelling tools and collaborative services. For MoSeS this portal is developed further with the use of portlets.

The project has application areas in three domains.

- Health care: In this field the objective of MoSeS lies in exploring the application of Grid technology to integrate data from a variety of sources like health and social care, in order to learn how these care services are used and hence how they can be improved. Additionally the integration of social networks in this area is simulated to examine potential benefits for the individual and the formal care systems.
- Transport: The simulations in this area are looking at plans for expansion (especially in case of the Northern Way, a 20 year programme to transform the economy in Northern England) in combination with the reduction of congestion. The models additionally involve business activity and changing demographics, resulting in the challenge for MoSeS to devise economic forecasts and show so called “what if” changes to the local infrastructure.
- Business: Here the aim is to build a model in which financial scenarios are simulated to examine their potential impact over the next decade. This includes important issues like the pension “time bomb” and the increased use of Equity Release Products (e.g. deflation in house prices, rise in interest rates).

Currently the simulations do not necessarily use the whole of the UK population in projections until 2031, but it is planned to implement this within the duration of the project and to increase this year by year. Furthermore the methods for demographic forecasting and projection will be developed to be fully dynamic, i.e.

better scalable to specific scenarios within each model. Demonstrator applications for a variety of scenarios will be built and the Grid-based portal will be improved over the time in terms of usability and functionality for use towards diverse policy-relevant questions.

Besides the MoSeS PI who wrote the proposal in starting from the Hydra pilot demonstrator projects none of the interviewees was involved in influential work previous to the project, but at least three of the Co-PIs also have been involved in writing the proposal. The others started with the initiation of MoSeS. One of the developers/researchers already worked at Leeds University but did not have some connection to the PI before, another has worked in the context of e-Infrastructures for some years. The MoSeS project consists of the PI at the School of Geography at the University of Leeds, six Co-PIs bridging geography, computer science and the three application domains (business, transport and health care) and the three person research and development team. Two team members have a computer science background and do more code related development than third, who is a trained geographer. The PI together with the three researchers/developers make up the MoSeS core project team.

Technology

The technical MoSeS framework is essentially a Java platform based as much as possible on open source third party software, which itself is based on Java or supports it. One interviewee pointed to the extensive list of software used in MoSeS which can be found under the blog pages of a project member (http://www.geog.leeds.ac.uk/people/a.turner/projects/MoSeS/software/) and to which only Shibboleth, Permis and GridSphere would have to be added. This page also suits as the unofficial project's software page.

The simulations to be done in MoSeS are computationally quite intensive, therefore a cluster of computers works parallel on the tasks, something which first had to be accomplished at the start of the project. A lot of tools are used to automate and distribute processes over the cluster as much as possible. Very useful for parallel and automated processes is providing a message environment through advanced Java objects and files using "MPJ Express". The software was designed and is still further developed by a group now at the Centre for Advanced Computing and Emerging Technologies (ACET, http://acet.rdg.ac.uk/) at the University of Reading. This group also is involved in diverse UK e-Science activities therefore making it easy for MoSeS to become aware of the software in the first phase of the project. Through using MPJ Express an exchange of information between MoSeS and the software developers began which helped to make the software better usable. At the same time MoSeS is listed as a user for the software on the ACET website, supposedly helping to make them better known in the community.

Another tool used for geographical mapping is GeoTool, which was developed in the already mentioned Hydra projects, which helps in collaborating with the tool's developers in case of problems or questions through the contacts of the PI. To having been able to get "*Geo tools working with the portlet which no ones done before as far as I am aware*", i.e. in an environment integrated with the Storage Resource Broker software (SRB, developed in San Diego, http://www.sdsc.edu/srb/index.php), is seen as an innovation for the Grid community. SRB is very important for the splitting and distribution of the huge data in the cluster, which otherwise is too big for one machine to handle. With the progress of the project also the amount of data increases and this technology becomes more and more essential.

For the development of the Grid portal and the use of Grid middleware GridSphere (a portlet engine running on top of Apache Tomcat as the servlet engine) is used because of its JSR168 compatibility, another important standard besides using

Java. In the overall development work also commercial software and systems are used as working tools like Microsoft Visual Studio and iMacs. Concerning standards one interviewee put it the following way, which exemplifies the approach of MoSeS (OGC is the Open Geospatial Consortium, Oasis is the Organization for the Advancement of Structured Information Standards):

> *"(..) how we get that to work requires the adoption of standards as well and you know, having free and open source software for one thing, but also stuff that is implementing the right standards or de-facto standards, they are those standards to defining organisations and developing organisations (..). So in particular things like W3C, ISO and OGC and Oasis."*

The funding through ESRC via NCeSS also formally demands the development in open source as much as possible. Using standards together with open source is seen as an advantage because of the large community and therefore the potential help in case of problems. Also the possibility to choose from a variety of software is very beneficial and it is said that in most cases the software is more reliable because of that.

E-learning and training

In MoSeS there is no formal training or the use of e-learning tools involved. If courses have been taken in terms of academic further training then, as one interviewee stated, "*most of what we are doing is not anything that we have learnt in these courses*". The notion of learning in doing research, developing tools and exchanging knowledge in the group and with others is widely supported.

Technological constraints

Security issues are generally very important and constraining because of the confidential nature of the data:

> *"And we still have got security problems that we can't have them access the data and all of the different things like that, because it is mainly data issues."*

This is especially true for the storage on hardware external to the UK, meaning that for example in the project CoLaB between the University of Leeds and the University of Beihang in China (for more details see next section) no UK data may be send, processed or stored there, which hinders the use of otherwise additional powerful computational resources.

Computational power still is limited (resources are simply not available or too expensive to buy in, i.e. latter is not intended as a model), especially thinking of what could be done in simulation with "*unlimited resources*". The capacity of the Grid is not big enough so far, other than maybe expected by some at the project start. Therefore the models have to be optimised so that they fit into the restricted resources, but this does only work to a certain point. So even with the very fast 32 node Beowulf cluster in Leeds one simulation run takes up to several weeks. As simulations for optimum results have to be repeated multiple times and for multiple years into the future, so far in cases just one run has to do – and it will take some times to solve this, as "*it's about five or ten years down the line easily*".

One barrier evolved when the team's tele-worker has to use the computer at home which constrains the connection via AG and other network tools through router and firewall, making collaboration more complicated in cases.

Another minor problem pointed out in dealing with cutting edge technology is that there often is no good documentation available.

Communication: Internal and with stakeholders

Internally the PI functions as a link between the other three core developers/researchers. Two of them normally have daily email and face-to-face contact, also during lunch or coffee times. They do not work in the same building, but on the same campus. One of the two works on the same floor as the PI, which on the other hand is very busy in different activities. All developers/researchers have their own field of work and do not normally work on the same code base. The third developer/researcher is tele-working from another city (and comes in only once or twice a month), so it is important especially for the PI to be flexible in communication and coordination and provide tasks and information to everyone when necessary:

> *"B is expecting to get something from C but C's not outputting something yet so the PI gives a dummy to B so B can carry on imagining what he is going to get from C is something like what the PI has given him; while C still carries on doing something before that, it's what still I haven't yet produced, something in a format that C was expecting to use; while I am doing that the PI has quickly provided a dummy to C so that C can start using it and I have come up with something and it's like: can we use this instead of that?"*

The work in the team seems to get done well. But as distance definitely is a barrier this sometimes becomes apparent in the level of general informedness, which is lower with the tele-worker. The daily and very detailed blog of one of the team members is a big help for the team, even if it is not quite clear, if more than one other team member reads it regularly. Blogging is considered to be very important by him – e.g. in terms of "*laying out the information trail*" – and he would like all project members to use this as an information space like himself. The blog also is beneficial as a chronological project memory and to know what is going on in the project overall. The software page of the blog is the unofficial project page regarding the project software and used de-facto standards, as mentioned before.

The regular mode of communication is email, face-to-face meetings and telephone. Two forms of project meetings have been established: a management meeting, which also includes the Co-PIs and a technical meeting with only the core team expected to attend. These had been regular meetings, but after three or four times things fell back to being irregular again. As one team member put it, they seem to only have them "*at times when it has been crucial to get some stuff done*". It is the overall impression that normally everyone knows what to do or, if not so, can ask the PI or get information in the blog and from the other project members.

The users, i.e. at least three of the Co-PIs, are experts in their application domain and have given important input towards the development of the basic models for each domain. On a computer technical level they use the application and currently mainly provide feedback on the user interface, which so far is a more unformalised process. In later stages the feedback is expected to be even more important and to be provided more regularly, because the applications will get more and more complex and mature. Still the leading role in how to incorporate all feedback lies with the core team of the PI and the three developers/researchers. Usually only the PI collaborates directly with the Co-PIs. One developer/researcher stated that it maybe could have been beneficial at some points in the past to have gotten feedback on the portal interface in a more direct and structured way from the users: "*They haven't complained but I don't know if they like it or not*", but in the end "*it seems to be working alright*".

The project CoLaB (Collaboration of Leeds and Beihang, http://colab.crown.org.cn/) between the Universities of Leeds and Beihang in China develops a Grid middleware called Crown-C (focused on high assurance dependable systems). Because of the large resources in manpower one of the interviewees assesses the

software already better than Globus Tool Kit 4, as "*in China they can put 80 or 100* [persons] *on the same thing, so in a very quick period of time it grows phenomenally fast*".

Important collaborations with stakeholders include the OGC community, especially within the Geolinking Interoperability Experiment (http://www.geog.leeds.ac.uk/people/a.turner/organisations/OGC/GeoLinkingIE/), where also researchers from Agriculture Canada (http://www.agr.gc.ca/) are involved. Edina (the JISC national academic data centre based at the University of Edinburgh, http://edina.ac.uk/) is a regular partner as is the University of Reading (MPJ Express software team, for details see description of technology above) and an especially strong relationship with GeoVue (another NCeSS funded node, http://www.ncess.ac.uk/research/geographic/geovue/) for map display tools to make the maps prettier and maybe more Google style. As for other standard organisations there is only collaboration if needed, used standards become the de-facto standards in the project:

> *"But most of the sort of liaison of the standard bodies is done by others we just wait for it to trickle through and then we will develop on that. So we are not working with the most recently in development standards that aren't yet the recommendations that aren't fully published."*

Grid data services in the UK used by MoSeS are mainly the National Grid Service (NGS, http://www.Grid-support.ac.uk/) and the White Rose Grid (http://www.wrgrid.org.uk/), a collaboration between the Sheffield, York and Leeds universities and commercial IT partners. Also the OGSA-DAI Project (http://www.ogsadai.org.uk/) helps sometimes within its mission of Grid middleware development to support data access and integration from separate sources.

NCeSS as the hub and administrative funding body of MoSeS functions as a contact point and propagator. There also is an exchange of knowledge between MoSeS and the e-Infrastructure for the Social Sciences project (NCeSS e-Infrastructure for the Social Sciences project, http://www.ncess.ac.uk/services/). This is not seen as a formal collaboration, but as the PI and another member from MoSeS work in both projects there is a benefit coming from this exchange, as the e-Infrastructure project is looking at broader development of Grid software and services. One developer stated that maybe in the future there will be a stronger collaboration "*within the core middleware type Globus Tool Kit*" towards security, as this will be an even more important issue as MoSeS progresses. More loose contacts are established with PolicyGrid (again a NCeSS node, http://www.ncess.ac.uk/research/semantic_web/policyGrid/) on "*some interesting issues*", and the e-sciency and e-social science community overall. The PI furthermore has a strong connection to the San Diego Super Computer Centre (SDSC, http://www.sdsc.edu/) because he has been a visiting fellow there.

Community structure and mobilisation

As described before there are three application domains in MoSeS, demographic simulation for health care planning, transportation research and the house market related business area. As the business area currently plays a smaller role in the project the other two fields are represented by at least one Co-PI working at respective institutes in Leeds. The Co-PIs, as scientific users are the interface between the projects core team to the other users from these domains. The modelling and simulation and therefore the collaboration with the application domains currently focuses only on the Leeds area. In the health care domain for example the Leeds primary care trust is involved through the Co-PI, with the main question of how to organise service for the population over the coming years best. At the same time the developed models evoke attention from other primary care trusts:

> *"Since we have been putting the information online about what it is that we have been doing, we are getting direct queries from these large organisations now saying, we have seen what you are doing and we are interested."*

The same is true for the transportation research area, where models are developed for Leeds which are correlate where people are living and working in the next 20 years and to where they move and how demographic, traffic and transport factors might change as a result. And these models also can be adapted to a larger scale or to another region.

The business application domain currently is the least developed one in terms of the application itself. So far this means mainly looking at house price modelling.

Adoption

The MoSeS project currently is in the first cycles of development of a mature programme, which means that there is nothing to officially use right now, except prototype demonstrators and the early versions for the applications domains. But as described in the last section, the content on the web shows great prospects and interests potential users and organisations highly for future use. One interviewee described the current state of the software as follows:

> *"It works, it's not great, it's very flaky software I would say, it would work fine if you use it properly but it just assumes you will use it properly, if you start doing some things you shouldn't do it will just crash or something, it's not production quality yet", but it speaks for itself that there is "appropriate web content that leads people to saying: give us it!"*

A concrete practical improvement therefore is seen in devising a friendly user interface, providing all functionality through a Grid portal.

The main obstacles seen do not lie on the technical site but in the computational power available over the Grid and in data licensing and data security concerns. Taking this into account it could be likely that in terms of a product ready for rollout it could be too early for a wide adoption and uptake at the end of the project. But there are no doubts that the concept and development have to be considered very successful. It has been shown to Leeds City Council, who are interested in producing specific reports on certain aspects, one of the tasks the MoSeS team is concentrating on hoping to achieve useful outputs in the next couple of months.

For the future it is common ground in the project team that the next year will be a very crucial one in terms of meeting the expectations and that "*with the follow up project Genesis* [if it will be funded]*, we're in a pretty good position for uptake*" (see section on resources for more details on Genesis).

Impact

The content on the internet (website & blogs) is considered to have lead to the main impact of the project so far, even if the software is still under development and there are not very many documents to download. Together with presentations and pilot demonstrators in the application domains as well as press releases in general a huge interest in the MoSeS project was generated, and although it aims at a very limited community a lot of outside interest was evoked (also see the interest of care trusts in models and in the general adaptability of the developed models to other regions or other scales mentioned in previous sections). Comparisons with SimCity (a popular simulation computer game, http://simcity.ea.com/) especially in the science and academic related specialised press in different international publications like Highlights from the UK e-Science

Programme (Issue 2/2007) or the US based International Science Grid this week (iSGTW, 01/08/2007, http://www.isgtw.org/?pid=1000537) raised awareness of the project dramatically. The connection between SimCity and MoSeS first was made by "*the University of Leeds put*[ting] *out a press release about Moses calling it SimCity for real and that's what did it.*" The team members are not necessarily happy with this label, because people could "*misunderstand what Moses is trying to do*". But they have to admit, that it has been an outstanding promotion. And one interviewee even sees more potential in using the internet: "*It will sort of explode if we get some good use cases flashed out with these particular groups that those three interface with.*"

Furthermore the promotion as an NCeSS node, scientific publications, conferences and presentations gave the MoSeS project a brilliant standing within the respective communities. So far only few papers have been published but the ones which have been done were very successful. One paper won the second best paper award prize at the All Hands Meeting 2007 in Nottingham and will be published in a Journal next year ("*Malcolm Atkinson who's the UK science envoy, he gave us 25 out of 25, said it's like a perfect example of an e-science project*"). And while attending the Supercomputing 2006 conference in Tampa, USA MoSeS did a live interview with a radio station, "*live from America about Moses*" and was mentioned in many newspapers and the New Scientist as well. Overall the team is confident: "*We have helped fix some problems and engage with the e-Science community. Maybe in five to ten years it will be powerful enough to do some more interesting work.*"

Change

At the start of the project the MoSeS team had to cooperate with four different organisations in the health care domain, which was difficult to coordinate. Because of a reorganisation in the national health care sector the Leeds primary care trust was installed as the sole organization making the collaboration between developers and users much easier. As the trusts got bigger, they also had to think and plan on a larger regional or even national scale, which boosted the already existing need for modelling and simulation in their field.

One project member stated that there had been no apparent change management in the project duration "*although details were not specified and this has given some freedom to adopt and utilise new technology and approaches as they have become available.*"

In the first six months of the project the current tele-worker had been working also in Leeds, but this seemed not to result in a huge difference for the specific work, but sometimes for knowing what exactly goes on in the project in other areas.

Teaching issues

One of the developers/researchers teaches a Master level course in the school of computing and next year it is planned to have him involved in an undergraduate course. For both courses MoSeS is used as an example study, which seems to work fine looking at it from the computer science perspective. Additionally a Master student currently is working on security issues around MoSeS for his thesis and in this way contributes to the project. In the School of Geography the PI has worked with several Master students on different issues helping the project. An upcoming idea is to find further students interested in doing a PhD within the MoSeS PhD studentship.

"*I can't imagine us running a course on Moses, now there is no need for it*" stated another interviewee who is situated in the School of Geography. Additionally the impression is that if it shall work, it will be difficult to run a course within a three year

project anyway, because such things would have to be set up right from the beginning to be successful. Furthermore after three years project time it is not sure if this then could be continued.

Something currently being explored is the use of MoSeS models in a teaching application within the University for geography students, but right know it is not sure, if this can be achieved in a "*little project*".

Resources

The project is funded with £574.772 over three years, whereas the main costs are for staff. Additional funding is not seen as an absolute necessity, but nevertheless it is considered to be important to find funding sources to finance one student doing a PhD in MoSeS besides the studentship in the computing department.

Furthermore an interviewee has applied for a Google research grant on Moses, which financially would be only a minor asset of £5.000 – more important in this context would be the exchange of knowledge and data. In this way MoSeS would be able to make use of Google's approaches to data modelling, also feeding in Google data as well as Google could have a look at MoSeS, so that both sides would benefit: "*It's not just financial resources* (..)*, sometimes we are after other resources that a company can offer.*" Not directly connected to MoSeS but with the same benefits and being a sign for the general expertise and further outreach activities of the MoSeS team in the area of e-social science is the participation in the NCeSS e-Infrastructure for the Social Sciences project.

In terms of planning for the time after MoSeS a proposal was handed in for funding of a new NCeSS Node (in the second funding round of nodes currently under way) combining the strengths of GeoVUE and continuing MoSeS to focus on urban modelling within the context of "Generative e-Social Science" (the so called Genesis project).

Policy input

The success of MoSeS foremost can be seen in the innovative concept, i.e. the combination of social science modelling and simulation with Grid software to address issues of high relevance for present and future developments in society and policy making. One of the scientific users pointed out, that so far no system exists in England, which can predict developments on base of a functioning model – and the underlying model itself for him is the key technology. So even being still in the development phase the potential of the software and its underlying models already have a huge impact in the respective communities, with the press and maybe most importantly for institutions like health trusts, city councils and governmental bodies. Furthermore the current scale in the application domains can be enlarged in the future (i.e. nation or even worldwide). For one interviewee also the exchange between social science and computer science through concrete work is pointed out as a huge benefit. Another project member sees this more critical and also points to barriers in understanding each other always in a multi-disciplinary project, which have to be bridged. At the same time technology itself can be a barrier, which has to be addressed. These are not severe problems, but an effort has to be made to handle them every time. Looking at the larger whole of research and impact an interviewee emphasised:

> *"I think our experience will be very beneficial to certainly other people in the social science system, the arts and humanities, because we've looked at some social science problems and we've looked at the e-Infrastructure that's available and figured out what works best and stuff like that so that's probably the best you can say in terms of innovations for e-Infrastructure for MoSeS."*

The challenges of MoSeS lie primarily in two areas, the lacking computational power for processing the simulations on the one hand and the confidential data and resulting security issues on the other.

As for the computational power it is the opinion of the team members that it would need more resources which can be allocated to projects like MoSeS within the UK National Grid Service – additionally to the 32 Beowulf cluster nodes already usable in Leeds: "*our simulation requirements to do our underlying virtual population creation in an hour would take 10,000 cpu's maybe 20,000, I was promised the best I could do when I enquired about this was 100 cpu's for 4 days*". The prognosis of the interviewees is, that it would take further five to ten years to fulfill such demands. The general aim of having fewer barriers within the Grid to make access between various services and with various data sets easier and more usable – i.e. "the Grid enabling of data" – is hoped to be realized in better ways in about two years.

The second major challenge, the security issues due to the nature of the data have to be addressed not only by the project itself but also through the constant improvement of the whole e-Infrastructure framework. MoSeS can implement and use Shibboleth as an underlying authentification and authorisation framework, but the data services and providers still have to support this also over the Grid. Even more difficult to solve are the legal issues connected with confidentially handling census data under national law (most notable the UK Data Protection Act), which have to be solved before a seamless access – or access at all – is possible. This is observed as the hugest constraint for the project "*more than anything*", thinking of e-Infrastructure not only as of computer power and users, but also of the legal framework as "*something to be addressed*". The data deluge additionally is mentioned as a special challenge, questions on which data to choose and how to aggregate it have to be answered.

All in all it will probably take some time to be able to use MoSeS to its full indent:

> *"If you think about the grander thing about what MoSeS is about, it's about modelling and simulation for e -social science. The grander vision for MoSeS is for a global look and see what's going on, and by that stage we might be living on the moon but I don't think five or ten years it is not in that horizon but 50 years maybe."*

Recommendations for policymaking are expressed by three of the five interviewees in different areas.

- For one interviewee the most important action would lie in the funding of one or many projects with a focus on researching how the handling of confidential social science data can be technically secured (as the legal framework seems to be not changeable enough in that area). The aim should be to enable using such data in collaborations and virtual organisations more efficiently and with fewer constraints, so that even the Chinese resources could be used with a secure and developed technology.
- Another team member points to funding concepts in general: *"(..) the way that we are trying to influence those kind of policy makers is through demonstrators, just through trying to demonstrate what we can do, the importance of the things that you can do with this technology in the hope that someone somewhere will see that and say yes that is interesting, important, useful, we want to invest in that, there is merit in applying some kind of serious resources to that, but I am not even convinced that government or ever European Union government is the organisation that needs to be doing that, it is kind of bigger than that."*
- One of the scientific users would like to see the funded programmes to be more understandable for the public, i.e. the future users, because if people "*don't*

understand what it is, they won't understand what it can do". The use of new tools and of research has to be communicated in the right way, so that in the case of MoSeS the people working at the policy end get to know that there could be means to make their life easier.

4.2.3 Communication Data – ComDAT (pseudonym)

This report concludes a detailed study on ComDAT (Communication Data, a pseudonym); a pilot project for the development of a web portal that provides a rich assembly of tools with the ambitious goal of bridging research gaps by proposing a new method, ultimately leading to important expected breakthroughs in the study of human communication. Based on data from an inclusive review of publicly available written materials including web sites, publications, and multi-media clips, and six detailed interviews averaging about fifty minutes with six members of the studied group, we find that the study faces a number of obstacles, especially difficulties in communicating across disciplinary boundaries, data sharing and confidentiality, and resource availability--challenges that have already limited the scope of the ComDAT technology. Lessons learned from this study are also are expected to apply more broadly to similar e-Infrastructure projects.

Background

The ComDAT study describes a small group of social scientists from three laboratories in large US universities. Participating scientists are considered central in their research communities, and, among others include members that focus on computational linguistics, and more traditional social and biological scientists who study human communication. The group is collaborating with software engineers and computer scientists—all of whom are Grid computing experts—to develop ComDAT (a pseudonym), which is a pilot application of a web portal for storing, sharing, and analyzing biological, behavioural, and social data over an e-Infrastructure. This web portal will address an important methodological shortcoming in social and behavioural sciences, namely the lack of consideration of multiple simultaneous measures over time, and is expected to lead to advances in both method and theory.

The vision is supported by large scale funding provided by a large granting agency – sizeable support in the US social science community. According to our informants almost all of these resources are allocated to development of the pilot technology, primarily for funding programmers. But all of our interviewees suggested that the vision that guides the project is probably more ambitious than the funding frame permits.

Current quantitative research on human communication is based on one, two, perhaps even three domain-specific measures. For instance, some scholars consider physical gestures. Others examine biological indicators. Still some researchers only investigate lexical selection. Yet, since social interaction consists of multiple biological, symbolic, and behavioural signals, the theories and models derived from specialized sub-fields are incomplete. Although the importance of simultaneous collection and analysis of multiple measures has been recognized since the 1950s, as one researcher noted "*people did try to address these issues, but they ran in horror*." According to this respondent, as well as others, the reason was the lack of available tools, resulting in the modern balkanization of the related scientific domains. With the development of Grid computing and other e-Infrastructure related technologis ComDAT's principal investigators suggested that "*now we really do have the tools that can make these [measures] cohere*."

Technology

The project provides a web-based data repository for the requisite tools, notably the collection and storage of various time series data, analytical tools, and advanced query capabilities. It is the belief of the project's principal investigators that there are two ways in which these tools can contribute to a radical scientific shift. The first is to restructure the organization of science, as the resulting theory may "*literally create a new discipline*." The second is to fill information gaps, since by "*using these tools they [social scientists] are about ready to putting that whole puzzle together and saying, here we can have all these data and we can try to see how all these things fit together.*" These scientists see three factors as key to building their vision: brokering research and building a community; building a community and community practices; and bringing social scientists back to the forefront of computation.

1. Brokering research and building a community. Although some of the tools related to e-Infrastructure have been developed for over a decade, ComDAT planners recognize that they are technologically too complex for a vast majority of the targeted community. Hence one role that ComDAT can play is that of a research broker between technology and social sciences. Brokering the technology involves not only developing tools but also interacting with Grid experts, learning new tools, and negotiating access with large e-Infrastructure providers for the whole community. A major challenge in building a community is getting social scientists to adopt it; the ComDAT model attempts to minimize barriers by requiring minimal learning from the users and making the service free or close to free of charge. In addition, a simple to use web services based portal should further reduce potential usability barriers. The principal investigators have devoted much thought to developing a user interface that can serve as "a YouTube for social science research."

2. Building a community and community practices. A major focus of ComDAT is to develop more efficient research practices, as well as supporting common desktop software, such as statistical packages, mathematical modeling software, and annotation tools, that can be utilized on the portal. It is primarily intended to enhance collaboration within the social science community in at least three ways. First, domain specialists can examine different types of data from a certain experiment in traditional fashion, which should enable a smoother transition to the new research model. Second, scientists may share their data with the wider community so that others can conveniently access additional data to examine their models. Finally, the project provides data provenance tools to allow scientists not only to digitally trace back every change and manipulation done over the course of analysis, but also to allow collaborators and peer reviewers to scrutinize each of these steps and validate the results. Of course, ComDAT may also be used by individual researchers after the pilot project ends.

3. Bringing social scientists back to the forefront of computation. Because ComDAT enables access to a large Grid infrastructure shared by scientists from a variety of disciplines it provides almost unlimited compute and data movement resources on a scale that far exceeds the typical resources currently available for social science research. Yet, as some of our interviewees recalled, a generation ago social scientists utilized mainframes more than others by running complex computations on census and other types of social data. Although the personal computer paradigm has pushed social science research to the isolated desktop environment some respondents believe that "*increasingly social scientists are crossing the threshold of being able to use parallel computing, because as soon as you are doing a lot of stuff parallel computing helps a lot.*" Taking advantage of e-Infrastructure tools already developed for other research communities, in particular physical and life sciences, substantially reduces the time and cost associated with this transition.

Community structure and mobilisation

ComDAT has a dispersed intra-organizational and intra-disciplinary network structure. Three research labs in different universities are involved. Developers are from two of these universities. They collaborate as a typical distributed team—through telephone conferences, email lists, and once in a while using face-to-face meetings. Core developers are linked to computer scientists, some of whom also participate in Grid infrastructure efforts. In addition, some of the domain specialists were trained as computer scientists, thus providing a common interface to the two disciplines. Social scientists also have direct ties to at least one or two of the Grid experts from previous collaborations—this was their channel for learning about e-Infrastructure and the potential for their research. From the perspective of the computer scientists this was "*a great opportunity to provide another community with some of the resources that their [e-Infrastructure tools] could provide.*" This response also explains the voluntary contributions made by a number of prominent computer scientists to ComDAT; efforts which seem to have shaped the direction taken by ComDAT insofar as relying on open source e-Infrastructure solutions .

Although the project is a test bed, rather than a fully functioning production facility for a large community, the principal investigators have identified their target community, since "*ComDAT is an infrastructure that needs to support a community of users.*" The social scientists involved in the project are well linked with scholars in other related fields, which could potentially serve as a basis to solicit user participation and community building. These related fields go beyond social and economic research, extending to such domains as communication, or even legal studies. Although personal contacts are important, the overarching connection is technology, since "*aren't these all [fields] from a technological point of view the same? And the fact is they are. Certainly the substance matter varies and the details, but a lot of the technology of looking at these things is the same.*"

The principal investigators noted that it took many years of research and deliberation for the vision to crystallize and that it was made feasible both because of developments in e-Infrastructure and funding availability. The mobilisation of the community still is hampered by the following challenges:

1. *Adaptation of technologies*. A number of computer scientists we spoke to suggested that from their perspective there is no real difference between physical sciences, life sciences, and the social sciences. As one expert who has worked with these communities argued "*there is no apparent variation in considering data that arrives from a telescope, or from EEG sensor – it is all time series data.*" Social scientists we interviewed disagreed. One of them claimed, for example, that "*they [computer scientists] can build bigger and faster computers but they don't have a clue on how to use this technology to deal with human behaviour. And that's the real question that has to be worked out.*"

More specifically, domain users pointed to a unique feature of social science data, namely that much of it is interpretive and contextual. Even basic physiological data that is considered by some as an important measure for understanding interaction requires some level of human interpretation to distinguish noise from actual data. As an example a senior scientist we spoke to referred us to one of common data types not only in human communication but in social sciences in general: interview data. In these conversations, claimed our respondent, there are a lot of nuances that need to be interpreted, a small hand gesture that is perhaps meaningless as opposed to pointing a finger to the speaker—a meaningful act when considering the context of the discussion. Activities that relate to the former category should not be coded as events, and the later type of activities should be considered events and subsequently analyzed. In contrast, each activity is considered an event in a time series data in other domains of science.

Without the ability to distinguish "real" data from "artefact," it is difficult to synchronize different types of data, and computer based analysis is limited. "*It is not about faster and bigger, it is not like other types of research—it is not converting analogue signals to digital. It is much more complex and interpretative*" summarized one of our interviewees. Thus, what seem to be missing are the basic algorithms to handle these fundamental problems. Without these capabilities the social scientists are unable to accomplish the primary goal of enabling a new method leading to breakthroughs in the study of human communication. Computer scientists "*don't have the time or funding to address the more particular problems [of the social sciences]. They want to proselytize big computers, and are not interested in developing algorithms for social scientists.*" According to this respondent, the problem is that large funding bodies and especially NSF do not find the latter appealing compared to the former.

2. *Communication*. Social scientists claimed that they have expressed these concerns to computer scientists from the start, but their requirements were not fully addressed. On a more profound level this discrepancy indicates a communication problem among representatives from the two disciplines; a gap that cannot be easily bridged and has impacted development attempts, even though developers are a part of the same institutions as the users. Those users involved in discussions with developers felt that "*the development is sometimes a bit opaque to the end user. Sometimes it takes a huge number of iterations before it could be really accessible.*" What they needed was "*patience, a willingness to cooperate, and to understand that it is going to take a fairly long time for the two groups to learn how to work together.*"

All the computer scientists we spoke to have had formal training in engineering or physical sciences, leading to certain accepted practices, understanding, and even use of a specialized language. All of these seem to impede communicative attempts across the two groups. The following passage from an interview we conducted with a core user, a social scientist nicely captures these differences:

> *"Their languages are different. Their work styles are different. And it has taken myself and some of my colleagues the better part of five years now to learn how to coordinating what we want to provide the end user with the technology that the developers have. We still have a long way to go—I think the interface between the developers and users at the level of developing the ComDAT is really one that has a lot of obstacles and challenges inherited in it."*

These reservations were backed by multiple examples, including:

> *"At the most mundane level what people mean by coding or analysis will be very different and for social and behavioural scientists coding may be some form of annotation the variety of different coding schemes both qualitative and quantitative coding analysis conforms to statistical analysis. Coding for developers may have more to do with tagging of the data, creating ontologies etc."*

3. *Translation*. Time may reduce communication difficulties. But although these teams have worked together for a few years and they regularly communicate with each other, they still experience significant communication barriers. Translators – individuals trained in both fields, who understand the language, problems and work styles of each group may aid in establishing a better flow of research and development. These individuals are hard to identify, do not necessarily have in depth knowledge of each domain, and may not have the incentive to serve this role. Two members of the ComDAT community were formally trained in both fields—one is a user, the other, among other things, a translator. Inquiring about the experience working with the user a computer scientist commented that his training "*is great for us, because he kind of understands the technology we are*

developing and we can discuss that with him on a computer science level." Others have pointed out the crucial bridging role played by their "translator."

Adoption

The implementation of the vision faced multiple barriers even at the initial development stages of the pilot project: the road to accomplishing the vision is bumpy at best.

The scope of the problems addressed, the required expertise to address them, and especially the high cost of experimental equipment have pushed certain disciplines, especially in the physical and life sciences to large scale collaborations. High energy physics, for instance, perhaps the most significant early adopter of e-Infrastructure, is organized around experiments with hundreds, and in some cases thousands of collaborating scientists. Yet, in the social sciences, where research tools are less costly than in the physical sciences and most problems may be addressed by an individual or a small group of investigators, collaboration is less apparent. Our interviewees have thus raised a concern that while ComDAT is geared toward enhancing collaboration among domain specialists within the social sciences, for example by providing a collaborative environment for annotation, "*we are dealing with communities that have not been historically interested in collaborating and developing larger projects. So they don't necessarily have to motivation to spend the time for doing this.*"

For all of our interviewees it was clear that incentives are critical to encourage user participation in ComDAT incentives. But the types of incentives may not be sufficiently compelling to the wider community. For the computer scientists involved "*the primary motivation [driving scientists to adopt these tools] is ease of specification and above all speed, in other words, the ability to take a workflow that is time consuming and parallelize that across a parallel computer.*" Yet it is unclear that there is such a requirement for processing speed from the domain scientists—either those studying human communication, or most social scientists in general. Our respondents concurred and further stipulated that the technology would be rewarding only for those researchers who "*can ask a question faster than the computer can provide the answer.*" At least to one senior social scientist we interviewed it was not clear that this benefit is meaningful to much more than a few individuals.

Although the other potential users are not experiencing computational bottlenecks, some computer scientists believe that the technology underpinning ComDAT provides sufficient motivation as it makes research better organized, such that a scientist will not need to be "limited by his own diligence." While this may be the case, users still need to gain awareness about these tools, learn them, and ultimately deeming this process worthy for changing their habits.

- *Gaining awareness*. Publicity to the work is done through common channels: a publicly accessible web site, published materials, presentations in academic conferences, and utilizing existing social networks. Despite these efforts our interviewees were concerned that they need to get much more exposure to encourage participation. In fact, in response to the question "suppose you had twice as much funding, how would you allocate it?" one of our informants suggested he would use these additional funds exclusively for organizing workshops and reaching out to users. The goal would be to engage "*people who are highly visible in their field, who are willing to take the time to learn these tools and then provide demonstrations of the added value of doing research with these tools.*"
- *Learning the technology*. Future production versions of ComDAT are meant to be made simple to use. Even if this vision is to be accomplished, ComDAT, as

many other e-Infrastructure projects, relies on a set of common technological solutions used by physical and biological scientists. These solutions do not include a model for handling commercial products, which are the primary analytical tools to many in the targeted communities. The main problems, as noted by a software engineer we interviewed, include licensing and porting. In a distributed environment as e-Infrastructure there are currently no accepted pricing schemes or licensing controls. And in some cases closed proprietary code may not be manipulated to transition from the stand-alone desktop environment to be used by hundreds of dispersed machines. Both of these technological constraints push developers and users to further rely on open source solutions and require potential users to learn a new set of analytical tools, perhaps even novel approaches, which may or may not better serve their research needs. Learning these new tools, many of which are not as user friendly and demand additional specialized knowledge bears a high cost to the potential user. The problem, we were informed, is not as acute in the physical sciences where there is less reliance on commercial tools, and there is much more experience in using open source, barebones solutions. The problem is more acute if we consider the following remark made by a social scientists who is well aware of the field, "*it comes down to how much people are comfortable with technology. As an example some of my colleagues do work with transcription of speech, observational coding of video, [but] they are still doing it in a fairly outmoded fashion where they have people do the codes and put everything in an excel spreadsheet. Actually, they first put it on a legal paper and then in an excel spreadsheet.*" For these individuals the learning curve may be too steep.

Our interviewees have suggested that using the common resources of the e-Infrastructure poses at least three additional challenges.

- *Data sharing*. If the aims are building a community and altering scientific practices then even the most sophisticated and powerful web portal will not amount to much without high quality research data. ComDAT's model assumes that scientists will share their data on the Grid and opening up opportunities for ad-hoc dynamic collaborative environment across virtual organizations. Yet, sharing data is not common in the targeted community. "*I think that data sharing is the biggest problem. The technology is already there*" argued one respondent who for many years has been advocating data sharing within his discipline. No incentives exist for sharing data. There are scientists who wish to contribute to the community by offering their data to be analyzed by others. However, these scientists have to consider additional costs, such as conforming to certain standards—which typically translates to re-formatting the data, and taking the time to learn the system. One solution, advocated by this interviewee was to institute a quasi-coercive system in which funding agencies would require scientist to share data that results from funded work. While some Federal agencies have made important strides in following this idea, others have not. According to our respondent's analysis of the e-Science initiative "*The Europeans have been particularly bad about this.*"

- *Confidentiality.* As mentioned previously, there are distinct characteristics to social science data. One of these features is the need to protect the privacy of subjects. One of the social scientists we interviewed was not concerned with this difficulty since he did not deem the data contained in ComDAT harmful to subjects' privacy, so long as appropriate releases were obtained, because "*there are no medical records, we don't have data on income, there are no addresses. The main violation is if a friend of yours was to see you and you were to do something embarrassing, then you would be embarrassed.*" Another social scientist we interviewed, however, suggested that "*confidentiality and privacy are very big issues because we are using audio and video data. It may*

become more of an issue with archival data where we don't necessarily have permission to have data shared and that's going to limit how much that data can be disseminated." Moreover, there is no apparent computational technique for automatically masking the identity of subjects—such as by blurring their faces for example. One way to resolve this difference in opinion is that the former scientist was thinking about a particular type of data, whereas the other was considering a wider community with broader research objectives. The more conservative view, as presented by the second interviewee may be held by others consequently further limiting the willingness to share data.

Asking computer scientists about data confidentiality in ComDAT also resulted in mixed views. One respondent who is working with other scientific communities suggested that these concerns are shared by the physical scientists as well; their concern being right of first discovery. For this purpose they use data over an e-Infrastructure with "*a very well defined protocol for who can access when. Those experiments have a definite notion of membership in the collaboration and of access rights to the data based on your membership.*" Another interviewee, however, suggested that while similar access procedures may be useful for the social scientists, there is another difference. When using a common infrastructure computer system administrators have full access to all data. Including these individuals in IRB may be cumbersome and altering the compute support model is problematic as well. It is clear, however, the following this model increases dependency on computer scientists. For a system administrator we interviewed the issue was clear "*the users [social scientists] have to trust us.*" But trust may be difficult to establish in light of communication barriers, as previously discussed.

- *Red tape.* While the bureaucratic hurdles are supposed to be ameliorated by the approach taken by ComDAT, primarily that it serves as a gateway to the e-Infrastructure, and the procedures is expected to improve over time, some of the users have experienced substantial delays in starting using the e-Infrastructure of one of the large US Grid facilities. These experiences were described by one respondent as "horror stories." The distributed project structure does help insofar as developers are better linked to e-Infrastructure operators and have the knowledge and experience for pushing these requests forward. On the other hand, this model does lead to increasing dependency of social scientists on computer scientists, which may discourage adoption.

4.2.4 Simulation Portal – SPORT (pseudonym)

This case description summarizes the results of a comprehensive investigation of SPORT (Simulation Portal, a pseudonym); an e-Infrastructure technology for supporting large simulations with a social scientific focus, and the perceived barriers for its adoption. For assembling our data we reviewed publicly available written outputs and conducted ten detailed interviews averaging over fifty minutes with ten members of the studies group. Our respondents included a diverse set of scientists from disciplines such as mathematics, social science, computer science, and physical science, in addition to software engineers. Legitimacy constraints in scaling domain expertise to traditional social sciences, lack of an institutionalized structure for resource sharing and utilization, technological complexity, and funding limitations were found to be among the most challenging barriers in getting the technology broadly adopted by social scientists.

Background

SPORT describes a group of a multidisciplinary scientists organized as middle sized laboratory (LaboS) in a large US research university. A common research focus unifies this community: they specialize in generating and analyzing large

scale simulations of synthetic data based on different types of raw data, and honing basic computational and analytical approaches to diverse problems, including some that pertain to the social sciences.

As all the studies in the lab require intensive computation and integration of multiple data sets core lab researchers have utilized a stand alone high performance computational environment starting in early phases on their research. Advances in Grid computing and the articulation of e-Science and cyberinfrastructure manifestos caught the attention of senior members at LaboS, as these developments meshed with their research vision. Consequently, with minimal outside assistance, LaboS computer personnel have started porting code to a Grid environment, running tests on a large e-Infrastructure, and designing an innovative application. Their aim was to base existing research entirely on the newly available cyberinfrastructure and by so extend the potential for research, collaboration, and even the research process itself.

This vision, however, is far from having materialized, primarily due to a lack of dedicated funding. The interviewees from LaboS identified a series of barriers to extending their computational approach to the social sciences more broadly.

Developing the vision was a challenge, since no funding was directly allocated to LaboS for e-Infrastructure development. The project, SPORT, was gradually designed and developed by piecing together institutional seed money and indirect provisions from a number of related projects. As a result, the project is far from completion. Indeed, our interviewees indicated that they have not yet determined the particular technologies planned for the project, such as the user interface, the programming language, and the middleware stack. As a senior scientists summarized, "*SPORT is in a rudimentary development stage.*" The underlying vision, however, appears to be much more developed.

Technology

Throughout the interviews SPORT was described as a tool for enabling the research conducted in LaboS to extend in a number of dimensions currently not feasible with existing technologies. Several important advantages mentioned by interviewees include:

1. Scaling up simulation capacity. With increased computational resources research capacity at LaboS is continuously growing. A few years ago they were only able to run simulations to model the behaviour of a small municipality. Today, using a 100+ CPU Linux cluster, they are able to simulate a large city, potentially even a geographic region of the US. Financial and technical constraints do not allow continual growth in institutionally available compute resources. But the problems facing some of the largest supporters of LaboS's research—funding agencies and policy makers—require larger scale simulations. For example, it is difficult to model wireless Internet infrastructure without considering population dynamics and Internet use patterns on a country-wide, perhaps even a global scale. Using SPORT over high capacity Grid infrastructure members of LaboS envision running massive parallel compute jobs, permitting both the simulation of large amounts of synthetic data and the modelling of individual behaviour at the most granular level—of every individual in this meta social system.

2. Expanding supported data. The research approach is comprehensive, "*whenever data are available we use it,*" suggested one of the core scientists. Multiple data sets, such as census data, income data, social surveys, and geographic information are used for constructing models. These data are hard to obtain and maintain even for a single geographic entity, and they are ever changing—an important difference from physical science simulations. Transformation in the environment, such as in population density, demographic

characteristics, or physical infrastructure have to be reflected in constantly refined simulation models.

Despite the search efforts there are "holes" in the data that limit the research quality. Using SPORT, LaboS scientists plan addressing these constraints by enabling the use of disparate data sets across institutional and geographic boundaries. Municipalities can update data that pertain to their location; data can be obtained from sensors from various locations; scientists may upload germane survey data; still others may include synthetic data generated by their own research. In short, the data element of SPORT is to serve, as indicated by an informant, as a

> *"… platform for integrating all [available] simulations of different kinds of systems… Embedding discrete datasets that were generated for different technological or social populations… so when a user starts utilizing synthetic data such as on the City of Chicago, he always uses the most up to date data."*

3. Enabling a synchronous research process. To borrow a term from computer science, the research process in LaboS is synchronous. During the research process LaboS staff members interact and receive input form policy makers and experts within funding organizations—for example, in validating the quality of the simulated data. After receiving feedback the scientists build and refine data and models, and present results to funders. The research process often continues as clients ask for information on how an added parameter, such as additional costs constraints, affects model outcomes. One of the main objectives of SPORT is to synchronize this research cycle. According to this design users—scientists, experts, and policy makers—would use a web portal and would be, according to one informant, "*completely oblivious to the fact that there is an [e-Infrastructure] underlying. [It would] allow the user to play with different simulations without knowledge to what he gets access to,*" receiving results within a relatively short time, even instantaneously.

The very same synchronous research model could enable users to collaborate by contributing data, models, and expert knowledge, regardless of geographic location, institutional affiliation. Some of our respondents have described this goal as a "*trans-disciplinary science; a way for people with different types of expertise to contribute to a model where all the assumptions are readily visible and no one has to have an arcane knowledge of its properties.*"

Computer scientists participating in this synchronous model may also benefit. Focusing on new questions—driven by central problems of the social sciences, rather than being occupied with those pursued by the physical science and engineering—has a potential of advancing developments in their own field. One of our respondents, a computer scientist, was excited about this possibility "addressing social science questions can take computing to a completely different way. You might start designing new machines, new algorithms…. I think this conversion is going to lead to a new kind of science as much as enriching the traditional [domain] sciences themselves."

Community structure

Members of the lab collaborate with one another in identifying, generating, and analyzing data. There is a fairly clear internal division of scientific labour, with some expertise overlap. Computer scientists generate algorithms and develop tools, statisticians check the suitability of the simulated data, domain specialists bring their expertise to determine model parameters, and mathematicians apply or adjust theory. A number of graduate students from these disciplines provide additional labour and often a fresh perspective. When expertise does not exist, or requires additional bolstering, the lab collaborates with others, often from other

institutions. But typically research is carried out within the lab. Over time this research production has led to an efficient tight organic structure, which supports understanding among staff scientists, including mutual comprehension of theoretical foundations, tools, and terminology. It reduces communication barriers and allows addressing a broad spectrum of problems ranging from biology, to technology, to urban planning with minimal internal adjustments.

One of the key domains of study at LaboS is social science, particularly the analysis of social structure and research on collective action. However, since there is little formal expertise in the social sciences, this is one of the areas in which the lab sometime collaborates with external experts. These experts, however, seem to specialize in computer modelling of social behaviour and are not leading social scientists in some of the more popular branches of research within these disciplines.

In contrast, LaboS maintains relations to prominent computer scientists, including collaborations with Grid experts within their own institution, as well as with senior e-Infrastructure architects. These links provide lab members with social resources that translate into refreshing knowledge and understanding of development in the field of Grid computing and e-Infrastructure, providing direct input to the testing of SPORT, and even enabling access to compute resources on a large Grid infrastructure project with level which potentially would not have been available otherwise.

Challenges to adoption

The target user community for SPORT include "social scientists with a computational bent"; in particular, those who are familiar and comfortable with computer simulation and experimental design. Although the tool itself is not in production, interviewees provided, based on their experience in promoting similar types of work, useful insights regarding the expected barriers to adoption:

1) High walls of legitimacy
2) Maintaining confidentiality
3) Sharing resources
4) Technical complexity

Ad 1) *High walls of legitimacy.* Social scientific problems, especially questions that relate to collective behaviour, are deemed central to the research activity at LaboS, and yet, aside from minor exceptions, core staff does not include trained social scientists. Although training alone does not necessarily determine disciplinary orientation, it appears that most of the scientists at the lab neither are familiar with major work in the social sciences that pertain to their research, nor do they regularly follow the core journals in these fields. Instead, a senior responded clarified, "*as far as we know we've been doing social sciences essentially—from a computing stand point… developing a computational social science. By that I mean trying to understand the modelling of social phenomena.*"

Computational scientists have the option to remain within the comfort of their own scientific domain and innovate in ways which may impact the social sciences without directly confronting social scientists. "Throwing your research over the wall and see if anybody picked it up" was the selected metaphor for this strategy by one of our interviewees. However, scientists at LaboS recognize that they have to climb over these high walls themselves in order to have their approach adopted because those currently interested in their research are not necessarily on the "other side", that of the social scientists.

Like other fields of sciences, such as bioinformatics, or computational linguistics, attempting to connect one domain of science with computer science is not new. But

for many scientists, even those sub fields that are computationally endowed, such as experimental economists these attempts to combine the two fields are not trivial, leading to legitimacy concerns, lack of trust, and even rejection of research. Interviewees noted that when they present their work to these audiences they are often confronted with challenges to basic research assumptions. LaboS scientists interpret this reaction as an expected response to challenging existing disciplinary practices. As one scientists keenly commented

> *"I don't think it has to do with social sciences at all. The same kind of pushback would be felt if social scientists were to start doing physics. Every area has a set way of doing things: accepted norms, and standards, and accepted leaders in that fields. My feel is that when you do something that is not in line with this taught process—people question you, and they question you hard."*

More particularly, the misalignment with existing social scientific practices is experienced in communicating the scale of research, as nicely articulated by one of our interviewees:

> *"People in the social sciences seem to be very comfortable with small systems because they feel that they can collect data on it and understand it very well... They find our project ambitious so they are intrigued by it but it seems they don't think this is doable. So there is an inherent sense of doubt in their minds. Even though we've done it for over a decade and it is very clear that you can build models of this size."*

Scaling up research questions and data also leads to question of validation, since conventional methods such as model fitting to data are not necessarily most adequate, or in the words of a LaboS member "*we feel that data fitting for instance is not the right approach for systems of this sort…. dose it [fitted data] means anything to me? almost nothing.*"

Ad 2) *Maintaining confidentiality.* Unlike in the physical sciences where e-Infrastructure has been widely adopted, observational, or survey data, are typically confidential. Elaborate regulations have been enacted over the years in many countries around the world, and particularly in the US, for protecting the privacy of subjects. Institutional review boards ensure procedural compliance, including, for example, restrictions to data access to authorized investigators, which constrain the potential for research collaboration.

One advantage that SPORT offers in this arena is that the data analyzed by its scientists are synthetic, meaning that they do not represent real subjects, but rather simulated ones. E-infrastructure hence serves as a mediating layer between raw data on individuals which are protected by rules of confidentiality, by producing synthetic data that can be used for analysis. However, the interviewees recognized the potential for re-identification of individuals if simulated data were combined with additional private data sets and analyzed using a high performance computing techniques.[26] Here lies a paradox in e-Infrastructure: the same resources that enable access to confidential study resources in some ways eliminating confidentiality concerns, may also lead to new concerns regarding privacy on a much greater scale. As noted by one of our interviewees "*you can go to a company and buy data on specific population, at specific addresses – they put together an amazing amount of stuff—which actually makes me kind of nervous about my privacy.*"

[26] For this reason, Public Use Microdata Samples used by US Census are not offered in high degree of granularity, and certain Federal agencies deem simulated data confidential.

Ad 3) *Sharing resources.* Two types of resources have been mentioned in this context: models and compute resources.

- Models. Once models are established they may be used by other investigators to refine their own, or to be incorporated in subsequent studies. Seamlessly sharing these models among SPORT users could enhance the overall accuracy used by modellers on a much wider scale than at LaboS. Yet, our informants have indicated that it is not common practice among scientists who follow the experimental/modelling paradigm to share their models. An attempt to develop a workshop for investigating a new domain previously not explored by LaboS resulted in the following observation:

  > *"It has occurred to me that I am essentially inviting people to get peer-reviewed again, for no benefit for them – I don't have any money to give them. The only thing that can happen from their view point is that they are going to tell me about their models and I am going to use this information to my competitive advantage."*

  This instance demonstrates that in a scientific competitive environment there is no apparent incentive structure for sharing data and models on e-Infrastructure; a problem which may be further exacerbated in certain fields of the social science where collaboration and sharing are not apparent. As noted by a senior staff member at Labos, while some junior social science faculty members within his university have shown interest in the work done at the lab, their willingness to collaborate was limited because their departments did not count publications with more than two authors in their tenure considerations; an institutional practice that substantively differs from comparable procedures in the physical sciences.

- Compute resources. When conducting a test on a large Grid infrastructure – much more powerful than the one used in their lab – LaboS scientists discovered that the computational duration exceeded that they could achieve using their private resources. For the common resources they were competing with other scientific groups that had higher priority. Shifting from a proprietary infrastructure to a collective one leads to a number of difficulties. At least in one case when a user needed to receive results quickly the procedure they followed was an informal one, facilitating their external associations – calling up the administrators at the Grid facility and asking them to advance their position in the compute queue. This example not only demonstrates the technological difficulties presently found with this Grid provider, it also suggests that scaling research beyond the research lab – sourcing out parts of the work currently done within the boundaries of the laboratory – creates a stronger dependency on external compute providers.
  Current providers may also not be at a level where they can offer a viable collective infrastructure to replace a private one. We were told by a computer scientist working with Labos that "although the resources exist, the effort it takes to bring these resources to solve a problem quickly has not been figured out by the system." These efforts include, according to this respondent "certain policies [that need to be] put in place," policies that adequately shift the mindset from supporting small groups of scientists to a large portion of the entire scientific community. In addition to the logistical difficulties there are also technological barriers. While Labos's scientists have been eager to port their source code to run in a Grid environment, a computer expert we interviewed has reported that e-Infrastructure in its present state may not be suitable for certain types of computation that require "a much closer coupling of the machines." Thus, although SPORT is a technology that represents most of the research activities at Labos, only specific parts of the research is envisioned to shift to the collective e-Infrastructure.

Ad 4) *Technical complexity.* The intended user population – those scientists with a "computational bent" – still need to learn much about the system in order to utilize it. As one scientist suggested, in order to use the technology one has to know "*an awful lot…. you would need to learn what it is capable of, understand whether you can apply these capabilities to your question, and if you decide you could then you really just have to talk to us – and we then have to tell you whether we can help you figure this out with our methods.*"

Our respondents, both scientists and software engineers, recognized that they need to simplify the interface as much as they can to enable wide adoption. One interviewee who was not a computer scientist further suggested that "*if you have cool tools, very user friendly tools, then no matter where they are located people are going to find a way and try to get to them…. But it has to be in a real product form, not in a research form as it is right now. It has to be like a commercial product: user friendly and with good documentation.*"

4.2.5 Understanding New Forms of Digital Records for e-Social Science (Digital Records) – DReSS

Introduction

The project "Understanding New Forms of Digital Records for e-Social Science (Digital Records)", short DReSS (http://www.ncess.ac.uk/research/nodes/DigitalRecord), is based at the University of Nottingham and funded by the UK's Economic and Social Research Council (ESRC). The project started in April 2005 and lasts until April 2008.

The overall aim is to develop technologies to record, represent and replay new forms of digital data for the social sciences. Its activities are structured around the exploration of three core themes:

- *Record*, which focuses on the development of technologies to support the recording of events that take place in physical and digital environments, and combines them to produce new forms of records for social science analysis.
- *Representation* and *Re-representation*, which focuses on the move from the raw data collected as part of the recording process to the production of diverse and variously structured datasets to support different kinds of social science analysis.
- *Replay*, which focuses on marrying multiple data sources together and replaying them simultaneously to support both co-located and distributed analysis in the 'here and now', and to permit the recovery of social science phenomena for analysis in the future.

The themes are being explored by three Driver Projects, which seek to shape design through substantive social science research in particular domains of inquiry (Ethnography, Corpus Linguistics, and Learning Science). The Driver Projects combine to inform the development of e-Social Science tools of general utility that span the qualitative and quantitative divide and enable transformations between the two. These three Driver Projects are:

- *Grid-based Assembly of Qualitative Records*. This project will develop support for social scientists undertaking social studies of technology. The primary focus will be on the assembly of qualitative records that marry conventional data sources with emerging digital resources to better understand the social shaping of technology in interaction.
- *Grid-based Structuring of Assembled Records*. This project will develop support for social scientists undertaking corpus-based studies of natural language use. Its primary focus will be on structuring a Grid-enabled multi-

modal corpus that combines conventional text-based representations with visual media.

- *Grid-based Coupling of Qualitative and Quantitative Analysis* will be driven by social scientists undertaking studies of learning to develop techniques that allow researchers to generate, manage, and track transitions between qualitative and quantitative representations of online teaching episodes and learning outcomes.

Background and involvement of the respondent

In order to obtain information on the NCeSS research node DReSS, an interview was conducted with Dr. Andrew Crabtree, ethnographer, co-director of the DReSS project and lead investigator in Driver Project 1. The information and viewpoints provided in this document are based on the opinions of Dr. Crabtree.

In his understanding of cyber-infrastructure, Dr. Crabtree asserts that CI is a vision (rather than a reality) which is, as such, open to negotiation. Thus it is not solely about high performance computing, virtual organisation, distributed Grid infrastructure, and workflow models but about the possibilities that computing opens up for social science research and the development of services and tools that actually respond to the needs of social scientists. From his point of view, cyber-infrastructure is less about grand visions and radical new futures and more about developing services and tools that respond to current research practice and bring about change by offering new possibilities to further develop current practice. As co-director he is responsible for driving the development of tools and services that support qualitative research in the digital society and quantitative views on qualitative data. He was motivated to get involved with CI through the e-Science programme and by attending a workshop in Edinburgh which was held about 3 years ago.

When asked about the background of the project and how the project was established, Dr. Crabtree replied that it was set up “in the usual ways”: Finding a number of interested parties, writing a research proposal that is of mutual interest etc.

Technology used

Within the DReSS project a software tool called ‘Digital Replay System’ (DRS) is being developed. It enables replay and annotation of (time-based) social science data sets and allows the simultaneous synchronized replay of multiple data sources, including videos, system log files, spatial data. The current development includes:

- adding support for structured analysis (coding);
- creating a rich meta-data store to allow flexible annotations and project and media meta-data; and
- managing multiple, distributed users.

The inherent data capture facilities focus on generating system logs of online interaction and combining these with video recordings and data derived from mobile and ubiquitous devices in the real world. The data analysis facilities focus on enabling social scientists to structure data and produce a coherent record from multiple sources of data. Lastly, the data sharing facilities allow scientists to search and retrieve data from persistent data archives and to collaborate in analyzing the data even if they are remote from each other.

Community structure and mobilization

The user and / or developer communities involved in the three DReSS driver projects consist of social scientists who are interested in a particular research

problem. Examples of such problems are: Ethnographic studies of technology in use, multi-modal language corpora, and teaching and learning outcomes in e-Learning environments. These social scientists act both as developers and as users of the DReSS Digital Replay System (DRS). In addition, DRS is increasingly used to analyse research projects in the Mixed Reality Laboratory (MRL) at the University of Nottingham (http://www.mrl.nott.ac.uk/). Members of the Real Life Methods Node (http://www.reallifemethods.ac.uk/) are using DRS in their research, and DReSS is currently engaged in discussions with Greater Manchester Police (GMP) with regards to the use of DRS. Currently, all of the users of DRS stem from academia and are located at the University of Nottingham and the University of Manchester. There is no general recruitment process for new members in the currently established communities. In fact, social scientists in the driver projects act as co-investigators in DReSS and the MRL use is fostered by the co-investigators, who are located in the MRL. Broader academic and non-academic use is encouraged through public events. All of these relationships are new and even more far-reaching links have been established through NCeSS outreach activities such as the NCeSS Showcase and invited talks.

Interaction between the project's participants takes place through quarterly meetings to account for work done and to plan future work. These meetings are expanded upon with informal monthly workshops between designers and social science researchers to further develop DRS. External users receive support by DRS developers who provide training and customize DRS to meet their particular needs.

The efforts procured for the project are led by the users. It takes time and development tasks have to be prioritised, which occasionally can be frustrating for users as resources are limited. This work is currently not regulated through formal contracts. However, if the GMP decides to adopt DRS, formal contracts will be necessary.

Learning has proved to be a very important part of the research process – social scientists need to learn what is computationally possible and computer scientists need to learn how social scientists work so that appropriate tools and services can be developed that resonate with established practice.

The DReSS project also has developed ties to the US cyber-infrastructure project "SID Grid", initiated through an NCeSS liaison programme. So far this connection hasn't influenced the work done on the project but affiliations such as these open up the possibility for collaboration in the future (as long as enough funding can be secured).

Adoption

The DRS software has been adopted by a number of members of different research facilities and the GMP is considering using the software in the future. According to the project's co-director, a major catalyst to foster the adoption of the developed CI could be dissemination by demonstration. Nevertheless there exist obstacles that could hinder adoption by the wider scientific community. A great many social scientists are sceptical about e-Social Science and would thus have to be convinced of its benefits through first-hand demonstrations. In addition, a large part of social science research is overly theoretical and is not sufficiently motivated by methodological and empirical considerations. Thus a shift in how social science research is conducted is needed, with a greater emphasis on methodology and empirically gathered evidence. Furthermore, while UK funding councils have placed greater emphasis on e-Social Science over the last years the increased funding has not yet had as significant an impact as expected.

Impact

According to Dr. Crabtree, the use of DRS has completely changed the way he works. When asked: "When you arrive to the office today, how is your work different than it was prior to the project?", he reported that the DRS system represented a significant step forward in terms of current work practice. Ethnographers such as Dr. Crabtree study future and emerging technologies and have to work with a wide range of different resources on a daily basis: Audio and video recordings, photographs, field notes, transcripts and, ever increasingly, system logs and recordings of interaction within digital environments. Dr. Crabtree explained that the system allows him to combine all these resources and play them back side-by-side. This functionality would provide him with a "richer, more comprehensive picture of interaction" in future and emerging technological environments - which is his topic of study. The ability to combine heterogeneous resources with system logs allows researchers to gain a better understanding of interaction in the digital society and, says Dr. Crabtree, is one of the main innovations of the project.

Major milestones of success for the DReSS project are the development and usage of DRS by social science researchers within DReSS, the MRL, and Real Life Methods.

When asked about new problems, questions or theories addressed by the DReSS project, Dr. Crabtree maintained that through DRS interaction in the digital society could now finally be understood. According to him the project offers a new, alternative paradigm for his field of work when compared to the much poorer tools and resources ethnographers currently have at their disposal.

To date it is still too early to ascertain the impact of the project. However, it is certainly meeting its aims and objectives as laid out in the funded proposal and a second round of funding seeks to move beyond the driver projects and involve the broader social science community in the use and continued development of DRS.

Some people have not yet picked up on the approach presented by and the tools developed in the project. This can however be partly explained by the fact that the first public version of DRS has only been available since August 2007.

At this stage, any long-term impact cannot be estimated as it very much depends on the resources and further funding that will be dedicated to the field. A lack of funding for this kind of work by research councils, the aforementioned scepticism towards electronic solutions and the reluctance within the scientific community to become more empirically oriented are all hurdles that will have to be overcome in the future if this project is to succeed.

Personnel and resources

At present, there exists no connection between research and teaching although one will be established in due course. The DReSS projected is currently focused on the initial development of tools and services. As these become more stable and uptake increases, cyber-infrastructures will inevitably become a topic of university lectures. The project already has PhD students employed as researchers. These students have majored either in computer science or social science, many of them specifically in the social sciences field of applied linguistics.

The main sponsor of the DReSS project is the Economic and Social Research Council. The project's budget amounts to €956,720 out of which all employed staff are paid. Therefore staff costs account for the largest expenses procured by the project. Training and consulting activities are also paid from the budget. The project leaders are seeking to extend the core research towards new approaches in the next phase of funding. Dr. Crabtree claims that if the project were to receive twice as much funding as it has so far, the money could be used to foster and promote broader social science involvement. On the other hand he acknowledges that a

decline in funding for research related to CI would not have an immediate impact on the current DReSS project phase. However it will most likely negatively affect future project phases.

Policy input

The main success of the DReSS research project so far has been the development and use of the DRS system by social science researchers within the project, the Mixed Reality Laboratory and the Real Life Methods Node. Furthermore, no failures have been reported as of yet and – Dr. Crabtree remarks – neither he nor any of the other members responsible for the project would have done things differently if given the chance.

The only recommendation towards policymakers that Dr. Crabtree would suggest is to increase funding for this kind of research in order to stimulate its acceptance and rapid adaptation within the social science community. This can be achieved by specifically funding projects which apply e-Social Science tools and services to substantial research problems.

4.2.6 Dokumentation Bedrohter Sprachen [Documentation of Endangered Languages] - DoBeS

Introduction to the project

The DoBeS (http://www.mpi.nl/DOBES; http://www.mpi.nl/lat) programme focuses on the documentation of languages which are in danger of becoming extinct. There are currently 39 documentation projects which document one ore more endangered languages in various locations worldwide. Part of the DoBeS programme is the creation of a central archive for all collected resources (audio, video, images, text). The Max Planck Institute (MPI) in Nijmegen, Netherlands is responsible for this task. However, the archiving framework developed at MPI is not solely developed for and used by DoBeS. It is part of various other national and international projects which all contribute to the development of the overall archiving framework.

Background and involvement of the respondent

The respondent is one of the archive managers at MPI. He interacts with users of the archive and is responsible for the archive's content in a technical sense. He is not a developer himself but instead interacts with software developers about requirements and functionality of the archiving framework. The respondent provided no further information about his involvement in and his understanding of cyber-infrastructures.

Technology used

When the project started at the end of the 1990s there were no ready-made solutions for multimedia archiving. Therefore it mostly developed its framework from scratch. The technology used by the project includes Java server side technology, Java client applications and XML. DoBeS has taken part in the development of several standards such as the IMDI metadata standard.

With regard to the support of learning, training and documentation processes, the respondent stated that the DoBeS project is primarily concerned with the documentation of languages and that all their resources are made accessible via the web and can then be used for e-learning applications. However, no specific framework is provided by the project itself to support that. DoBeS project members regularly give training courses on the use of the archiving software.

A relationship exists between the DoBeS project and other CI technology stakeholders: While the project is single-handedly setting up a Grid of language archive servers, it also takes part in various projects and organisations working on interoperability between different types of archives. One example of this is the CLARIN (http://www.clarin.eu/) project, a large EU project on research infrastructures which for a large part was initiated by DoBeS members.

No technological constraints were reported.

Community structure and mobilization

The user and developer communities involved in the project include the academic community, the language communities of the languages that are being documented, the general public and journalists. The recruitment of such communities takes place automatically. In addition, there is a lot of public interest in the archival technology developed by DoBeS and its possibilities since DoBeS has one of the largest and most advanced archives in the field.

Participants in the project interact with users and use their feedback to improve the software and adapt it to the users' needs. Furthermore there is an annual meeting where findings from the different parts of the DoBeS project are shared and new developments regarding the archive are presented. This is deemed to be sufficient in terms of interaction as the various DoBeS documentation projects mostly work individually.

The DoBeS project is connected with other projects in the US, the UK and several other European countries: DoBeS is part of the European DAM-LR (http://www.mpi.nl/dam-lr) project, the DELAMAN (http://www.delaman.org) network, the European CLARIN project and has been part of various other international projects in the past. DoBeS also takes active part in the development of several ISO standards related to language archiving technology.

On the other hand the project itself is influenced by other projects. As the respondent mentioned, DoBeS members are always on the lookout for what their colleagues are doing, especially those in the US and Australia. Collaboration between related projects has led to mutual agreements on the type of technology being used and to the development of common standards.

Adoption

The e-Infrastructures developed within the project are already in use today. The project has established a number of instances of its archiving framework in different locations and will continue to do so in the near future. Some of the locations include IIAP (Iquitos, Peru), Museo do Indio (Rio, Brazil), CAICYT (Buenos Aires, Argentina), SOAS (London, UK) and Kiel University (Kiel, Germany). According to the respondent, the project is a pioneer in the area of language archiving and only few different solutions with the same set of functionalities are available. Still, national and/or institutional interests might be an obstacle to having the framework adopted by people in the wider scientific community. For example, when an institute is related to a project working on a similar solution, it is more likely that that solution will be chosen.

Impact

That the work maybe different prior to the DoBeS project was not reported by the respondent. The following major milestones of success were mentioned: The establishment of a large archive and a widely adopted archiving framework, the development of various widely used tools, both web-based and client-side, and the creation of awareness for the necessity of properly archiving resources. The main

innovation that has emerged from DoBeS is their solid, advanced language archiving framework. The future focus of the project will be to achieve interoperability with other archives and to support the creation of customized user interfaces.

Alternative paradigms in the field of the DoBeS project were not mentioned by the respondent. Quite contrary, the respondent maintained that while people may choose different backend frameworks and different technological solutions, the basic principle always remains and should remain the same. According to the respondent another indication of the impact the project has had is that many DoBeS tools are widely used by the linguistic community today, most of all the annotation tool ELAN (http://www.lat-mpi.eu/tools/elan/).

The future impact of cyber-infrastructures in the field that DoBeS works in will likely be big. Having access to archived resources is going to be increasingly important in linguistics. It will facilitate many studies which previously were very difficult to perform, e.g. searching for similar phenomena in different languages.

Personnel and resources

The DoBeS documentation projects involve PhDs as well as students. Thus it can be maintained that within DoBeS there is a connection between research and teaching. However, the students are not involved in the development of the archiving framework. With regard to project funding it was mentioned that DoBeS is a project that is funded by the German Volkswagen Stiftung (http://www.volkswagenstiftung.de/index.php?id=3&L=1). There is currently no information on the budget available. The main expenses associated with the archive infrastructure project are costs for the personnel developing the software architectures. Since the MPI for Psycholinguistics is involved in several other projects, it receives additional funding from a number of different sources for the development of various parts of the archiving solution. The general trend towards a decline in funding for research related to cyber-infrastructures seems to not have had an impact on the DoBeS project. The archive manager could not identify such a trend in the field DoBeS is involved in at all since the MPI for Psycholinguistics has been rather successful in obtaining funding from the European Union.

Changes

Since the DoBeS project has been developing the framework for ca. eight years now, many changes have taken place from the original planning over the course of the project. The respondent was not able to list specific changes that have occurred but had no doubts that the goals and the focus have changed throughout the course of the project.

Policy input

The respondent did not mention anything concerning the successes or failures of the DoBeS project or what could have been done differently - if they would have the opportunity to.

In terms of recommendations towards fostering the uptake of e-Science in the social sciences and humanities, it was his opinion that although the EU has clearly expressed an interest in supporting the development of e-Infrastructures through the granting of the CLARIN project, it would be helpful if this support could be sustained over a longer period of time.

4.2.7 TextGrid

Background

TextGrid (http://www.textgrid.de) engages in the development of a virtual research library that aims to satisfy the specific needs of text-oriented scientific domains. It develops a toolset to help scholars to process, analyse, annotate, edit and publish text data. Basically TextGrid allows tapping text corpora, labelling them and connecting them to metadata. For instance, researchers may search for autographs and compare different editions of a text. TextGrid helps to embed text in certain contexts through linking it with background information like the history of its reception.

Key user communities of TextGrid will be researchers in philology, linguistics and related fields. Based on a Grid-enabled workbench its design is modular to ease future implementations of new tasks. All modules are integrated in one user interface. Examples for such modules are:[27]

- Text processing tools like an XML editor, a metadata annotations tool, a dictionary, a streaming-editor, a tokenizer, a sorting tool, etc.,
- Text retrieval tools like a query interface,
- Link editors like such for pictures and texts, text and text etc.,
- Administrative devices like editors for the technical workflow and editors for the administrative workflow.

Eight partners work to establish the TextGrid. Project Coordinator is the Goettingen State and University Library. The further partners are:

Five higher education institutions

- Technical University Darmstadt
- Institute for the German Language
- University of Trier
- University of Applied Sciences Worms
- University of Würzburg

plus two companies

- DAASI International GmbH
- Saphor GmbH

TextGrid is the only non natural science project in the German D-Grid initiative. This initiative funds projects to facilitate a sustainable development of Grid technology and e-Science methods in Germany.

Technology and standards

TextGrid does both, it uses existing technology and standards and develops new ones. It is an open-source project using open-source programs and open standards.

The project started with an analysis of the needs of the potential community. It turned out that some of the planned tools already existed isolated as e.g. intranet

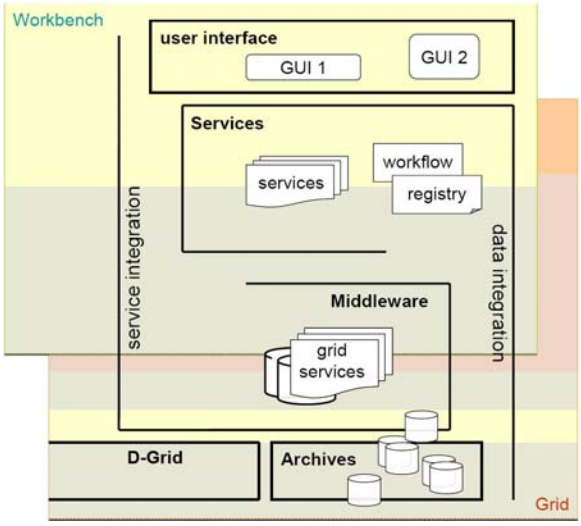
[27] Most of the tools exist in a beta version only up to now. One of the few in alpha version is e.g. the XML editor.

or desktop applications. They had been developed independently by different researchers in different ways and computer languages. A very open generic infrastructure was needed to integrate those tools in TextGrid. Specifications could only be set in a very carefully and diffident way to become accepted in the community. Hence, it has been designed as open workbench for a potentially large number of different tools always being ready to integrate new tools.

All tools are integrated horizontally in the TextGrid workbench (see Figure 4.1). The workbench is subdivided into four vertical layers:

1. *The user environment*. Users may use different, user-defined environments to fulfil their specific needs, for instance an offline version etc.
2. *The service layer* encapsulates specific complex functions via web services based on standards like SOAP, WSDL etc. which may be recombined in any needed way to integrate them in different user environments. External initiatives, for instance initiated by users, may expand it. The service layer is platform and language independent. Hence, TextGrid tools are not fixed to a certain computer language. Nevertheless, existing tools are programmed in Java and Python only. Part of the current work is to improve the integration of tools written in further languages.
3. *The middleware* connects Grid technologies with other technologies (like semantic technologies). The aim is to implement the needs of text researchers in a data Grid.
4. *Archive.* External heterogeneous text archives have to be integrated in TextGrid. They are virtualized in the middleware. The integration is accomplished stepwise.

Figure 4.1: TextGrid workbench



Source: Aschenbrenner et al., 2007, p. 5.

Tools are needed to fulfil certain needs. They may work in more than one and even across all layers. Four different kinds of tools can be distinguished:

1. *Streaming Tools.* The configuration of streaming tools is realised through a GUI frontend in the RCP. This component is running a batch service mode, the enactor. Streaming tools are part of the service layer and/or the user environment.
2. *Interactive Tools*. They don't have a batch component are controlled by the user in an interactive mode. They exist in RCP only.

3. *Basic tools.* An example is the search tool. They may have components in all layers.
4. *Help tools.* They are embedded in the service layer or in the middleware as parts of other tools.

The choice and development of the used technology has been determined by two factors. As part of the D-Grid initiative TextGrid collaborates very closely with projects from the natural sciences. Particularly it uses Grid technology developed or used by these other, mostly older and more experienced projects. Examples of adopted technology are

- Globus Toolkit to build the Grid,
- WS Resource Framework (WSRF) as standard for the Grid,
- Web Service Definition Language (WSDL) as specification for describing network services,
- Service Oriented Architecture Protocol (SOAP) to provide a basic messaging framework on which layers can build.

A second determining factor is the integration of projects from the humanities. Before TextGrid there were several projects trying to do what TextGrid does and one aim is to integrate all these projects into one single framework. Therefore some of the technology and standards like TEI-XML encoding scheme have been adopted.

TEI is one example for a technology that has been significantly enhanced by TextGrid. All interview partners agreed that the process to develop such new technology has been very hard and drastic. It was not easy to find even a common language among researchers from the humanities and computer sciences like Grid specialists. The definition of common requirements and cross-disciplinary communication was a long process and even more problematic than the technical realisation of TextGrid itself. One interviewee called the process a “ping-pong process”: A technician making a suggestion that the humanities researchers didn’t understand, responding consequently in a way that the technicians didn’t understand. The communication problem was solved through putting team members with different backgrounds into one “basket”. In a first step one technician and one researcher from the humanities developed together a plan thus learning from each other. This plan was the common basis to integrate more researchers into the team.

There have been few training events up to now. The development of an e-learning concept and a related platform are key elements of a future work package.

Community structure and mobilisation

Since TextGrid is still under construction the community is relatively small and consists currently of few prototype users only. The existing community members are all from academia, highly motivated and fully embedded in the development process. The main two tasks of the current work are to improve the developed standards and to enhance the technology. Both require the collaboration with the community but the ongoing development process does not allow a large user community.

Like training the mobilisation of users and promotion of TextGrid is part of a future working package. Despite that the future community is not clearly defined yet. However, there are a lot of requests from all over Europe to open TextGrid for current projects. Especially surprising for the team members is, that these requests come from very different research fields and not just from the linguistics and text,

language and literature sciences as targeted originally. Some are from the social sciences or related fields like dramatics etc.

A plan how to contact potential community members does not exist so far. Despite the many requests to use TextGrid, e-Infrastructure is not yet widely accepted in the humanities. It is considered a challenge to make TextGrid a living member of the humanities community. Only via new projects will it be possible to finance the continuation of TextGrid and for this purpose an active user community will be essential.

Personnel and Resources

TextGrid is divided into six work packages. Every work package is led by another organization or company. The team of coordinators at Goettingen library consists of two scientists plus a student assistant. Both scientists work almost exclusively for TextGrid but are involved in tuition at the university. Overall are 30 scientists engaged in the project. Twenty-three of them are graduate students. Most of the scientists have a humanities background. People with a background in management or the like are not included which is considered a weakness among the team members.

TextGrid has been evaluated by the German Federal Ministry of Education and Research (BMBF) receiving governmental funding since February 2006 with a budget of 1.6m Euro and a term of 3 years. During the life of the project it has been necessary to increase the budget to about 2m Euro. It turned out that the primarily planned storage space has been underestimated. Thus new technology had to be bought.

Impact

Since TextGrid runs in beta version only it has not caused any significant impact as yet. Among humanities researchers the level of prejudice against computer technology is quite high. However, those who are open to new technologies and approaches appreciate TextGrid and are euphoric. New fields of research have been reported inspired by the new technological possibilities. But the diffusion to the potential user community is still at the beginning and only the small beta user group is currently involved in the project. A very first step to raising acceptance is the integration of TextGrid into educational programmes at Goettingen University.

It is very likely that TextGrid will have a follow-on project. The Federal Ministry of Education and Research has already signalized that the link between Grid technology and repositories will remain an important area for building tools for the humanities. Thus stability and continuity are very likely.

Barriers and recommendations

The interviewees complain that the German funding policy usually does not cover a full-time project manager. However, a project manager for documenting all steps and tasks of the project is considered to be crucial for its success. Since communication is the most important problem to solve a clear communication is essential. In the funding scheme project management is not considered as a separate task that should be done by specialists. Therefore, it has to be done by more or less all team members in parallel to their other project tasks as specialists in non-management fields. Hence management and especially documentation become second class tasks in every day work constraining the success of the project in the long run.

It is still hard to make a proposal for researchers from the humanities especially in such a technical field like Grid technology. The “style” and culture of humanities

and the natural sciences are very different and the former are not always taken seriously.

The sponsoring policy in German Grid technology postulates a financial involvement of all participating users constituting a barrier against trying out a new technology. The interviewees propose that free access to Grid technology would raise the demand dynamically. Thus the sponsoring policy should rather include universities than individual projects as financing partners.

4.2.8 FinGrid (pseudonym)

Background

The FinGrid project was conceived upon a call from the national Ministry of Research for projects that addressed the modelling of complex systems. It was evaluated positively and funded from November 2003 to November 2006 with a six months extension till April 2007.

Its original aim was to use the Grid paradigm for research on complex systems in economics and finance. The development intended to produce a national facility for economic and financial data based on Grid technology, and supply the user community with a basic set of user-friendly data management commands for uploading/downloading data to/from the Grid, for removing and browsing the data, and for all the usual file manipulation operations. This should enable researchers to study problems that could otherwise not be addressed given the computing resources locally at their disposal.

FinGrid was the first project in which the technical developers developed and applied Grid technology for a professional purpose. They started to work on Grid applications out of professional interest for a topic that had become very en vogue in computational physics around 2000-2001. The Large Hadron Collider (LHC) Grid (http://lcg.web.cern.ch/LCG/) was being built by the High-Energy Physics (HEP) community and the topic was pushed very strongly. However, their institution was not involved in HEP and it was somehow left outside of these developments in computational physics. It had, however, a community of statistical physicists who happened to be very interested in financial problems. Moreover, their approaches always have been very computer-intensive and they considered the Grid as a way to get computational power. The application of Grid technology to finance thus became a logical consequence of the collaboration of statistical physicists with economists and finance researchers which were interested in finding out how relevant grids were for their field.

Technology

The contract with the project sponsor required that existing Grid middleware was used and thus the collaboration with the key national player of HEP and related Grid developments and contracting partner in the Enabling Grids for e-Science (EGEE) project was established. The relationship to EGEE intensified throughout FinGrid in technological regard: FinGrid implemented and used the LCG (LHC Computing Grid) middleware and subsequently the gLite middleware in order to satisfy the requests from their finance user community.

The first release of FinGrid took place in October 2004. It consisted then of a two-tiered topology: peripheral sites with low bandwidth providing Grid services only to local users, central sites with high bandwidth providing services to the whole community.

As the close link to existing middleware and EGEE had been established in the project contract, so it was not possible to change it, though the interviewed FinGrid

developers presumed that it would have been simpler to redo many things without using what was available at that time from EGEE. The LCG/gLite was described as problematic for use by the FinGrid user community in several regards: limited usability of the software from the end user point of view, complex installation and maintenance of a gLite Grid site, poor documentation and no controlled access to files in Grid storage.

The last point was critical, as FinGrid was subject to a particular legal constraint: the disclosure regulations of the stock exchanges demanded that special attention was paid to privacy and data security issues, i.e. that not all users within the FinGrid user community had indiscriminate access to all stored data. For example, some researchers may have an exclusive contract with the London Stock Exchange, while others may have an agreement with the New York Stock Exchange for information pertaining only to specific companies. FinGrid implemented technological solutions to regulate data access which were then also considered useful by other communities on the EGEE infrastructure (see below). A former FinGrid user reported a different type of solution to this problem: at his current (non-Italian) organization access to the entire Grid including its data resources is possible; access is managed at the organizational level and organizations included in the network have access to the Grid-based resources.

Several problems led to a second, new release of FinGrid in June 2006:

- One large computing site was insufficient to demonstrate the Grid potential for distributed resource allocation.
- The two-tiered topology was problematic, as the local users lacked the necessary skills for installing and maintaining the peripheral sites and the FinGrid team itself had not enough manpower for this. Hence, the topology was dropped by giving up on peripheral sites altogether.
- Lacking support for security and privacy of stored data on the middleware; the resulting workaround was complex and had scalability limits;
- Only a small part of the community adopted the command line tools and the user interface distributed through the Live-CD technology; "*although users had been spared the need to reinstall their workstations, they complained the usage was awkward and that it was interfering with their way of working. A web portal, then, promised to be a very good tool to address these issues.*" (FinGrid technical developer)

Another key technological constraint couldn't be solved in a satisfactory way: to integrate into the regular Windows computing environments of the wider user community. It would have been an order of magnitude too complex for the available resources and beyond the project's timeframe. Even confining the project to the Linux environment, it was not trivial in the end, because of the necessary glitches and required system support. Higher reliability of the technology and an interface with little entry costs for the users would have been essential for gaining a larger user community.

Different approaches were tried for training and teaching the users: a testbed was always available on which researchers could log-on and learn how to use the Grid; the Live-CD technology was used to install a Grid where a training session took place without having to reinstall local machines; later in the project a virtualised Grid that was self configurable in 15-20 minutes was used. In addition events were organized where end users would bring along an application they used for their research, which would then be Grid-enabled and launched on the Grid during the training event. Documentation was handled through a Content Management System, accessible through a website.

Over the entire duration of the project, FinGrid developed three tools:

1) *Data management tool* for guaranteeing privacy and security of the high-frequency data coming from stock exchanges which were subject to very strict access policies;

2) *Web portal*: for facilitating Grid use the FinGrid portal was built on technology from Hungary;

3) A *live-CD* which contained all the LCG middleware at that time was developed to help users with setting up the Grid: through booting a Linux computer from the CD they were able to set up a node in the computational Grid. Soon it was realised that this live CD was a nice learning tool.

Community structure and mobilization

Developer community – EGEE: Though FinGrid was tightly linked to EGEE and its large developer community, the collaboration was described in the interviews as rather problematic. The main problem consisted in the small size of the finance and econo-physics community behind FinGrid, which had rather little weight compared to other communities within EGEE. Hence, the requests and contributions put forth by FinGrid were not readily accepted. Moreover, EGEE was described as an attempt to convert a tool conceived for HEP into a tool that was of interest to science in general. However, the core technology and the developer community were high-energy physicists and it took a lot of time before needs that were extraneous to HEP became just listened to:

> *"We had some needs that were specific to our community, for instance, just to mention the biggest, the problem of security. That was not specific to our community in the sense that no other community could be interested, but certainly HEP would not be interested. It was an important topic for medical sciences, another, much bigger community. EGEE was a physics project that was trying to expand but didn't have a lot of resources to become general purpose." (Interview FinGrid site coordinator)*

In the early days of EGEE it was also often unclear who assumed responsibility for particular issues, for instance data security. These problems translated into problems inside the FinGrid developer team, as team members didn't get answers to their questions and became frustrated with their work. This situation improved and became more motivating again, as the FinGrid people got to know the EGEE community better.

Upon the second attempt FinGrid became an unfunded Virtual Organization (VO) within EGEE-II with its own portal. Other collaborations with groups working on related issues could not be established: in one case it was due to the different middleware that was used; in another case, the European project BEINGRID, it didn't advance beyond initial contacts.

User community – public science: The FinGrid infrastructure is available, but it is only used to little extent by the original user community right now. Requests from users are satisfied when possible and not requiring large-scale adjustments or support, as the FinGrid funding has ended.

The core user community who used the infrastructure intensively consisted of very few people, in the order of ten, all from national universities and public research institutions. They mainly belonged to academic groups in finance, statistical physics, econo-physics and economics. They were linked to the FinGrid team through the community of statistical physicists at their local institutions with whom they had collaborated in the past or they had been requested by the funding body to implement their analyses on FinGrid. The number of involved institutions remained constant throughout the project, however, some new users from affiliated groups joined as the project developed.

Interaction between users and developers was realised through several meetings every year. These meetings were targeted towards end users (finance researchers) to teach the use of the infrastructure, and system administrators who had to install and maintain a Grid site. Global meetings of all involved institutions were related to releases of the environment, when some substantial improvements could be presented. In the first year some trips to the different institutions were added as well as visits to Trieste from individual sites.

Users contributed in several manners: First, all the data in FinGrid belonged to users. Moreover, they explained their requirements regarding the processing of the data: for instance, a lot of discussion was related to how the data could and should be filtered. Providing their applications to the developers the latter ported and integrated them into the FinGrid infrastructure. They provided the computational power and the infrastructure and the idea how to use it. This exchange between users and developers needed continuous interaction. Interaction between different users was less pronounced and it was explained by one of the users with the fact that there were only few users with different backgrounds (mathematics, physics, economics, and statistics) and approaches.

The dissemination of the technology to a wider user community was not pushed very hard; as the first tests with users demonstrated that they were finding it difficult to use the tools. So the developers concentrated on improving the experience of the existing users instead of expanding the user community, which looked like the more productive approach. Only towards the end there was a call for proposals to bring in some new users from the affiliated institutions which produced some responses. Only lately after the original project had been terminated, appeared a new user from a foreign university.

The FinGrid developers also have come to the conclusion that the public user community did not have a strong motivation of using the Grid. This was explained with the structure and content of the current European Grid which is just providing large computational resources, but not much content that can be used by wider user communities (see below). In addition, the domain researchers who wanted to use FinGrid were confronted with learning efforts and time to bring their applications to the Grid (see below).

User community – private finance research: The project received some attention from the private finance community, too. In particular software and IT consulting firms with clients in the financial sector showed interest. The FinGrid team managed to engage an enterprise software firm that is very active in financial services in a follow-up research proposal to FinGrid that, however, did not pass the evaluation. The firm committed itself to sharing 2000 software licenses for the EGEE infrastructure to facilitate a mixing of the tools provided by the public EGEE infrastructure and their tools, the private Grid technology applied to finance. This shows that the public developments were actually of interest for private applications. As the research proposal didn’t get funded the current interaction with the private finance community is just limited to knowledge exchange.

It is not the infrastructure, but mainly the technology that captures the attention of players from the private sector. Private finance institutions resemble public research organizations in regard to the compartmentalisation between different departments and the need to share resources and protect the data. So, the Grid is an important technology to share resources in a controlled way.

The finance sector and its IT consultants hence pursue several own developments in this area which are, however, usually not made public. According to the perception of the FinGrid interviewees it is a lot more advanced than the academic sector.

Personnel and Resources

The developer team in Trieste consisted of a maximum of 5 people of which two dedicated their efforts to porting applications on the infrastructure. The people were mathematicians, engineers and physicists, all with a background in the IT sector – more precisely from the Linux community – hired specifically to work on FinGrid. People with a background in finance were not included, as the developers mainly had to provide the technology and take care of the infrastructure, but not engage in any type of analysis with the data. It was not an easy undertaking to find the developers as the needed skills were not readily available at that time (and neither they are right now). Students were not involved, because the principal developing organization is not a university and doesn't have any students.

The development of the web portal was done in collaboration with another team from Hungary, as their technology was used and modified for the portal.

The total project budget consisted of 900,000 Euros of which two thirds were allocated to the main developers for developing the infrastructure. FinGrid was funded by the national Ministry for Research; other sponsors were not involved. The main costs were personnel costs. The project developers did not perceive any funding problems or shortages throughout the project. If significantly more money had been available they would have invested in programmers located at their users' organizations to deal with problems of software instability and support. This has been voiced as one of they key barriers to adoption: as finance researchers themselves – like many other user communities even in technical and science fields, according to the opinion of our interview partners – lack computing skills to use the Grid themselves, they fall back on existing tools and applications. To avoid this, the interdisciplinary collaboration with computer scientists/engineers and domain scientists needs to be intensified in whichever way possible (see below).

Relationship to established practices and policies

The main advantage of doing financial calculations on the Grid lies in its larger computational power and the ability to do calculations quicker as well as use computing resources more efficiently. This advantage cannot be denied, but for several reasons, both specific to the FinGrid project and community as well as generally applying to the European Grid infrastructure, it has not been realised. Mainly the following reasons were mentioned by the FinGrid interviewees:

1) The current European Grid uses an approach that is not in line with the needs of the finance community,
2) Communication problems between the academic finance community and the technical developers,
3) Technology and content need to be provided to facilitate state-of-the-art research.
4) Changing research practices as the Grid becomes more common

Ad 1) *The current European Grid uses an approach that is not in line with the needs of the finance community.* The European Grid is not a good place to run computations of the scale that is usually requested by the academic research community in finance.[28] The Grid is good at providing thousand CPUs and doing very large computations *quickly* – however, the academic community does their computation with little time pressure. Moreover, most of the computations can be done by using a small cluster and in case of specific (and very rare) large scale needs there are still supercomputer sites that can be visited. The European Grid is not a place where you would go to in order to obtain two hours of computing, it

[28] It might be different for private finance research, but, as mentioned elsewhere, private firms would not use a public infrastructure for reasons of data security and secrecy.

functions at a different scale, a scale that is however rarely needed by academic finance research.

In addition, the approach to computing was described as different: The EGEE environment is not interactive, and researchers can't simply do calculations and get back the results immediately, as finance researchers would expect according to their work practices. "Batch mode", submitting a list of jobs and getting back the results the next day or later, is something that is not common in this community and therefore clashes with the day-to-day work practice.

FinGrid interview partners suggested either to strengthen the roles of other communities outside of HEP in the development of a European Grid Infrastructure in order to improve the matching between the working mode (and flexibility) of the infrastructure and the needs of the varied user communities; or, using a different approach, to keep Grid for HEP and other user communities separate, if the needs of different communities are better served this way and by providing different tools. This was also to some extent confirmed by a former FinGrid user who finds his needs better served by a proprietary Grid engine provided by a software firm, though he also mentions some disadvantages of not having an open Grid standard.

Ad 2) *Communication problems between the academic finance community and the technical developers.* Cross-disciplinary communication proved cumbersome and wasted resources in several instances in FinGrid. Misunderstandings took place frequently and after presumed problems had been solved by the developers, it turned out that the actual problems had been somewhere else:

> *"If I had to summarise the relationship to the users, "I didn't mean that" would be the most concise explanation." (Interview FinGrid site coordinator)*

Another issue is the flexibility of the tools and computations: academic finance research does not rely on standard, frequently used tools. They instead develop many small tools which are tried and used for short periods of time to do specific tasks. This created problems in the development of the FinGrid infrastructure which were perceived as being due to a non-formalised and unstructured way of research in finance:

> *"So, it was difficult for us, because their tools where ever changing. So it was difficult to sit down and identify the needs that they have. We can bring the code on board which costs us a couple of months, and then they need it just for one month. There is very much non-structured research going on in this community which makes it difficult to find the right way to work." (Interview FinGrid technical manager)*

An FinGrid user confirmed this view at least partially by conceding that "*we were not clear on what we needed and what the Grid could do.*" A developer proposed a concentrated effort to find or develop applications that are standard tools of analysis for the field to deal with these different work practices.

The problem of different languages of provider and users was crucial and not simple to solve. "Translators", interface figures, were proposed as one possible solution to avoid these misunderstandings and bridge the language barriers. They would stand between the technical developer and the user communities, be familiar with the working practice of the users as well as with the European Grid Infrastructure. They would need to translate from one side to the other, in disciplinary terms and in terms of the vision that each side has, what it is offering, and what it wants to see on the other side. They would act as mediators, look into the needs of the research community, formalise these needs and have an impact on the developers, as they can express themselves in a language understood by them. These translators would also need to be easily available, ideally sitting next door to the users. Long distance telephone calls and emails don't provide the

necessary communication richness and people would not use them but try other workarounds.

In order to spread the Grid among SSH a different approach would also need to be found in training and dissemination events. The language with which a scientific community is addressed, that has identified its needs of computational power quite clearly, needs to be different from the language used for a community with fewer computing skills and less structured and formalised problems.

Ad 3) *Technology and content need to be provided to facilitate state-of-the-art research.* The provision of computational power is important, but not the only aspect for doing successful research in finance with high-frequency data from stock exchanges. At least as important is the possibility to access, store and use the proprietary data in an efficient way.

The first stepping stone in this process is the purchase of the data from stock exchanges, banks or other sources which demands special contracts, if consortia of researchers from several organisations want to use them. The writing of such contracts needs legal expertise which the users, finance researchers, don't have. Moreover, as the data is not for free, funding regulations need to include this type of costs.

After the data is purchased, it needs to be processed before any type of calculation can be done. This processing is labour-intensive and costly and one of the possible gains that might result from a shared data infrastructure.

Data access can then be granted to all people that have the right to access and work with it which means that clear data access regulations and their enforcement need to be established on the infrastructure. Essentially what is needed to do research in finance is an information infrastructure and not only technology and computational power:

> *"I have the impression that from the point of view of the EU infrastructure is something which is of course focused on the infrastructure itself, the hardware and software, but which is not related to the information inside, at least for us in the field of social science. I think it will be extremely important that the infrastructure must not just be a computer infrastructure but also an information infrastructure." (Interview FinGrid user)*

FinGrid advanced in the direction of creating such an information infrastructure for finance in some important aspects, in particular in regard to data management and enhancing usability. However, the problems listed here affect usability and demand solutions at other levels.

Ad 4) *Changing research practices as the Grid becomes more common.* The interviews also showed that technology developers' possibilities to training their users are limited: they do not fully understand what the users actually want to do and find it hard to translate what they can offer into a language understood by the users. One FinGrid user suggested that research practices change over time and the next generation of finance researchers will need to be able to work with grids in order to do their research. Datasets in finance are becoming too big to be used on individual computers. The change is yet an evolutionary and not a revolutionary one. One Grid user in finance described his practice as follows: he uses the Grid to carry out statistical analyses with data series of different stocks; the analyses are first programmed and tested with one data series on a local Linux machine and then, if the test is successful, ported to the Grid where the same software applications are installed; then they are run on the Grid with the larger amount of data. So, essentially the Grid contributes to reducing computing time in this case.

However, in order to achieve this inclusion of the Grid in finance research several preconditions need to be fulfilled: 1) hardware and grids need to work in a reliable

way, 2) software tools need to be available on the grids, and 3) computing knowledge and coding skills as well as the awareness of how to use it for research need to grow in the finance community. The latter issue entails that innovative finance researchers need to pass on their experiences to graduate students and the next generation of researchers. One of the first examples where this is see http://www.youtube.com/watch?v=e5zsMTf9YpQ).

Impact

As described in a project presentation, FinGrid had a strong commitment for training and the dissemination of Grid technology applied to finance. This would need to be measured at first level by the size of the user community; at second level the actual impact, such as the amount of published work done by the user community would need to be measured. The FinGrid key technical developers concede that the project was not very successful at either level.

However, the FinGrid project nevertheless managed to make some impact above all in the community of Grid developers: gLite is perceived as more user friendly, the documentation has improved and the EGEE developer community has been sensitised for the issue of data security and access management. This impact was mainly realised through having tools that were developed in and for FinGrid accepted as parts of other e-Infrastructures, so far in particular in the EGEE environment:

- Part of the live-CD, the training tool in FinGrid, has been adopted for dissemination activities in EGEE.
- The data management tool is implemented in a storage management infrastructure that was developed together for EGEE. It is a stable tool that is very well interoperable with other tools and one of the competitors for the data management solution in EGEE.
- The portal is still confined within FinGrid, as offers to share it could not be realised because the necessary support can not be provided.

The involvement of the industrial world could be considered as another success of the project (see above).

The success of FinGrid is thus visible in other communities than the originally addressed reference community; whereas the failure mainly consists in not establishing an active user community. The FinGrid technical developers suggest that in e-Infrastructure development projects the roles of users and providers should be clearly defined in the manner of “masters and slaves” to avoid this reason for failure: the users should be the masters of the project telling the Grid providers, the slaves, what they actually need and what should be achieved. This model should also rule over the research interests of the involved computer engineers. Although the borders between technical development and research are fluid, it should be clear from the beginning that the main focus of an e-Infrastructure project is to produce running e-Infrastructure.

4.3 Synthesis of the investigated cases

This section compares the eight analysed cases and synthesises the findings. The results are summarised in the following tables and the most important issues are discussed in the text below.

Tables 4.2 a-e: Comparison of the cases

a) Technology

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
Mission	Providing services to UK Access Grid (AG) users and fostering the proliferation of AG in higher education and research in the UK	The use of massive data resources and computational power to address intellectual and applied problems through modelling and simulation	Development of a tool for generating and analyzing large scale simulations based on different types of raw socio-economic data; enabling trans-disciplinary collaborations	Development of a web portal and appropriate methodologies for storing, sharing, and analyzing biological, behavioural, and social data - "a YouTube for social scientists"	Development of technologies to record, represent and replay new forms of digital data	Documentation of languages which are in danger of becoming extinct and creation of a central archive for collected data.	Development of a virtual research library that provides text data and a toolset for processing (annotating, editing), analyzing and publishing it	Development of a national facility for economic and financial data based on Grid technology including a user-friendly data management interface
Stage	Ongoing service for AG use	Underlying models and demonstrators are developed, right now start of concrete application development phase	Pilot development for internal use	Testbed project is about to be completed	Software DRS (Digital Replay System) has been developed and is being improved.	Archival and language documentation technology fully developed and at a very advanced stage.	TextGrid runs as beta version open only to few selected projects.	Infrastructure is in place, but funding has terminated and future support cannot be provided.
Constraints	Smooth interaction of different network protocols, improving and guaranteeing audio quality, system stability; also improving the ease of use (user interface)	Computational power still too low for large simulations; confidential data: legal and technical security issues;	"Difficulties of the commons"; technical complexity to non-expert users	No existing algorithms to comprehensively handle complex data. Commercial software licensing schemes unsuitable for a Grid environment. Comprehensive access permission to administrators may clash with institutional (IRB) demands.	No mentioning of any constraints.	No mentioning of any constraints.	Integration of different standards developed in previous projects	Middleware was suboptimal for the user community: e.g. data management and security issues were not dealt with; integration of the tool into the computational environment of the users was difficult

b) User Community

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
Users' characteristics	Multidisciplinary academic user community	Multidisciplinary academic user community and city councils, health trust, regional bodies; interest also from governmental bodies	Currently lab's staff; targeted community includes a broad community of social scientists and decision makers with a "computational bent"	A small group of social and behavioural scientists from three universities; targeted community in subsequent developments may include a large group of social and behavioural scientists who are familiar with standard scripting languages	So far strictly academic user community consisting of social scientists and research teams from various universities. In the future possibly users from the Greater Manchester Police will be involved.	Large user base consisting of the academic community, communities of the languages being documented, the general public and journalists.	Intended user community of text-oriented social scientists and humanities researchers, e.g. linguistics, languages, literature	Small user community in one scientific field (finance); few contacts to private finance research but not as users.
User recruitment	Steady growing recruitment through projects and groups already using AG and spreading the benefit; sometimes hindered through technical problems on the node site, or support is not sought leading to not using AG	Through existing ties and through the evoked interest and prospect of possibilities of the innovative and scalable application	Significant hurdles may prohibit recruitment of social scientists primarily for legitimacy concerns: not trained as social scientists lab's scientists experience difficulties establishing their legitimacy, including concerns with tools, methods, and validity	Establishing a user community is one of the challenges; a relatively high investment in learning new tools, shifting from existing more familiar software, and increased dependency on computer scientists may limit participation.	Broader non-academic use is encouraged through public events and NCeSS outreach activities (such as the NCeSS Showcase) and invited talks.	User recruitment occurs automatically and is unproblematic since there is significant public interest in the archival technology developed.	Not yet established	No explicit user recruitment; focus was laid on improving the usability for the initial user community.
Developer-user interaction	Email, phone, web-based support, weekly test sessions, biannual workshops, user survey, joint research projects	Email, phone, irregular meetings, feedback on models and interface, demonstration of prototypes; no important barriers apparent, but in the last development stage exchange has to be intensified	Interact with users as a part of ongoing work at the lab; as developers have worked closely with users for many years there are no apparent communication barriers.	Substantial barriers of language and understanding between developers and PIs/users resulting from divergent disciplinary practices; "translators" brokering the fields involved help reducing communication difficulties.	User-driven project; driver projects safeguard that needs of pilot users are considered; wider user community not yet mobilised	Developers use user feedback to improve the software and adapt it to users' needs.	Users are involved in the design and development, wider user community and mode of interaction are not yet established	Interaction through email, phone, (training) workshops, site visits; significant communication problems between users and developers

c) Funding and staff

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
Initial/current funding	UK e-science programme funded setting up AG nodes (hardware) in universities and research institutes; furthermore e-science and e-social science projects in the AG context have been funded and still are	UK e-science programme funding through public R&D grant; emerged from two previous pilot demonstrator projects	Current funding through institutional seed money and indirectly benefiting from a number of related, funded projects	Main funding through public R&D grants	Current funding through public R&D grant	Funded by the German "Volkswagen Stiftung" and through participation in other project.	Current funding through public development grant	Initial funding through public research grant; no current funding; recent research proposal in FP7 was rejected
Long-term business model	Free of charge services to AG users; main funding through public funds	Free development of open source software	No business model as project still in early development stage	No business model as project still in early development stage	No business model as project still in development stage	No business model mentioned.	Still unresolved, pay per use versus institutional subscriptions;	No business model developed.
Developers/PIs characteristics	Head, op. manager (and researcher/ developer) and four support officers plus one associated researcher/ developer at Manchester Research Computing Services	PI, three developers/ researchers and Co-PIs located at one UK university, bridging geography & computer science in development/ research plus application in transportations, health care and business,	Lab's staff; software engineers some with advanced degrees and working knowledge in Grid computing; in the future serve as a broker between technology and users	Participating institutions include two universities, each including software engineers and computer scientists – some are well known experts in Grid computing; in the future aim to broker technology and users	Social scientists from three universities	Linguists, social scientists, computer scientists, archivists and library scientists.	Leaders of the team are humanities researchers (library science, German literature and language studies and text-oriented studies). All have graduate or postgraduate degrees.	Technical developers are computational physicists and computer scientists from one org.; PIs are finance researchers from different org. and backgrounds in physics, statistics, mathematics, & economics
Recruitment and training of staff	Already working at/ recruited from Manchester Research Computing Services and partially initiated AGSC; and from IT service in general; no formal training of staff	PI and most Co-PIs from predecessor demonstrator project; three developers/ researchers recruited locally; no training	Efforts to foster ties with Grid experts	Recruitment through pre-existing ties and institutional affiliations; a number of Grid experts have joined the project on a voluntary basis; reliance on open source efforts opens up development to links with a larger community of Grid development	Staff is recruited only from members of the universities' research teams.	Recruitment of specialists from all over the world for specific documentation projects; regular training courses	Not discussed in the interviews.	Staff recruited at the beginning of the project; difficulties in finding developers due to specific qualifications needed; training on the job.

d) Relationship to established practices and policies

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
Disciplinary ownership and sharing	No issue for AGSC	Not mentioned	Sharing simulation models is not an accepted practice; confidentiality may be a concern when data is used inappropriately.	Data sharing is not acceptable in the field, especially because it requires high involvement of contributors including: appropriately designing data collection, learning the tools, and adjusting data to accommodate supported standards	No mention regarding sharing policies.	Very open towards sharing, connected to a multitude of related projects in Europe, USA and Australia sharing experiences and agreeing on standards.	TextGrid is defined as frame for projects in the field. Openness for new projects and easy access to existing projects is part of the concept.	Sharing data is only possible under the (restrictive) regulations of the data providers, however, it is essential for the success of the infrastructure
Academic rewards	Not relevant; AG is external technology provided as a service commercially (inSORS) and as open source	Despite no emphasis on scientific publications 2nd best paper at UK All Hands Meeting 2007; addressing issues in a new way for social science through modelling and simulation; finding solutions for de-velopment problems	Does not concern staff members, but participation may not offer much rewards to potential social scientist collaborators for institutional authorship considerations	Easy access to data and computationally intensive analysis tools could speed up research process; acknowledging use of investigators' data may reward those who collected data; computer scientists benefit from adoption of their technologies.	New ways of working with and analyzing data can provide new insights for social science research.	e-Infrastructure facilitates certain forms of linguistic research enormously; developed archiving framework can be applied to other fields.	Since TextGrid runs in beta status there are no rewards yet.	Rewards for technical developers are not an issue; usual rewards for scientific contributions.
Cross-disciplinary collab. & comm.	No issue for AGSC	Functioning multidisciplinary collaboration in the project itself and with the application domains	Functioning interdisciplinary collaboration *within* the project team; significant challenges in linking back to the core social science fields	Differing agendas of domain and computer scientists; communication problems; involvement of “translators” who are formally trained in both fields	Interdisciplinary collaboration between project teams is not mentioned as problematic; problems in linking back to the core social science fields and demonstrating the benefits of the tool	No issue, cross-disciplinary communication is working very well and the archiving framework developed is being considered for use in other disciplines.	Considerable problems of communication and mutual acceptance between domain and computer scientists, eased through intensified efforts and building of interdisciplinary micro-teams	Communication and language barriers between developers and users were significant and produced waste of resources.
Institutional environment	Embedded in Manchester Research Computing Services,	Different departments/ schools at the university; successful collaboration between computer science,	Group of multidisciplinary scientists organized as a middle sized laboratory in a US	Previous projects relating to e-Infrastructure in the participating institutions reduce the cost for project engagement thus	DReSS has connections with the US Cyberinfrastructure project SID Grid.	DoBeS is part of various other international projects. It also takes part in the	TextGrid is part of the German D-Grid initiative. D-Grid involves 17 projects from the natural	High interest in the technology by the developers’ institution; institutionalised collaboration with

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
	benefiting from collaboration with related research projects; exchange with institutions and research groups in the UK through supporting the AG	and geography; the NCeSS structure fosters exchange with hub, all nodes and additional projects; collaboration between GeoVue and PolicyGrid; collaboration with Univ. of Beihang, China	research university with a common research focus; social science is a key domain; also collaborations with other institutions and Grid experts when additional expertise is needed	enhancing the reward.		development of several ISO standards related to language archiving technology.	sciences. TextGrid is the only project from the humanities.	EGEE

e) Impact

	AGSC	MoSeS	SPORT	ComDAT	DReSS	DoBeS	TextGrid	FinGrid
Vision	Bringing AG to all research institutions and projects in the UK, maybe worldwide	Giving solutions for important problems in society and policy decision making through modelling of population and their ageing	Potentially addressing problems in unparallel scales of social and economic simulation; promoting a new kind of science.	There is a possibility for supporting a major theoretical contribution by linking diverse types of data;	Offer a new, alternative paradigm for working with a multitude of different types of data.	Document endangered languages to prevent their extinction and find common traits between them by having a searchable archive.	Potential to change the everyday work of scientists working with text corpora through easing access and understanding them in their reception history.	Beyond FinGrid: Grid-based computational and information infrastructure for economic and finance research.
Main challenges	Fostering the uptake of AG in scientific communities for collaboration; devising new AG tools and services (with the help of associated research projects)	Finding solutions for more computational processing power (takes time) and for the confidential data issues (security & legal)	Lack of legitimacy and funding constraints limits the promise	Advancement cannot be achieved without dedicated funding for less "attractive" activities, as specialized algorithm development for data processing and synchronization	SSH are still sceptical about using computer tools and have to be convinced of their use; SSH needs to become more empirical and not strictly theoretical for the tools to be of use.	Convince national institutes to adopt the framework instead of a locally developed one.	Make TextGrid sustainable by recruiting an open and active user community; attractiveness for humanities communities is vital to guarantee future funding.	Enlarge the user base and develop a sustainable funding model.
Realised impact on research	Uptake and use of AG by different scientific com-munities; further development of AG in associated projects improve services; projects get funded also because of the success of the AGSC	Demonstrator, presentations and publications evoked interest in the respective community and in the media, even if the system right now is not usable	The impact on research is not manifested as the tool is still in rudimentary development stages; Research planning, however, is directly affected as new domains and scales of simulation possible only through e-Infrastructure are proposed to funding agencies.	Limited impact on research as no appropriate algorithms for utilizing social and behavioural data on e-Infrastructure exist ; research time reductions for some communication scientists; computer scientists re-use models developed for other domains;	Researchers can now gain a better understanding of interaction in the digital society through the ability to combine heterogeneous data sources with system logs.	An organized, searchable archive facilitates research and analysis of data.	Successful integration of different projects working independently on the same field to focus know-how and resources.	Little impact on original user community; impact on European Grid development in regard to data management and usability of tools.
Realised impact on teaching/ learning	No institutionalised connection to teaching activities	Teaching courses; Master students involved in development; PhD studentship planned	Graduate students are involved in development and use, but not through formal coursework; the technology is not sufficiently developed to train users	There are no active attempts to integrate developments in formal coursework.	No connection to teaching activities, however, e-Infrastructure will have to be integrated into future curricula	No connection to teaching activities so far.	None so far, future work-package in the project	Development of a training tool for Grid installation

4.3.1 Technology

Among the investigated cases five have a focus on the generation of data repositories including tools and applications for regulating access as well as managing and processing the data (ComDAT, DReSS, DoBeS, TextGrid, and FinGrid). Of these five cases four are still in the development phase and only one (FinGrid) has been terminated so far. The terminated project has not yet been able to acquire the necessary funding to keep the infrastructure running; a proposal within FP7 for a European follow-up project has not been selected for funding. Two further projects (SPORT and MoSeS) use data for modelling and simulating socio-economic events and processes. The eighth project, the AGSC, is a support service for users who use a conferencing and collaboration application.

Data protection. Several of the projects encountered as a major challenge the issue of data protection, an issue that has usually not been covered in the existing Grid middleware at their time of conception. The necessity to protect the data may for instance originate in legally binding constraints of the data providers (FinGrid), from institutional regulations on how to treat data on human beings or organizations (ComDAT) or from national law in case of census data, which has to be handled under strict regulations (MoSeS). The projects had to solve this issue by developing tools and applications that implemented data rights and access management – respectively in MoSeS a seamless connection of Grid and legal framework still has to be established in a feasible way. These technological solutions were possible when it came to regular numerical or textual data, though they might have required devising new applications that were not (yet) common in the broader technological environment, such as the EGEE environment of FinGrid. However, when it comes to new types of data, like audio or video recordings in ComDAT, technological solutions for masking the identity of the recorded individuals without invalidating the recordings are less straightforward and not yet established.

Reliability and usability of the applications. Another technological constraint that was mentioned in several cases relates to the often negative experiences of the (pilot) users when using the applications (see AGSC, SPORT, TextGrid, and FinGrid). These negative experiences resulted for instance from complex user interfaces (UI), low stability of the applications, and difficulties in integrating existing applications and standards into the new environment.

Solutions to these problems were also often sought in the technical sphere, e.g. re-designing UI, adding and re-launching applications, quality testing programmes (AGSC) etc. In several cases (AGSC, DReSS, DoBeS, and FinGrid) the developers and providers also engaged in training events with the users. In FinGrid they conceded however, that the training of SSH users needs to implement a particular approach that takes account of their lower computing skills and less structured and formalised problems.

Computational power. A lack of computational power was only mentioned in one of the eight cases (MoSeS) as a restriction, though the need for more computational power was a driver in some of the other projects, too (e.g. SPORT, ComDAT, DReSS, and FinGrid). More computational power does not imply, however, that the approach to computing is of the same scale and mode as in the fields that currently drive grid developments in Europe, in particular high-energy physics (HEP). On the contrary, interviewees from the case studies remarked that it is nearly impossible to align the different approaches to computing followed by social scientists and HEP (see the FinGrid case). These approaches are engrained in field-specific cultures and practices and SSH rather discontinue to use the grid and set up new or use existing small-scale clusters that serve their computational needs very well than adjust their practices in order to use the grid.

Other technological issues and constraints. In ComDAT, one issue was mentioned that seems to be specific to some social sciences dealing with human interaction, like psychology and communication studies: the interpretive nature of some types of data,

e.g. video recordings, makes it difficult to capture the signal, distinguish it from the noise, code it accordingly and then subject it to automated analyses.

4.3.2 User communities and involvement

The investigated case studies either address a broad user community from several SSH fields and beyond (AGSC) or focus on one specific field for which the applications are being or have been developed.

Establishing a sufficiently broad user community in the field. Projects in early stages (SPORT, ComDAT, MoSeS, DReSS, and TextGrid) rely on pilot users which work with prototypes and testbeds. Only two of the eight projects have large user communities at the moment: AGSC is to some extent a special case offering free services to users of a proprietary technology and DoBeS has a large user community among the language researchers of the languages included in the project. For the other projects the establishment of a user community is still an open and critical issue for success. MoSeS already at this early stage evokes a huge interest from potential user communities (up to the governmental level) who see the benefit in the project's simulation and modelling capabilities on a large scale – but the future still has to prove its success.

The strategies for recruiting users are rather weak and little developed (except for the AGSC, which as a service is continuously developing strategies to increase the uptake of AG): projects tend to rely on what is offered by their funding or institutional environment, e.g. DReSS relying on the NCeSS activities. In some cases the developers and PIs expect that the application speaks for itself and that word-of-mouth advertising at conferences or other events will do the trick. However, the FinGrid project, that has been discontinued not the least for failing to attract a user community, shows that this is not enough. The strategies and measures of finding, involving, and preparing users need to be more sophisticated.

Few measures to support user-user interaction. One of the weaknesses seems to be that interaction on a project is mainly thought of in the lines of user-developer interaction using the traditional means of communication, phone, email, and face-to-face meetings at workshops, seminars or site visits. This communication between users and developers is without doubt extremely important for designing and improving the infrastructure and itself fraught with problems of differing languages and communication barriers (see p. 135). However, it is not suitable for making the merits of an infrastructure visible to potential users. In addition to user-developer interaction, more user-user interaction would be required, for instance pilot users presenting showcases to potential users or PIs disseminating their results in the user domains.

Involving leading domain scientists in the diffusion of an e-Infrastructure and building of a user community might be a good strategy – peers and scientists in the field are the main information source on e-Infrastructure, as we learned in the early adopter survey (see p. 44). This should be a worthwhile but not necessarily easy undertaking: First, it should not be neglected that it still takes considerable time, as interviewees from ComDAT and SPORT point out themselves, to learn and master new e-Infrastructure technologies. The necessary effort depends on both, the development status of the technology as well as the technological level of the learner. And time is a scarce resource, especially the time of eminent scientists. Second, it should not be underestimated that in particular the established scientists also may owe their position in part to the current infrastructural arrangements, e.g. their access to particular resources or technology (Edwards et al., 2007, pp. 26-27). Hence, they might not be willing to put their position at stake through supporting the diffusion of a new technology.

4.3.3 Funding and staff

Six projects have been funded through public R&D grants in different research programmes. The SPORT project has been funded through institutional seed money and DoBeS through a non-profit foundation, both projects also benefit from related projects. Naturally funding enables research and development projects to come into existence in the first place. However, this usually also means, that projects can only be established for a limited span of time. In this context especially the development of services and tools pose the question of sustainability. On one end of the scale the AGSC will probably be funded for at least eight years fostering the sustainable use of AG, whereas, on the other end, there is currently no more funding for the FinGrid project leaving a developed e-Infrastructure unsupported. In-between e.g. the MoSeS project emerged from two pilot demonstrator projects giving the previous work some continuity. Therefore two approaches seem feasible: either such projects would need a longer funding period or an appropriate business model could secure sustainable provision and successful outreach.

Service-oriented business models. It is an incomplete and misleading conception that e-Infrastructure in the social sciences and humanities is only or even primarily about technology. Though technological constraints without doubt still have considerable influence on user satisfaction and project success, social scientists and humanities researchers mainly demand advanced computing and support services as the AGSC and ComDAT studies show.

The success story of the AGSC, a duplication of room-based AG nodes every year since 2004, confirms the value of “robust, resilient services” to academia, in particular when it comes to supporting collaboration. An ingredient to this success seems to be that the service is offered free or close to free of charge for the users, as we also see in the ComDAT example. The TextGrid interviews also point in this direction, as the interviewees consider the requirement of charging individual projects and users for the service to be a major barrier of adoption in the future.

Of course, if the users themselves do not pay, alternative funding schemes need to be found that ideally provide long-term funding to secure the continuity and improvement of the service and make sure that users’ investments into a technology don’t get lost. The investigated cases do not provide any guidance on possible solutions as they are still mainly funded through public research (and development) grants. As historical studies of other infrastructures such as road, rail, water, energy and telecommunication networks have shown, it was often public investment or funding arrangements that coupled private investment with public regulation that led to the establishment of a network (Edwards et al., 2007, p. 29).

At the same time, users will have to commit themselves to long-term solutions and accept the service idea that comes with the technology. They will have to provide funds that cover more than the initial set-up of a technology or tool and include support and maintenance. In a networked application it affects the service level of all participants if maintenance and quality standards of one networked user are unsatisfactory and the AGSC desire of coercing AG users to conduct quality tests is hence understandable.

All projects to some extend develop applications or tools (as already described above), but with the exception of FinGrid are all still in a rather early stage. Therefore procedures for a larger rollout of the software have not been mentioned – as for FinGrid the infrastructure is in place but with no further funding future support cannot be provided. Only MoSeS explicitly refers to using open source and free software whenever possible and also developing as open source as this is also a requirement from the funding side. Similar to the free provision of services also the free use of software under an open license could be a model to foster sustainable use – if models for the necessary further support can be found and established.

Recruitment and training of staff. In recruiting its personnel, FinGrid seems to be the sole project with difficulties in finding staff (developers), and together with DoBeS both are

said to be the only projects to have engaged in looking for people from outside their own department, university, existing collaborations, projects or other ties. In addition to the regular staff SPORT is looking to foster ties especially with Grid experts. Remarkably DoBeS is the only project with reported regular training courses for staff, while three other projects (AGSC, MoSeS, FinGrid) at least mention training to take place more informally on the job, as otherwise it would be too time consuming or at all ineffective. None of the interviewees seemed to miss training in important areas. The lack of training seems to be a general characteristic of e-Infrastructures in SSH, as the recent HERA survey obtained the same result (see Kaur-Pedersen & Kladakis, 2006).

4.3.4 Relationship to established practices

All projects are well established and connected to other (current or previous) projects, institutions, networks and/or researchers within their respective domain areas but also in the fields of e-Infrastructure, e-Science and e-Social Science. Most of the projects also have international networks in this context.

Data sharing is unproblematic in humanities and difficult in social sciences. In three of the projects (AGSC, MoSeS, DReSS) there is no mentioning of data ownership or sharing. This is especially understandable for the AGSC, as this simply is not an issue for a supporting service. For two projects (SPORT, ComDAT) interviewees stated, that due to the mainly confidential nature of the data and because of the disciplinary practices sharing is not accepted in the field. FinGrid, another social science project, had to find ways between existing restrictive policies of data providers and the essential need for sharing data. The situation is somewhat different in the projects mainly led by the humanities: In aiming at building libraries/archives for languages and text data both DoBeS and TextGrid naturally tend to support data sharing in order to benefit from such a practice.

Academic rewards. For most of the projects and their project members the usual way of academic rewards in form of contributions in renowned scientific publications is not happening in the same extent, especially in social science and humanities disciplines. These disciplines are still more traditional in that regard, which makes it difficult to succeed coming from a multidisciplinary environment. Only FinGrid states clearly to have the “usual rewards for scientific contributions”. The publications coming out of the e-Infrastructure related projects therefore often are placed in e-science or related communities – but here with huge success, as the “2nd paper award” of MoSeS at the “UK e-science All Hands meeting” conference shows. At the same time one of the interviewed authors points out, that the number of publications would be lower for an innovative e-Social Science project. In this context it is also more likely to have contributions with a technical focus, but still rewards for technical developers are often “not an issue” (FinGrid).

The biggest success and therefore reward is generally seen in addressing issues in a new way beneficial for research questions, methods and data in social science and humanities. Here this is said to be especially true for simulation and modelling (MoSeS, SPORT), replaying and analysing new forms of digital data (DReSS) and linguistics (DoBeS).

Cross-disciplinary communication and collaboration. Several of the presented cases have struggled with communication barriers between social scientists or humanities researchers and computer scientists. These barriers place a burden on project development: specialized languages, “ping-pong” communication and differing work styles translate into differing expectations on what a project can and should achieve.

This lack of interaction and mutual understanding of domain and computer scientists goes on beyond the development phase, as SPORT interviewees highlight: a “Throwing your research over the wall and see if anybody picked it up” attitude usually results in nobody picking it up. Field-specific practices, conventions and standards have developed over decades and scientists tend to be sceptical and unwilling if somebody tells them that

they have to change, in particular if that somebody is considered to be an outsider without expert knowledge in the field. These differences are still often ignored by computer scientists and developers for whom there is little difference between processing astronomical or socio-economic data with their tools (see e.g. the ComDAT case). They only see the possibility of making them available to yet another community. It is also striking that nearly all of the discussed projects stressed their close ties and involvement with the global Grid community, but not their contribution to the development of their social science or humanities "home base".

Some proposals and examples on how to deal with these communication barriers also surfaced in the cases:

- TextGrid successfully reduced the communication barriers by involving both, domain and computer scientists, early on in the projects, letting them closely discuss the critical issues and establish a joint basis for further work.
- In DReSS the user-developer collaboration is institutionalised in the structure of the project. So-called "driver projects" intend to make sure that developments are triggered by and linked-back to user needs.
- Another solution, implemented to some extent in ComDAT, may be to engage "translators", individuals trained in both fields, who understand the language, problems and work styles of each group and can bridge communication between the involved domains.
- In MoSeS the collaboration between computer scientists and geographers works well, as both parties have a hand in developing and the work on the same university campus helps the daily exchange of information. Users are represented by the three co-PIs (one in each application domain), who successfully collaborate with the developers to transfer user requirements and other important information.

4.3.5 Impact on research and learning

Each of the projects follows the vision to address and solve existing problems in a new and ambitious way through the combination of using and building e-Infrastructure tools and/or frameworks in and for their application domains.

- MoSeS and SPORT use the potential of simulation and modelling to engage social, political and economic issues on an unparalleled scale.
- ComDAT, DReSS, DoBeS and TextGrid all offer new ways of linking, archiving and working with various types of data within diverse disciplines.
- The AGSC is a service supporting the use and fostering the uptake of AG in the UK and maybe beyond.
- FinGrid had the aim to develop a national information and computing e-Infrastructure for economic and financial data.

The challenges in achieving the project's goals are particularly seen in making the use as well as the funding sustainable and enlarge the user base (AGSC, ComDAT, DoBeS, TextGrid, FinGrid), followed by solving confidential and security data issues (MoSeS, SPORT) and still bridging the gap between creating new prototypes for the social sciences and humanities and having an application which at one point is considered to be helpful in research and will de facto be used (DReSS).

Impact on research. There a different categories of impact which have been identified.

- The AGSC can state the uptake and real use of AG and its own support services by various scientific communities. In the last years projects connected to the AGSC are funded and improve AG and related services through testing of tools and new developments.

- MoSeS and SPORT do not see the impact of their research manifested in real use beyond pilot systems so far, but evoke huge interest in various communities, which leads to new funding opportunities or concrete scenarios for future use envisioned by researchers from other domains.
- DReSS, DoBeS and TextGrid in different ways foster the use of digital data and repositories through new means of integration using e-Infrastructure.
- The ComDAT project encounters limited impact on research due to inappropriate means for “utilizing social and behavioural data on e-Infrastructure”, but reports reduction on research time and re-use of successful models for other domains.
- In the completed FinGrid project the impact on the original user community was little and shifted to creating benefits for the European Grid development community.

Impact on teaching and learning. Most of the projects so far have no connection to teaching or formal learning activities, but the needs for e-Infrastructure “to be integrated in future curricula” (DReSS), to address this in a future work-package (TextGrid) or when the technology will be further developed (SPORT) are recognised. While FinGrid did develop a training tool to help with Grid installation, MoSeS and SPORT are the only two projects to have graduate students included in development. MoSeS is the only project to conduct formal coursework and additionally plans to implement a PhD studentship.

5. Policy recommendations

5.1 Introduction

Our task in this study was to provide recommendations about the possible scenarios for a large scale roll out of virtual research organisations, and novel services for students based on CSCL environments. We followed a social shaping of technology (SST) approach, which has proven its value in a number of science and technology studies. Our recommendations are informed not only by the survey and case studies undertaken for this project but also by our other work (Procter, 2007; Voss et al., 2007) and the related literature. We consider these recommendations as somewhat complementary to recommendations and proposals that have been made by others, in particular the following:

1) *The ESFRI Roadmap report* (2006) sets out to describe the scientific needs for Research Infrastructures of pan-European interest for the next 10-20 years, taking into account input from relevant inter-governmental research organisations as well as the industrial community. ESFRI's agenda is necessarily concerned with the formulation of strategic, policy-level recommendations and contrasts with the focus of the AVROSS project which has been to identify how e-Infrastructure development and adoption are perceived at the 'grass roots'. Nevertheless, we find several examples of where the two connect. The ESFRI Roadmap identifies three long-term strategic goals for SSH research infrastructures (comparative data and modelling, data integration and language tools, coordination and enabling) and a number of individual, pan-European infrastructural projects critical for the realisation of these goals (ESS, SHARE, CESSDA, EROHS, CLARIN and DARIAH).

2) The *e-Infrastructures Roadmap* from e-IRG has the purpose of outlining the necessary steps Europe should take in regard to e-Infrastructures in the next twenty years (Leenaars, et al., 2005). Coming from a computer science and engineering perspective, the Roadmap includes several recommendations on networking infrastructures, middleware and organisation, resources, and crossing the boundaries of science. These can contribute to building a European infrastructure for e-Research.

3) The *NSF Workshop on Cyberinfrastructure and the Social Sciences* focused on identifying the social, behavioural, and economic sciences' needs for e-infrastructure/ cyberinfrastructure, their potential for helping in the development of this infrastructure, and their capacity for assessing its societal impacts (Berman & Brady, 2005). Its recommendations address first what infrastructures are desirable from the perspective of the latter fields; second it suggests certain topics where social science research will be beneficial for e-Infrastructure development in general; third it stresses the needs for sustainable funding schemes; last but not least the document highlights the necessity to develop the e-Social Science community.

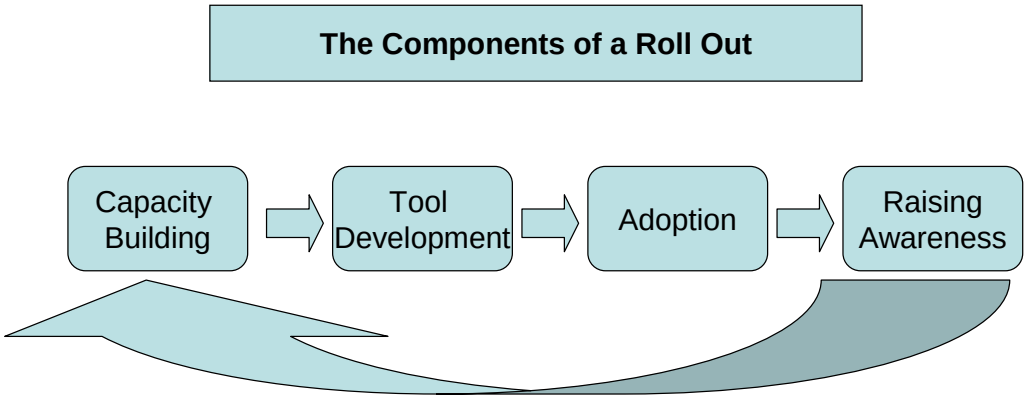
The recommendations set out in this report should be viewed as complementary and summarising lessons learnt in e-Infrastructure projects to-date which should be absorbed and acted on as new projects, funded by ESFRI, EC, NSF and others, get under way. In our empirical work we identified numerous issues that will be critical to developing and disseminating e-Infrastructures for social scientists and humanists. Any roll out that requires domain scientists to take up a new approach has several separate components that each independently need to be successful. These include:

1. Capacity building for e-Infrastructures in the social sciences and humanities: the base of motivated scientists and skilled technicians trained on e-Infrastructures needs to be broadened through education and training – with an important role for CSCL – and funding needs both, to take the specific demands of SSH into account and to move on to sustainable funding schemes.

2. Developing appropriate tools: Tool development must be done in close, permanent and effective interaction with the users. Use barriers are lower if the users are familiar with tools which "only" have been ported on the grid environment; standardisation raises the confidence in sustainability.
3. Fostering the adoption of the approach by domain scientists: Incentives need to be given and barriers that hinder adoption need to be reduced. Such incentives should be instituted in funding schemes – e.g. to reuse existing data and make new data available through repositories – and become part of SSH research and academic practice, for instance in publishing, evaluation, and promotion. Barriers require at least as often organizational solutions as they require technical solutions, for instance when it comes to reducing the language barriers between technical developers and domain scientists.
4. Making domain scientists aware of e-Infrastructures: Awareness needs to be raised above all through demonstrating the benefits of e-Infrastructures. This is most effectively done through field-specific information channels and between peers. Institutional environments, of course, need also be responsive to the pay-offs of e-Infrastructure investments. Last but not least, the knowledge on what type of infrastructure and support SSH researchers actually need and where they stand in the adoption process needs to be broadened (also raising awareness in the process of doing so).

Figure 5.1 provides a visualisation of this sequence.

Figure 5.1: The components of a roll out of e-Infrastructures in social sciences and humanities



Source: AVROSS

Previous research has also made it clear that successful infrastructures are a combination of 'top down' and 'bottom up' processes, implying they cannot be planned in any complete sense (e.g., Edwards et al., 2007). They succeed because a stable socio-technical constituency – an ensemble of technical components (hardware, software, etc.) and stakeholders (people, interest groups, visions, values, etc.) – emerges. Socio-technical constituencies stabilise when stakeholders are able to strike a balance between their interests and those of the wider community. We also note that each cycle of innovation is disruptive, there are winners and losers as previously stable and successful socio-technical constituencies unravel (Procter, 2007). We believe that the following recommendations will improve the chances for success at each step of the process described in Figure 5.1.

Table 5.1: Overview of policy recommendations

Capacity Building	Tool development	Adoption	Raising awareness
1. Develop dedicated training events for SSH 2. Step up the role of e-Infrastructure in graduate education 3. Increase the use of CSCL environments 4. Support small-scale initiatives 5. Design effective funding and programme coordination structures 6. Fund field-specific flanking measures in general, multi-disciplinary e-Infrastructure programmes 7. Support the development of service-oriented business models	8. Involve users at all stages 9. Mandate user-centred design 10. Port existing SSH tools to e-Infrastructures 11. Target vertical areas to ensure tool adoption across sub-fields 12. Support standardisation	13. Institute activities to promote the reuse of SSH data 14. Assign scientific credit and ownership rights 15. Reduce technical barriers through providing organizational solutions 16. Promote understanding of SSH among IT specialists 17. Improve cross-disciplinary communication and collaboration	18. Create supportive institutional environments 19. Increase user-user interaction 20. Increase the information exchange across projects 21. Involve lead users in community-building 22. Institute an ongoing analysis of computational needs and resources in European SSH 23. Institute an ongoing evaluation program with scientific analysis of adopters and non adopters

Source: AVROSS.

5.2 Capacity building

5.2.1 Broaden the base of scientists and technicians trained on e-Infrastructures

The typical e-Social Science project has a staff of about 14 individuals, of whom 5 are scientists, 3 are graduate students and 6 are other, technical, administrative and supporting staff (see section 3.3.2). Projects need not be large, but they need a dedicated and motivated staff with a range of competencies. The importance of leadership, of being able to bridge the differences between computer science and domain sciences through multidisciplinary individuals or teams, and the necessity of being patient to allow for training and capacity-building of scientists were stressed by the researched projects. It is also shown in our survey and case studies that individual scientists or teams carrying out such projects must have deep understanding of SSH research issues and methods, i.e. teams must involve qualified scientists from these disciplines (see p. 41). All in all, these results point to the key role of capacity-building for working successfully with e-Infrastructures.

This is not an entirely new issue and it reaches beyond SSH. Two years ago the e-IRG proposed to increase efforts in the training of scientists and computer support personnel on working with grid environments (Leenaars, et al., 2005) and set up an Education and Training Task Force (http://www.e-irg.org/about/ETTF/). The Open Grid Forum also instituted an Education and Training working group (ET-WG) which postulates:

> *"Education must change, so that graduates of our educational systems are well equipped with fundamentals to understand how and when to take advantage of the new methods enabled by grid computing whatever their*

own academic discipline." (http://www.ogf.org/gf/group_info/view.php?group=et-cg)

This is in line with US and UK scientists' substantial concern about sufficient numbers of trained individuals for the full exploitation and maintenance of e-Social Science investments.[29] However, these initiatives still have to produce results and obviously more needs to be done.

Recommendation 1: Develop dedicated training events for SSH.

Dedicated training events like seminars, courses, summer schools and others certainly should be supported. The wide variations in awareness, experience, and comfort with advanced technologies in the humanities and social sciences make it difficult to establish generalized education, outreach and training programs, or adapt the programs used in other, more technical fields. Languages, contents and style need to be targeted to the SSH communities. This means that in addition to computer scientists and infrastructure developers, innovative domain scientists and users need to be involved in the training.

Recommendation 2: Step up the role of e-Infrastructure in graduate education.

The role and contribution of graduate students and young researchers need to be strengthened in SSH e-Infrastructure projects. Training on the use of e-Infrastructure needs to be provided during graduate education and on the job/during post-doc periods, to show how the infrastructure can be used in producing interesting research and integrate the formation of computing/e-Infrastructure skills with the formation of research skills. Developers and PIs in new projects might be committed to include such training measures, e.g. in the form of summer schools or as parts of regular graduate programmes in their fields. For example, the recent e-Social Science conference in Michigan featured a very successful doctoral colloquium. Proposals for such training events might be summoned through new calls within FP7.

The need to link back grid and e-Infrastructures to education has been stressed in the US, too. The Computing Research Association, for instance, proposed in 2005 an initiative to develop the Cyberinfrastructure for Education and Learning for the Future, or CELF (see Computing Research Association [CRA], 2005). We would like to point to the recommendations made in this initiative.

Recommendation 3: Increase the use of CSCL environments.

As the community is still small and widely diffused it seems necessary to increase training measures which make use of CSCL and learning environments themselves. A first goal would be to make sure that scientists and students have access as environments are available at each university location. We have seen that such environments are somewhat more common in US American than in European e-Infrastructure projects (see p. 35). The reasons for this are unclear. More efforts are necessary to make SSH scholars aware of their potentials. For instance an annual price for innovative CSCL and learning environment projects might be issued that includes a wide dissemination of the price winners' and runners'-up approaches.

5.2.2 Provide resources for e-Infrastructure development

There appears to be wide consensus about the key catalysts and key barriers to e-Infrastructure adoption: adequate seed funding, development of costs, and qualified staff are high up on the priority scale (see sections 3.4.2 and 3.4.3).

[29] Unpublished summary reports NSF/SBE cyberinfrastructure workshops Sept 18, 2004 and Oct 22, 2004; survey results from ESRC review of NCeSS hub, 2005.

Recommendation 4: Support small-scale initiatives.

The current structure of e-Infrastructure involvement in the social sciences and humanities differs between continental Europe, the UK and the US. US scientists have the longest experience with e-Infrastructure and have some of the largest projects in terms of funding volume and team size (see p. 24). Continental Europe appears to be catching up with the scale of US projects and the UK e-Social Science program currently encompasses relatively small projects. The UK policy seems to be more in line with the finding that social scientists and humanities researchers may be more likely to seek involvement in small projects deploying practical tools which are easy to master, along with arrangements to support established work routines, than in large-scale projects demanding entirely new ways of doing research. e-Infrastructure projects are often not large in scale: the median project in the AVROSS survey was initially funded at just over 335,000 Euros; the median annual budget was just over 122,000 Euros (see p. 27). The implication for funding schemes would be to enable a wide range of new ideas to be tested in project work. This grass-roots innovation would then provide cases of success to carry forward into development and diffusion. However, we do not want to conceal that it is difficult to be sure at this stage whether small-scale or large-scale strategies for promoting e-Infrastructure uptake in the social sciences and humanities will prove the more successful.

Recommendation 5: Design effective funding and programme coordination structures.

In terms of funding strategies, whether the UK model (fund hub and work downwards) or the US model (sow seed from the top straight to projects) are more appropriate depends on the thrust of the overall programme. It seems likely that the US model will be more appropriate for a strategy of new methods discovery, whereas the UK model would be more effective in facilitating the maturing, selection and uptake of methods and tools already under development.

The funding of research infrastructures and their development is mainly provided within national or institutional boundaries in Europe. Few cross-national and inter-institutional sources exist which are compatible with the demands of distributed virtual organizations (Procter, 2007). The situation is even more difficult in the social sciences and humanities where no such organizations as ESO, EMBL, or CERN exist and when we leave Europe and take a global perspective. Clearly, it is not an easy undertaking to change established funding structures, but in particular when benefits from network effects and large user communities are possible funding organizations should be open to pilot projects that transcend the usual geographical limitations.

Recommendation 6: Fund field-specific flanking measures in general, multi-disciplinary e-Infrastructure programmes.

Given the greater distance of SSH researchers from e-Infrastructure use, where e-Infrastructure programmes are directed in principle at all disciplines, additional incentives compared to other disciplines are needed to ensure SSH research profits proportionately. Moreover, funding regulations need to be sufficiently flexible to take the specific and differing needs of individual fields into account. Our research has shown, for instance, that archaeologists realise different projects than economists or computer linguists (see pp. 29f.): the projects differ in regard to size, technologies, or outcomes. This needs to be accounted for as – as previous research in the field has also convincingly shown (Fry, 2004; Kling & McKim, 2000; Walsh & Bayma, 1996; Wouters & Beaulieu, 2006) – a “one size fits all” approach is doomed to failure. Part of the funds in multi-disciplinary programmes might have to be earmarked for SSH projects and requirements in regard to project size and technological sophistication might have to be reduced to increase SSH participation in the programmes.

Recommendation 7: Support the development of service-oriented business models.

Social scientists and humanities researchers mainly demand support services in the areas of information and data, advanced computing and collaboration/communication, when they speak about e-Infrastructures. As the case studies have shown these services may be genuinely public infrastructure (without access and use restrictions) or extensions to proprietary technologies. They need not use open source software, though the transparency of the latter might create advantages in regard to reliability, security, interoperability, and modifications to software functionality and provide additional programmers who contribute to the improvement of the application. The core issue is that the integration of applications into the work routines of SSH researchers is accompanied by sufficient support measures. These are costly, and it would be a false conclusion to expect that e-Infrastructure resulting from public research can be provided without any costs when the development has been terminated.

An ingredient to success seems to be that the service is offered free or close to free of charge for the users. If the users themselves don't pay, alternative funding schemes need to be found – an issue on which the investigated cases don't provide any guidance as they are still mainly funded through public research (and development) grants. Historical studies of other infrastructures such as road, rail, water, energy and telecommunication networks have shown that it was often public investment or funding arrangements that coupled private investment with public regulation that led to the establishment of a network (Edwards, et al., 2007).

As the ongoing debate on the sustainability of e-Infrastructures shows this issue is of wider importance and not specific to SSH.[30] Studies are needed that identify best practice cases across different domains and types of e-Infrastructures and develop viable models for the requirements, offerings, customer/user groups, costs and revenues included in e-Infrastructures.

5.3 Tool development

A critical component to adoption is the development of tools that domain scientists will use. Other work has also stressed this crucial role; in particular, we would like to endorse the recommendation of a clearinghouse for informing, evaluating and possibly even educating scholars on new digital tools that was made by the Summit on Digital Tools for the Humanities (see Frischer, B., Unsworth, J., Dwyer, A., Jones, A., Lancaster, L., Rockwell, G., et al. 2006, p. 15).

Respondents to the AVROSS survey as well as case study informants unanimously stressed the importance of involving the users of e-Infrastructures as soon as possible and having the tools used in research practice (see sections 3.5.1 and 4.3.2). That leads to the following set of recommendations.

Recommendation 8: Involve users at all stages: conceptualization, design and development, diffusion.

One of the key lessons learned by the early adopters of e-Infrastructure in the social sciences and humanities is the substantial benefit of involving a broad base of users and other stakeholders in the development of e-Infrastructure. Though many of the prototype tools and services generated within e-Infrastructure programmes have benefited from the involvement of committed groups of users this is, in itself, not sufficient to ensure broad-based deployment. This is true for several reasons: first, requirements identified by these users may not be representative of the requirements of the wider user community; second, early adopters may be more tolerant of limitations in new tools and services,

[30] See for instance the Report of the e-IRG Task Force on Sustainable e-Infrastructures (SeI) (2006) and the April 2007 e-IRG workshop in Heidelberg (http://www.e-irg.org/meetings/2007-DE/workshop.html).

being prepared, for example, to work around 'bugs' or to cope with poor usability; third, new users of e-Infrastructures are often confronted with high learning and installation costs and unclear returns on these investments.

Our research provides some pointers on what could be done to ensure that technology development with a "throw it over the wall" approach is avoided.

Recommendation 9: Mandate user-centred design.

Project sponsors should require that the principles of user-centred design be applied. This could be done in two ways: either through the direct involvement of domain scientists in the project, or through a requirement that the design method includes extensive periods of use in SSH teams with appropriate feedback into the development process. In software and technology development common methods of assessing user needs are workshops, focus groups or user-developer seminars (Harrison & Zappen, 2003; Miettinen & Hasu, 2002). In e-Infrastructure development these are costly and difficult to implement, as it is characterised by spatially distributed developers and users. For example, scenario methods for collaborative design have been proposed as an interactive way to enable the continuous, distributed development and evaluation of use scenarios throughout the development cycle (van den Anker, 2003; van den Anker & Schulze, 2006).

Project proposals submitted for public R&D funding should be required to include adequate measures and processes to obtain user feedback throughout all stages of a new project. Moreover, one of the metrics of the success of development projects should be the uptake by social science and humanities researchers.

Recommendation 10: Port existing SSH tools to e-Infrastructures

Enable scientists to gain benefit without requiring change. In order to do so, port existing analytical tools such as SPSS, STATA, Matlab to the e-Infrastructure, and provide them ideally free of charge for a limited period. This would have the benefit of increasing awareness of e-Infrastructure, and ensure a wide, relatively fast adoption – albeit with a limited utilization of e-Infrastructure capacity. The associated challenge is the need to work out licensing schemes with vendors possibly based on a per-usage model.

In the case of software that is in the scientific domain and created through publicly funded research the challenge is of a different type: namely providing sufficient funds for the building, maintaining and consolidating of this work (Leenaars et al., 2005).

Recommendation 11: Target vertical areas – by method, not by problem area – to ensure tool adoption across sub-fields.

The suggestion proposes to support what others have called "application-neutral" and "multi-disciplinary" tools (e-IRG SeI, 2006) which can be used by more than one field and are superior to field-specific tools. Methodical domains for such tools need to be identified. Possible domains in SSH include: text analysis/mining tools, data mining and natural language processing of textual data, algorithms for automatic audio transcription, optical character recognition engines, large scale simulation/network tools, detection equipment for recording neurobehavioral events separately from "noise." Brokers that have knowledge and experience in both domain sciences and in e-Infrastructure should be used in this process to forward and implement specific requirements. Resultant products should be linked to open source solutions that may eventually replace comparable commercial tools.

Benefit: New tools directly aid scientists in their supporting current research models. Utilizing these technologies on e-Infrastructure will also lead to facilitation of higher performance capacity currently not required by most social scientists. Additionally, as researchers will have a strong incentive to adopt new tools designed for their research

would learn the new, open source environments, shifting from the desktop commercial approach currently more prevalent in the social sciences.

Challenge: need to selectively choose areas for development based on cost, development time, and vertical reach dimensions.

Recommendation 12: Support standardisation.

The benefits of standardisation have not received particular attention among our survey respondents in the e-Social Science and e-Humanities communities. However, as others before us and in e-Science more broadly we are convinced that standardisation is a key issue in the long term (e-Infrastructure Reflection Group [e-IRG] Task Force on Sustainable e-Infrastructures [SeI], 2006). Standardisation could solve a major concern which hampers adoption of new technologies, namely the concern by (potential) users about the sustainability of new tools and the resulting interoperability. In order for social scientists to invest time and energy in e-Social Science, they need to be convinced that the tools that they are using will not become rapidly obsolete. There are several examples in the history of computing in which the development of an industry standard provided a decisive push in the diffusion (Williams, 1997).

Standardisation can be supported through requesting that new projects and tools link up to existing infrastructures instead of producing new solutions. This might cause some additional efforts and frictions, as our research has shown (see e.g. p. 118), but resulting adjustments and improvements of the existing infrastructure are beneficial and supporting wider use. Multi-disciplinary use as suggested above also works towards standardisation.

5.4 Facilitating adoption

The adoption of e-Infrastructures are often limited by the complexity, reliability and user-friendliness of the technology; further problems lie in the integration of older code and the handling of complex problems, such as granting access to personal data without infringing regulations on privacy and data protection (see section 4.3.1). Though some of these issues without doubt need technological solutions and advances, which then should be tailored to users' needs as much as possible (see above), we are convinced that in several instances organizational measures might also reduce technological problems.

Recommendation 13: Institute activities to promote the reuse of SSH data.

The large bodies of data which have been used to date in SSH, e.g. data from questionnaires put to large populations of individuals, are much more complex to describe and difficult to share or reuse than data in the physical sciences and engineering, much of which consists of machine readings and images from standardised laboratory-based experiments. According to our case studies, data sharing seems to be rather unproblematic in humanities fields, but more problematic in the social sciences (see section 4.3.4). The large importance of databases in the humanities also points in this direction (see Kaur-Pedersen & Kladakis, 2006). However, the storage and controlled reuse of data could produce different types of benefits: New data is often expensively captured where existing data that could not be accessed would have sufficed. The possibility of replicating analyses reduces the risk of fraud and increases the robustness of previous findings if they can be confirmed after methodological advances have become available.

In improving opportunities for replication, storage and re-use of data must be widened. More needs to be done to make data sharing and reuse part of the daily research practice in SSH and to make repositories and archives of SSH data more usable by multiple researchers. The eSciDR study (http://www.e-scidr.eu/) has investigated the situation of data repositories in detail (see Lord, 2007) and we can support some of their conclusions: Public research funding has to play first violin in this concert and increase

the requirements of tagging and sharing data generated with public funds. Of course, if data must be made available the technological and organizational preconditions have to be provided, for instance meta-data standards and regulations for anonymisation and data protection need to be defined and communicated to the researcher community. As previous research has shown (Wouters, 2002), national regulations and policies influence the behaviour of institutions and contribute to more data sharing activities at organisational level.

International collaboration should lower the barriers to accessing data from other countries which are an essential asset for international comparison and scientific research of global relevance. Countries should proceed in a coordinated way to make research data accessible to researchers – the recent OECD Guidelines provide a framework for this (OECD, 2007). In addition, national data archives and international initiatives such as DRIVER (http://www.driver-repository.eu) and CESSDA (http://extweb3.nsd.uib.no/opencms7final/ opencms/cessda/home.html) play very important roles in this regard and should be supported in their work. The vision should be to ensure that every social scientist and humanities scholar who works with data consults one multilingual and international source where she gets a quick, correct, concise, and intelligible response on whether data she needs for her work is available. If the data is available, ideally for a substantial percentage of the requests, she should have immediate access to the data itself as well as a fully-fledged documentation on how it was generated. If the data is not available and she needs to collect new data herself, there should be strong incentives for her to process and submit it after the completion of the project.

Recommendation 14: Assign scientific credit and ownership rights.

The incentives to sharing knowledge are missing in the SSH community. There is no adequate scientific credit given for dissemination of existing research datasets (or tools, software code and other methods), and this results in disincentives to sharing. Further barriers to wide data sharing result from their character as research resource (see e.g. Arzberger et al., 2004 and the articles in Wouters & Schröder, 2003): the production of empirical databases is costly; ownership and access to databases constitutes an important resource and input to empirical research. Hence, scientists might be unwilling to share these resources as long as they haven't drawn all the benefits from them. Or they might not want or be able to provide sufficient information for other scientists to use the available data with confidence. As Woolgar and Coopmans (2006) argue, the sharing of raw data might not be fully realised and hindered by practices that are not in line with the idealistic and mostly discarded Mertonian norm of communalism. In other words, there is substantial misalignment both in assignment of ownership rights and in how academic credit is granted. Ownership rights in data generated in a collaborative project are difficult to assign, yet the data themselves may have substantial financial value. Likewise, most social science communities and departments do not have a tradition of granting academic credit to tool builders or researchers who share their data widely.

The EC and member states research policy should consider promoting the few available publication paths for e-Social Science. Authors of papers on empirical research in these disciplines might be encouraged to cite their sources of methods, tools and data in a similar way to the publications whose content they may have used, enabling traditional, citation-based assessment of the success of methods innovation. Encouragement of this citation practice will require scientists on journal scientific committees to take these principles into account and journals to include this in their review and author guidelines. University boards and tenure committees should be encouraged to revise their promotion guidelines to better take the creation of digital data and other results of "technical" work into account (see also Frischer et al., 2006, p. 18).

Recommendation 15: Reduce technical barriers through providing organizational solutions.

The Access Grid Support Centre (see section 4.2.1) is one example of how the usability of a technology can be enhanced considerably and adoption can be supported through providing dedicated user support and assistance. This element can easily be stressed in new projects by adding a requirement in the call texts; service modules would need to be added to ongoing projects in case they haven't been foreseen in the beginning.

A related issue, which has also been raised in the United States, is that the successful development of middleware requires a support infrastructure that is beyond that envisaged by initial grants. Of course, hardening and sustaining research products is difficult because products are heterogeneous, the process is costly, and researchers are trained to break new ground, rather than sustain existing projects.

Recommendation 16: Promote understanding of SSH among IT specialists.

Understanding of SSH research methods is as yet very thinly spread among computer scientists and engineers, leaving a communication gap in mixed-disciplinary teams attempting innovation in SSH methods. As a result, SSH researchers have often felt it necessary to develop their methods and tools themselves. Given their lack of specialised IT knowledge, this has not always been as productive as it might have been. A policy direction might be to promote specifically understanding of SSH research needs, approaches, practices and conventions among computer scientists working in or being educated for e-Infrastructure development for instance through summer schools, workshops or other opportunities for meeting and information exchange reaching beyond disciplinary communities.

Examples for initiatives which successfully promote interdisciplinary understanding and support interaction between computer scientists and social scientists or humanities researchers exist:[31]

- The Dutch Continuous Access To Cultural Heritage CATCH program (Netherlands Organisation for Scientific Research, 2005) funds the development of tools, new methods and techniques for research on Dutch cultural heritage. It employs a particular setting for its research projects: computer scientists are located physically in cultural heritage institutions and work jointly with domain scientists on the project.
- Another example is the Telota initiative of the German Berlin-Brandenburg Academy (see http://www.bbaw.de/initiativen/telota/index.html) that includes a "task force" travelling around between different projects and developing project-specific tools.

Recommendation 17: Improve cross-disciplinary communication and collaboration.

Communication barriers between social scientists or humanities researchers and computer scientists are a general feature of e-Infrastructure development in the social sciences and humanities. These place a burden on project development: specialized languages, "ping-pong" communication and differing work styles translate into differing expectations on what a project can and should achieve (see section 4.3.4; Ribes and Finholt, 2007). The lack of interaction and mutual understanding between domain and computer scientists also burdens deployment. Some proposals and examples on how to deal with these communication barriers appeared in the AVROSS case studies: for instance establishing micro-teams of domain and computer scientists, institutionalising user-developer collaboration through the project set-up, engaging "translators" which are educated in both fields.

[31] We owe these examples to Andrea Scharnhorst, Virtual Knowledge Studio for the Humanities and Social Sciences of the Royal Netherlands Academy of Arts and Sciences.

5.5 Raising awareness

Recommendation 18: Create supportive institutional environments.

Local IT staff and university administrations, deans and senior leaders in the home organization need to be more responsive to the challenges and possibilities of e-Infrastructure development. The responses to the AVROSS early adopters' survey point to barriers to a more widespread use of e-Infrastructures which originate within scientific organizations: IT staff with other priorities and agendas, decision-makers which are unaware or overtly sceptical to the possible gains of investing in e-Infrastructure, or lacking support personnel which might assist with the installation and maintenance of the technology (see sections 3.4.3 and 3.5.1).

We have seen examples where this scepticism or lack of resources has been circumvented through providing external support to scientists willing to invest time and effort into e-Infrastructures, such as the AGSC or the Dutch CATCH programme. Such positive examples should be promoted and communicated to the wider social science and humanities communities. An additional measure could be a general awareness-raising campaign for the latter disciplines, for instance through issuing a prize or medal for particularly innovative institutions. Flagship projects could be another measure of raising awareness by promoting the expansion and medium to large scale piloting of successful e-Infrastructure applications in SSH. Large scale is seen as a useful attribute to help improve outreach and impact.

Recommendation 19: Increase user-user interaction.

Interaction in e-Infrastructure projects is mainly thought of in the lines of user-developer interaction (see section 4.3.2). Our findings suggest that in addition to user-developer interaction, more user-user interaction would be beneficial, for example, as a mechanism for awareness raising and for disseminating lessons learnt. Possible avenues for this would include pilot users presenting showcases to potential users or PIs disseminating their results in the user domains. Although some interaction already takes place at the methodological sessions of conferences and workshops, more formal opportunities should be established in order that key SSH domain scientists become aware of e-Social Science. For instance, dedicated funding could be provided for organising conference panels on e-Infrastructures in key conferences across SSH.

Recommendation 20: Increase the information exchange across projects.

Several of the early adopters commented that the exchange of information across different e-Infrastructure projects and domains opened up new avenues and produced interesting solutions to existing problems (see section 3.5.1). Since the development of e-Infrastructures has been going on for some years, there is a risk that if information is not exchanged, new comers to the field will reinvent the wheel without adequate knowledge management.

It should be one of the objectives of the European Commission to ensure that information is not only exchanged across ongoing projects but also between completed and new projects. Moreover, projects at national level in the EU Member States should be included and links to the United States and other countries should be established and cultivated.[32] Clearly, the information exchange should not be restricted to technological issues and address computer scientists only, but it should cover the domain sciences as well. Measures that facilitate networking such as conferences and seminars but also project repositories are important elements that lead to more information exchange. Others such as the organisation of interaction between projects and knowledge transfer

[32] Indeed, a recent NSF workshop on e-Infrastructure itself stressed the necessity of such an undertaking (Edwards et al, 2007).

between these through dedicated organisations such as the National Centre for e-Social Science (NCeSS) in the UK have also proven their value.

Recommendation 21: Involve lead users in community-building.

Involving leading domain scientists in the diffusion of an e-Infrastructure and building of a user community might be a good strategy, as peers and scientists in the field are the main information source on e-Infrastructure and can publicize advances in their domain (see p. 44). There are some caveats associated with this approach, however. In particular, mastering a new tool takes considerable time and the effort is the higher the lower the technological level of the learner. In addition, established scientists may owe their position in part to the current infrastructural arrangements, e.g. their access to particular resources or technology (Edwards et al., 2007), which they might not be willing to put at risk.

Recommendation 22: Institute an ongoing analysis of computational needs and resources in European SSH.

Computational requirements of the research were more often a driver to use e-Infrastructures among European researchers than among non-European researchers, as our early adopter survey has shown (see p. 50). This might be explained in two different ways: either computing requirements are larger in European research, or the locally available computing power in SSH departments does not meet the needs of European researchers. Either interpretation suggests, that something should be done to better satisfy the computing needs of SSH in European universities and non-university research organizations.

The European grid environment EGEE offers computational resources with an approach that is rather unusual for SSH in regard to its scale and interaction mode as we have learned in one of the investigated cases (see section 4.2.8). Hence, SSH researchers tend to rely on other solutions, like small-scale clusters, to get their jobs done instead of using the grid.

Our findings on this are rather anecdotal, as it was outside of the core objectives of the AVROSS study, and we suggest that a broad and representative assessment of the computing needs and resources of European SSH is undertaken, before any policy strategies are developed. Such a study should also investigate and ideally identify best practice on how the computational needs in SSH are served most efficiently, i.e. through decentralised resources, (sub-)national and domain-wide centres, field-specific (inter)national centres or others. In addition, it should go beyond a mere technology reporting and include organizational and other aspects like support and assistance, skills, training etc. to identify supporting measures that need to be included in a strategy for improving the computational environment of European SSH.

Recommendation 23: Institute an ongoing evaluation program with scientific analysis of adopters and non adopters

This study has provided much valuable data on adoption patterns of e-Infrastructure within SSH. However, our findings must be understood as being provisional and bounded. This is for two main reasons: 1) the limited time and resources available have constrained the scope and depth of the data collection and our analysis; 2) the adoption of e-Infrastructure within SSH is a fast changing and dynamic picture as new user communities engage and new technological solutions come into play. The character and impact of barriers to adoption are highly likely to change as this process continues and a one-off evaluation activity cannot capture this.

A capacity for continued monitoring of adoption patterns, processes and challenges faced as e-Infrastructure diffuses into new SSH user communities is essential if the value of the investment is to be maximised and the mistakes of earlier programmes are not to be

repeated. This is especially important as new projects are launched in response to strategic programme roadmaps such as ESFRI. We therefore recommend that an ongoing evaluation programme be put in place that is able to feedback into the strategic planning and execution of e-Infrastructure programmes.

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Appendix I: Early adopters survey

Appendix I.1: The questionnaire

A1 Country
The first section of this questionnaire will gather some background information on yourself, your organization, and your experience with eInfrastructures.
In what country is your organization located? **A_1** **(see separate document)**

A2 Organisation Type	
Is your main organization a…	**A_2**
University or technical university	
Polytechnic/university of applied sciences	
Non-university research institute	
Science foundation or research council	
Other	**A_3**

A3a Time	
What percentage of your annual working time do you spend on:	
	Percentage
Teaching (courses, grading and preparing)	**A_4**
Research	**A_5**
Other professional work (e.g. professional practice, third mission, patent and license work)	**A_6**
Administration and unallocable internal time	**A_7**

A3b No Collaborators

How many of your collaborators are located at the following organizations?

	None	Very few	Less than a third	Between a third and two thirds	More than two thirds
Your own organization (university, research institute)	**A_8**				
Other organizations close by (your city or area)	**A_9**				
Organizations elsewhere in your country	**A_10**				
Organizations in other countries	**A_11**				

A4 eInfrastructure

For the purposes of this study, eInfrastructures are defined as integrated ICT-based research infrastructures. Key elements include networking infrastructures, middleware and organisation and various types of resources (such as supercomputers, sensors, data and storage facilities). The definition includes “old” components like supercomputers, the World Wide Web, or e-mail, but requires them to be part of an integrated system. The only requirement for any component is that it should be able to exchange information at some point through a standardized interface like a grid protocol.

Have you ever been involved with social science or humanities projects using eInfrastructures?

Yes

No **A_12**

A5 Currently eI

Are you currently involved with social science or humanities projects using eInfrastructures?

Yes

No **A_13**

A6 Intend eI
Do you intend to work with social science or humanities projects using eInfrastructures in 2007?
Yes
No **A_14**

A7 Why Stopped					
Why has your participation in social science or humanities projects using eInfrastructures stopped?					
	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Lack of sustainability of funding	**A_15**				
Lack of staff available to help with development and deployment	**A_16**				
Not enough scientific pay-off	**A_17**				
Technology was not mature enough	**A_18**				
Other **A_20**	**A_19**				

A8 Cause Interruption					
What caused the interruption in your participation in social science or humanities projects using eInfrastructures?					
	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Lack of sustainability of funding	**A_21**				
Lack of staff available to help with development and deployment	**A_22**				
Not enough scientific pay-off	**A_23**				
Technology was not mature enough	**A_24**				
Other **A_26**	**A_25**				

A9

In which year did you first work with eInfrastructure projects in any discipline?

A_27

A10 No. el projects

How many social science or humanities projects using eInfrastructure have you ever been involved in? .

A_28

None

One

Two

Three

Four

Five

B1 Intro 1

The next section of this questionnaire will gather some background information on your current or most recent eInfrastructure project.

What is the name of your current or most recent project that uses eInfrastructure?

If more than one, please name the project using the most advanced eInfrastructure technology.

B_1

If possible, please provide the URL of the project

B_2

Is/was the project your first eInfrastructure project?

Yes

No **B_3**

B1 Intro 2

The next section of this questionnaire will gather some background information on your future eInfrastructure project.

What is the name of your future project that uses eInfrastructure?

If more than one, please name the project using the most advanced eInfrastructure technology.

B_4

If possible, please provide the URL of the project

B_5

B2 Features

What are/were the particularly innovative or advanced features of information and communication technology used in your project?

Please describe.

B_6

B4 Items

Which of the following items do/did you use in the project?

	Use	Do not use
High performance computing	**B_7**	
High performance communication	**B_8**	
High band width	**B_9**	
Distributed data, data repository	**B_10**	
Collaboration tools/systems	**B_11**	
Learning environments	**B_12**	
Grid-enabled videoconferencing	**B_13**	
Virtual/3D environments	**B_14**	
Innovative data collection methods (please specify) **B_16**	**B_15**	
Other (please specify) **B_18**	**B_17**	

B5 Sources					
Which of the following sources of information and know-how were important in your decision to begin using eInfrastructure?					
	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Meetings or workshops which provided information on eInfrastructures	**B_19**				
Infrastructure or administration people at your own organization (university, department etc.)	**B_20**				
Infrastructure or administration people from other organizations (e.g. research networks, ministries, funding bodies etc.)	**B_21**				
Journal, magazine or other printed or electronic information source	**B_22**				
Other scientists, colleagues or collaborators	**B_23**				
Other (please specify) **B_25**	**B_24**				

B10 Institutions
Please list the main institutions that are currently/were involved.
B_26

B11 Discipline	
Select the main domain areas below which are currently/were represented in the project. Tick all that apply	
Agricultural Sciences	B_27
Archaeology	B_28
Art (arts, history of arts, performing arts, music)	B_29
Computer and information sciences (software)	B_30
Economics and Business	B_31
Educational Sciences	B_32
Electrical engineering, electronic engineering, information engineering (hardware)	B_33
Engineering and technology (civil, mechanical, chemical, materials, environmental or medical engineering, bio- or nanotechnology, others)	B_34
History	B_35
Languages and Literature (excluding linguistics)	B_36
Law	B_37
Linguistics (including computational linguistics)	B_38
Medical and Health Sciences	B_39
Natural sciences (mathematics, physical, chemical, biological sciences, earth and environmental sciences, other natural sciences)	B_40
Other Humanities	B_41
Philosophy, Ethics and Religion	B_42
Political Science	B_43
Psychology	B_44
Social and Economic Geography, Regional Science	B_45
Sociology	B_46
Others B_48	B_47

B12 No People
How many people have worked on the project?
Please count all professors, lecturers, post-docs, PhD students, computing or other technical staff.
B_49
How many of them are/were scientists (excluding graduate students)?
B_50
How many of them are/were graduate students?
B_51

C1 First?

For the next section of the questionnaire we are interested in the funding and results of your eInfrastructure project(s).

Who funds/funded this project?

Select all that apply

Your country's research council or national research foundation	**C_1**
European Union	**C_2**
National or state research and/or education ministries	**C_3**
Your institution	**C_4**
Private Foundation	**C_5**
Other **C_7**	**C_6**

C4 Funding

What was the initial funding period for this project?

years:

C_8

months:

C_9

C3 Amount

What was the initial budget (in local currency)?

Total:

C_10

Annual:

C_11

Indicate currency:

The currency names are sorted alphabetically. Currency names used in more than one country are listed in the form "country name + currency name" e.g. United States dollar and Colombian peso.

C_12 (see separate document)

C5 Outcomes		
What have been the main outcomes of the project so far?		
	Yes	No
Publications	**C_13**	
Patent Applications	**C_14**	
New methods	**C_15**	
New data	**C_16**	
New tools	**C_17**	
Follow on collaborations	**C_18**	
Others **C_20**	**C_19**	

C6a
Please describe the new methods in 2-3 sentences (quantitative-qualitative, data generation or data analysis, simulation etc.)
C_21

C6b	
What type of data has been produced?	
Numerical data	**C_22**
Verbal data (any type of text)	**C_23**
Visual data (e.g. pictures, charts, results of video takes)	**C_24**
Other (please specify) **C_26**	**C_25**

CGC
Please describe the main function(s) of the new tool(s) in 2-3 sentences.
C_27

C7n Constituency
Does the project already have a constituency of users?
Yes
No C_28

C8 Area of Constituency	
In what domain areas is or might be the constituency of users?	
Tick all that apply	
Agricultural Sciences	C_29
Archaeology	C_30
Art (arts, history of arts, performing arts, music)	C_31
Computer and information sciences (software)	C_32
Economics and business	C_33
Educational sciences	C_34
Electrical engineering, electronic engineering, information engineering (hardware)	C_35
Engineering and technology (civil, mechanical, chemical, materials, environmental or medical engineering, bio- or nanotechnology, others)	C_36
History	C_37
Languages and literature (excluding linguistics)	C_38
Law	C_39
Linguistics (including computational linguistics)	C_40
Medical and Health Sciences	C_41
Natural sciences (mathematics, physical, chemical, biological sciences, earth & environmental sciences, other natural sciences)	C_42
Other humanities	C_43
Philosophy, ethics and religion	C_44
Political Science	C_45
Psychology	C_46
Social and economic geography, regional science	C_47
Sociology	C_48
Others C_50	C_49

BB2 Other Projects

You stated that you have realized other einfrastructure projects in addition to the one just described. Please give us some very basic information on these other projects.

Of your other eInfrastructure projects, have they used equally advanced eInfrastructure?

By "equally advanced eInfrastructure" we mean: there is no order of magnitude (factor 10 or more) change in bandwidth, processing power or storage; there are no completely new applications; the applications used do not provide completely new features; nor does the operating system or network provide a completely new set of services.

Yes

No **BB_1**

BB3 First

Of the projects using equally advanced eInfrastructure, which project was the first deployed and when?

Short description of first eInfrastructure project:

BB_2

(Start) year of first eInfrastructure project:

BB_2

D1 Intro

For the questions in this section, we are interested in potential catalysts and barriers to the development and implementation of eInfrastructure projects.

We have identified a number of potential catalysts in the adoption of eInfrastructure technology.

Which of the following would you identify as having been particularly important in your development of or work with eInfrastructures?

		Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Seed funding from an outside agency	D_1					
Seed funding from home institutions	D_2					
Organizational incentives within your institution	D_3					
Collaboration	D_4					
Observation of successful projects in other areas	D_5					
The computational requirements of your research	D_6					
Contribution to interesting research expected	D_7					
Support for teaching activities	D_8					
Emerging standardization of available tools	D_9					
Other D_11	D_10					

D2 Barriers

We have identified a number of potential barriers to the adoption of eInfrastructure technology.

How important are / were the following in your project?

		Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Not at all Important
Lack of initial funding / difficulty in obtaining initial funding	D_12					
Costs associated with eInfrastructure development and deployment	D_13					
Lack of information about usefulness of eInfrastructure in social sciences	D_14					
Lack of staff available to help with development and deployment	D_15					
Insufficient applicability of existing technology to social science research problems	D_16					
Problems with intellectual property right intellectual property rights, ownership, publication conventions or attributing credits	D_17					
Lack of trust and confidence in the sustainability of the available technology and services	D_18					
Problems with protecting confidentiality of data on distributed networks	D_19					
Locked into other technologies	D_20					
Other D_22	D_21					

D3 Positive Lessons
Please identify three positive lessons you have learned during the project that could be shared with others. 1. **D_23** 2. **D_24** 3. **D_25**

D4 Negative Les
Please identify three negative lessons you have learned during the project that could be shared with others. 1. **D_26** 2. **D_27** 3. **D_28**

E1 Intro

For the questions in this section, we are interested in further eInfrastructure projects and people which could provide interesting information for this study.

Please list the three most promising and interesting eInfrastructure projects in other fields of which you are aware.

	Project Name	University/ Organization	Contact Name
1	**D_29**	**D_30**	**D_31**
2	**D_32**	**D_33**	**D_34**
3	**D_35**	**D_36**	**D_37**

E2 Others

The purpose of this survey is to provide a complete picture of the eInfrastructure activities and initiatives in the social sciences and humanities in 2007. To that end, we intend to involve as many scholars as possible who work in advancing eInfrastructures.

Please list other people who in your opinion could provide valuable information on eInfrastructures and that should be contacted with this questionnaire. Provide their names and email addresses, if you have them at hand, or their universities and departments so we can retrieve the contact information ourselves.

	Name	University/ Organization	E-Mail
1	**D_38**	**D_39**	**D_40**
2	**D_41**	**D_42**	**D_43**
3	**D_44**	**D_45**	**D_46**

Appendix I.2: The Email

Dear colleague,

We are conducting a survey for the the European Commission (Information Society and Media Directorate General) about the adoption and use of eInfrastructure (cyberinfrastructure) in the social sciences and humanities. A major concern is that eInfrastructure such as grid technologies and high-speed networks is not very widespread in these domains despite the fact that other sciences have made great strides as a result of the adoption of such technologies.

The purpose of this questionnaire is to provide the European Commission with a comprehensive overview of recent adoption of eInfrastructure in the social sciences and humanities. You have been identified as an early adopter of this kind of technology through your participation in US, UK, or European activities and your response will greatly help us to inform policy makers on the adoption of eInfrastructure.

Please fill in the questionnaire before March 9, 2007. It will take you approximately 10 - 15 min. You may interrupt without loss of data. Please follow this link: http://ww3.unipark.de/uc/avross/?code=4eAkPtvP

Thank you for your help!
The AVROSS team.

For further questions please visit our webpage at
http://international.fhnw.ch/avross/ or contact:

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Appendix I.3: Tables

Table A.1: Clusters of respondents according to time use pattern
(arithmetic mean and median values of working time in %)

	Teaching time		Research time		Professional work time		Administration time	
	Mean	Med.	Mean	Med.	Mean	Med.	Mean	Med.
Cluster 1 "Researchers" (n=141)	6	0	80	80	6	0	9	10
Cluster 2 "Professionals" (n=47)	6	2	15	10	61	60	17	15
Cluster 3 "Administrators" (n=65)	5	0	24	25	10	5	60	50
Cluster 4 "Scholars" (n=164)	37	35	38	40	9	8	16	15
All respondents for time use (n=417)	18	10	47	40	14	5	21	15

Source: AVROSS WP2 survey.

Table A.2: Current status of e-Infrastructure use grouped by countries

	UK		Continental Europe		USA		Other countries	
	N	%	N	%	N	%	N	%
Current user	67	51.10%	50	51.00%	68	52.70%	15	45.50%
Interrupter	8	6.10%	8	8.20%	9	7.00%	2	6.10%
Final dropout	6	4.60%	6	6.10%	7	5.40%	0	0%
Future User	10	7.60%	7	7.10%	3	2.30%	6	18.20%
Non-user	40	30.50%	27	27.60%	42	32.60%	10	30.30%
Total	131	100.00%	98	100.00%	129	100.00%	33	100.00%

Source: AVROSS WP2 survey.

Table A.3: Current involvement with e-Infrastructure by activity profiles
(in % of all projects entered by respondents with the respective activity profile)

	Current user	Interrupter	Final dropout	Future user	Non-user	All respondents
Researchers	51.6%	4.1%	4.1%	5.7%	34.4%	100.0%
Professionals	60.0%	6.7%	0.0%	8.9%	24.4%	100.0%
Administrators	51.6%	8.1%	8.1%	12.9%	19.4%	100.0%
Scholars	47.8%	8.9%	5.7%	4.5%	33.1%	100.0%
All respondents	51.0%	7.0%	4.9%	6.7%	30.3%	100.0%

Source: AVROSS WP2 survey.

Table A.4: Project size (personnel) by field
(median values and percent of total personnel)

	Total personnel		Scientists		Graduate students		Other staff	
	Med.	%	Med.	%	Med.	%	Med.	%
Archaeology	14	100%	5	35.7%	2	14.3%	7	50.0%
Economics and business	15	100%	8	53.3%	3	20.0%	4	26.7%
Sociology	12	100%	5	41.7%	2	16.7%	5	41.7%
Social geography, regional science	15	100%	5	34.5%	3	20.7%	7	44.8%
Linguistics	20	100%	7	35.0%	4	20.0%	9	45.0%
All cases	14	100%	5	35.7%	3	21.4%	6	42.9%

Source: AVROSS WP2 survey.

Table A.5: Project size (personnel) by activity profiles
(median values and percent of total personnel)

	Total personnel		Scientists		Graduate students		Other staff	
	Med.	%	Med.	%	Med.	%	Med.	%
Researchers (n=44)	14.5	100%	7.5	51.7%	2.0	13.8%	5.0	34.5%
Professionals (n=15)	15	100%	5.0	33.3%	2.0	13.3%	8.0	53.3%
Administrators (n=28)	30	100%	10	33.3%	5.0	16.7%	15.0	50.0%
Scholars (n=70)	10	100%	5.0	50.0%	3.0	30.0%	2.0	20.0%
All respondents (n=157)	14	100%	5.0	35.7%	3.0	21.4%	6.0	42.9%

Source: AVROSS WP2 survey.

Table A.6: Project results by activity profiles
(in % of all projects entered by respondents with the respective activity profile)

	Publi-cations	Patent applications	New Methods	New data	New tools	Follow-on collaborations	Others
Researchers	89.6%	3.0%	87.0%	84.8%	91.3%	81.8%	50.0%
Professionals	68.4%	0.0%	77.8%	52.9%	85.7%	81.0%	42.9%
Administrators	86.7%	0.0%	80.0%	82.6%	80.6%	96.7%	66.7%
Scholars	88.9%	2.9%	84.5%	82.1%	86.2%	89.4%	75.0%
All respondents	86.4%	2.2%	83.6%	79.6%	86.5%	87.6%	60.0%

Source: AVROSS WP2 survey.

Table A.7: Source of information by origin
(% of respondents who considered a source as very or somewhat important)

Source	UK	Continental Europe	USA	Other countries
Meetings or workshops which provided information on e-Infrastructure	66% (N=43)	56% (N=31)	58% (N=120)	69% (N=11)
Infrastructure or administration people at your own organization	65% (N=42)	50% (N=26)	60% (N=123)	75% (N=12)
Infrastructure or administration people from other organizations	67% (N=44)	67% (N=37)	70% (N=148)	81% (N=13)
Journal, magazine, or other printed or electronic information source	34% (N=22)	54% (N=28)	44% (N=89)	47% (N=8)
Other scientists, colleagues, or collaborators	82% (N=55)	91% (N=51)	87% (N=186)	76% (N=13)
Other	50% (N=3)	40% (N=4)	56% (N=20)	71% (N=5)

Source: AVROSS WP2 survey.

Table A.8: Source of information by discipline
(% of respondents who considered a source as very or somewhat important)

Source	Humanities	Natural sciences	Social sciences
Meetings or workshops which provided information on e-Infrastructure	60.4% (N=26)	50.0% (N=12)	56.9% (N=41)
Infrastructure or administration people at your own organization	54.5% (N=24)	65.4% (N=17)	60.6% (N=43)
Infrastructure or administration people from other organizations	75.0% (N=33)	69.2% (N=18)	68.9% (N=51)
Journal, magazine, or other printed or electronic information source	50.0% (N=22)	52.0% (N=13)	44.3% (N=31)
Other scientists, colleagues, or collaborators	84.1% (N=37)	92.6% (N=25)	89.2% (N=66)
Other	55.6% (N=5)	50.0% (N=2)	62.5% (N=10)

Source: AVROSS WP2 survey.

Table A.9: Source of information on e-Infrastructure by field of the project
(% of respondents who considered a source as very or somewhat important)

Information sources	A	EB	S	SG	L	All
Meetings or workshops which provided information on e-Infrastructure	50.0%	59.1%	60.0%	57.1%	47.6%	57.6%
Infrastructure or administration people at your own organization	58.3%	70.5%	57.6%	66.7%	57.5%	59.8%
Infrastructure or administration people from other organizations	66.7%	76.7%	69.1%	69.8%	68.3%	70.7%
Journal, magazine, or other printed or electronic information source	41.7%	54.5%	44.8%	44.3%	31.7%	44.1%
Other scientists, colleagues, or collaborators	83.3%	95.5%	86.8%	90.3%	86.0%	87.7%

A: Archaeology (N=24), EB: Economics and business (N=44), S: Sociology (N=70), SG: Social geography, regional science (N=63), L: Linguistics (N=42), All (N=205)
Source: AVROSS WP2 survey.

Table A.10: Source of information by discipline and location of collaborators
(% of respondents who considered a source as very or somewhat important)

Source	Humanities		Natural sciences		Social sciences	
	Local	Non local	Local	Non local	Local	Non local
Meetings or workshops which provided information on e-Infrastructure	20.8%	17.9%	21.1%	15.5%	20.7%	18.1%
Infrastructure or administration people at your own organization	21.4%	19.3%	19.3%	19.0%	23.5%	18.1%
Infrastructure or administration people from other organizations	21.4%	21.7%	19.3%	22.5%	19.4%	20.9%
Journal, magazine, or other printed or electronic information source	7.1%	15.5%	13.2%	15.5%	11.5%	14.5%
Other scientists, colleagues, or collaborators	29.2%	25.6%	27.2%	27.5%	24.9%	28.4%

Source: AVROSS WP2 survey.

Table A.11: Source of information by discipline and adoption date
(% of respondents who considered a source as very or somewhat important)

Source	Humanities		Natural sciences		Social sciences	
	Early	Late	Early	Late	Early	Late
Meetings or workshops which provided information on e-Infrastructure	16.8%	18.5%	16.7%	18.7%	14.9%	21.1%
Infrastructure or administration people at your own organization	20.4%	15.2%	20.2%	17.9%	20.4%	16.7%
Infrastructure or administration people from other organizations	22.6%	23.6%	20.2%	21.1%	20.7%	22.3%
Journal, magazine, or other printed or electronic information source	13.0%	14.5%	16.7%	13.1%	14.6%	12.7%
Other scientists, colleagues, or collaborators	27.2%	28.3%	26.1%	29.1%	29.5%	27.1%

Source: AVROSS WP2 survey.

Table A.12: Source of information by length of the project
(% of respondents who considered a source as very or somewhat important)

Source	Short-term projects	Medium-term projects	Long-term projects
Meetings or workshops which provided information on e-Infrastructure	59.0% (N=23)	52.8% (N=38)	57.1% (N=20)
Infrastructure or administration people at your own organization	60.0% (N=24)	63.5% (N=47)	52.9% (N=18)
Infrastructure or administration people from other organizations	64.1% (N=25)	67.1% (N=51)	77.1% (N=27)
Journal, magazine, or other printed or electronic information source	35.9% (N=14)	45.8% (N=33)	40.0% (N=14)
Other scientists, colleagues, or collaborators	77.5% (N=31)	91.1% (N=72)	91.4% (N=32)
Other	55.6% (N=5)	63.6% (N=7)	50.0% (N=4)

Source: AVROSS WP2 survey.

Table A.13: Catalysts for work with e-Infrastructure by location of the respondent (% of respondents who considered the catalyst as very or somewhat important)

Catalysts	UK	Continental Europe	USA	Other countries	All respondents
Seed funding from an outside agency	82.7%	75.0%	87.9%	75.0%	81.6%
Seed funding from home institutions	56.0%	65.2%	69.0%	76.5%	64.9%
Organizational incentives within your institution	57.1%	51.1%	60.3%	68.8%	57.7%
Collaboration	90.6%	88.0%	93.2%	88.2%	90.5%
Observation of successful projects in other areas	65.3%	69.6%	64.9%	73.3%	67.1%
The computational requirements of your research	69.8%	72.7%	53.4%	53.3%	63.5%
Contribution to interesting research expected	88.5%	87.0%	83.1%	81.3%	85.5%
Support for teaching activities	41.5%	48.9%	42.1%	43.8%	43.9%
Emerging standardization of available tools	65.3%	57.4%	53.6%	62.5%	58.9%

Source: AVROSS WP2 survey.

Table A.14: Catalysts for work with e-Infrastructure by field of the project (% of respondents who considered the catalyst as important of all respondents)

Catalysts	A	EB	S	SG	L	All
Seed funding from an outside agency	89.5%	80.6%	76.3%	79.2%	75.0%	81.6%
Seed funding from home institutions	73.7%	62.9%	63.9%	64.2%	68.6%	64.9%
Organizational incentives within your institution	63.2%	57.1%	51.7%	61.5%	60.6%	57.7%
Collaboration	100.0%	91.9%	88.7%	90.7%	92.1%	90.5%
Observation of successful projects in other areas	63.2%	68.6%	65.5%	70.6%	58.3%	67.1%
The computational requirements of your research	61.1%	63.9%	52.6%	64.7%	64.7%	63.5%
Contribution to interesting research expected	88.9%	91.7%	87.9%	86.5%	85.3%	85.5%
Support for teaching activities	47.4%	42.9%	44.8%	52.9%	48.5%	43.9%
Emerging standardization of available tools	10.5%	13.9%	24.6%	19.6%	14.7%	21.4%

A: Archaeology (N=19), EB: Economics and business (N=36), S: Sociology (N=59), SG: Social geography, regional science (N=53), L: Linguistics (N=36), All (N=167)

Source: AVROSS WP2 survey.

Table A.15: Catalysts for work with e-Infrastructure by activity profiles
(arithmetic mean of the responses from 1=very unimportant to 5=very important)

Catalysts	Researchers	Professionals	Adminis-trators	Scholars	All respondents
Seed funding from an outside agency	4.2	4.2	4.3	4.2	4.2
Seed funding from home inst.	3.8	3.8	3.7	3.6	3.7
Organizational incentives within your institution	3.6	3.8	3.8	3.3	3.5
Collaboration	4.6	4.6	4.5	4.5	4.5
Observation of successful projects in other areas	3.8	4.1	4.0	3.6	3.8
Computational requirements of your research	3.9	3.6	3.6	3.8	3.8
Contribution to interesting research expected	4.5	4.2	4.4	4.3	4.4
Support for teaching activities	3.0	3.1	3.2	3.2	3.1
Emerging standardization of available tools	3.7	4.2	3.4	3.3	3.5
Other	3.9	4.5	4.0	3.6	3.9

Source: AVROSS WP2 survey.

Table A.16: Barriers for work with e-Infrastructure by country of respondents
(% of respondents who considered the barrier as very or somewhat important)

	UK	Continental Europe	USA	Other countries
Lack of initial funding / difficulty in obtaining initial funding	70.0% (N=35)	78.7% (N=37)	77.6% (N=132)	87.5% (N=14)
Costs associated with e-Infrastructure development and deployment	73.1% (N=38)	76.6% (N=36)	79.1% (N=136)	93.8% (N=15)
Lack of information about usefulness of e-Infrastructure in social sciences	44.9% (N=22)	47.6% (N=20)	47.9% (N=78)	75.0% (N=12)
Lack of staff available to help with development and deployment	61.5% (N=32)	70.5% (N=31)	68.8% (N=117)	75.0% (N=12)
Insufficient applicability of existing technology to social science research problems	59.6% (N=31)	54.5% (N=24)	47.9% (N=80)	46.7% (N=7)
Problems with intellectual property rights, ownership, publication conventions or attributing credits	40.0% (N=20)	45.7% (N=21)	40.8% (N=69)	43.8% (N=7)
Lack of trust and confidence in the sustainability of the available technology and services	51.0% (N=26)	38.6% (N=17)	46.1% (N=77)	56.3% (N=9)
Problems with protecting confidentiality of data on distributed networks	53.8% (N=28)	28.9% (N=13)	40.8% (N=69)	43.8% (N=7)
Locked into other technologies	36.2% (N=17)	35.0% (N=14)	31.0% (N=49)	18.8% (N=3)
Other	85.7% (N=6)	33.3% (N=1)	66.7% (N=14)	100.0% (N=4)

Source: AVROSS WP2 survey.

Table A.17: Barriers for work with e-Infrastructure by discipline of the project
(% of respondents who considered the barrier as very or somewhat important)

Barriers	HUM	NAT	SS	OTH	All
Lack of initial funding / difficulty in obtaining initial funding	77.6%	76.9%	77.8%	84.1%	77.6%
Costs associated with e-Infrastructure development and deployment	78.8%	77.8%	78.3%	75.7%	79.1%
Lack of information about usefulness of e-Infrastructure in social sciences	51.2%	45.0%	47.8%	40.3%	47.9%
Lack of staff available to help with development and deployment	69.4%	70.9%	66.1%	72.1%	68.8%
Insufficient applicability of existing technology to social science research problems	50.0%	50.9%	50.4%	44.8%	47.9%
Problems with intellectual property rights, ownership, publication conventions or attributing credits	45.8%	42.7%	40.5%	39.1%	40.8%
Lack of trust and confidence in the sustainability of the available technology and services	50.0%	51.8%	49.1%	47.8%	46.1%
Problems with protecting confiden-tiality of data on distributed networks	33.3%	44.4%	42.7%	50.7%	40.8%
Locked into other technologies	33.3%	33.3%	35.5%	42.6%	36.7%

HUM: Humanities, NAT: Natural sciences, SS: Social sciences, OTH: other disciplines
Source: AVROSS WP2 survey.

Table A.18: Barriers for work with e-Infrastructure by field of the project
(% of respondents who considered the barrier as very or somewhat important)

Barriers	A	EB	S	SG	L	All
Lack of initial funding / difficulty in obtaining initial funding	77.8%	83.3%	74.1%	80.4%	68.6%	77.6%
Costs associated with e-Infrastructure development and deployment	83.3%	77.8%	74.6%	78.4%	71.4%	79.1%
Lack of information about usefulness of e-Infrastructure in social sciences	58.8%	51.4%	45.6%	49.0%	48.5%	47.9%
Lack of staff available to help with development and deployment	58.8%	68.6%	65.5%	71.2%	60.0%	68.8%
Insufficient applicability of existing technology to social science research problems	58.8%	44.1%	45.6%	58.0%	45.7%	47.9%
Problems with intellectual property rights, ownership, publication conventions or attributing credits	55.6%	44.4%	36.8%	39.2%	43.8%	40.8%
Lack of trust and confidence in the sustainability of the available technology and services	55.6%	51.4%	42.1%	43.1%	43.8%	46.1%
Problems with protecting confiden-tiality of data on distributed networks	44.4%	45.7%	34.5%	46.2%	38.2%	40.8%
Locked into other technologies	35.3%	29.4%	34.5%	31.3%	25.8%	36.7%

A: Archaeology (N=18), EB: Economics and business (N=36), S: Sociology (N=58), SG: Social geography, regional science (N=51), L: Linguistics (N=35), All (N=170)
Source: AVROSS WP2 survey.

Table A.19: Barriers for work with e-Infrastructure by activity profiles
(arithmetic mean of the responses from 1=very unimportant to 5=very important)

	Researchers	Professionals	Adminis-trators	Scholars	All respondents
Lack of initial funding / difficulty in obtaining initial funding	4.0	4.2	3.7	4.2	4.1
Costs associated with e-Infrastructure development and deployment	3.9	4.2	4.0	4.2	4.1
Lack of information about use-fulness of e-Infrastructure in social sciences	3.5	3.6	3.0	3.1	3.2
Lack of staff available to help with development and deployment	3.8	3.8	3.9	3.7	3.8
Insufficient applicability of existing technology to social science research problems	3.2	3.5	3.1	3.2	3.2
Problems with intellectual property rights, ownership, publication conventions or attributing credits	3.1	3.2	3.0	2.9	3.0
Lack of trust and confidence in the sustainability of the available technology and services	3.2	3.5	3.2	2.9	3.1
Problems with protecting confidentiality of data on distributed networks	3.2	3.3	3.4	2.7	3.0
Locked into other technologies	2.7	3.3	2.7	2.8	2.8
Other	4.0	4.0	1.0	3.8	3.8

Source: AVROSS WP2 survey.

Appendix I.4: Verbatims

Question A2: Other main organizations

Online bibliography produced by a university
Government
Publicly funded service institute
NGO for digital library research and development consortium of research universities
Consultancy firm
q364
Higher education not for profit organization
International development
Non profit consortium of 15 Universities doing earthquake research
Part independent research organization/part university
Data archive
Research center
Consortium hosted by a University
Used to be Polytechnic (early retired 1992)
Non-university publicly funded infrastructure institution for the social sciences
Royal Academy
NHS & Personal Initiative - Hodges model
Higher education funding agency
Data publisher
Government research and funding charity (it is based in a University, but mainly provides Research Council funded data services)
University-based national center
Community College (two year college)
Research data archive
University Library
Government
Non-profit organization
Library consortium research department in company cyberinfrastructure center
Not-for-profit intergovernmental/organizational organization.

Source: AVROSS WP2 survey.

Question B2: Description of innovative or advanced features of the project

wiki organizational and communications formats
Developing tools to support the distributed, collaborative and real-time analysis of video and associated data. Building interfaces and infrastructures for collaborative research, using physical interfaces and configurations to support digital annotation
The project has really just begun so it is difficult to answer this
Prototype an infrastructure based on grid technology that allows sharing of resources (computing, storage, but also services and multimedia content) between different administrative domains. A portal for humanity/cultural heritage studies based on this.
A truly pan-European initiative to provide language resources and language technology support for social sciences and humanities using Grid technology.
Shared virtual workspaces and video conferencing facilities.
E-mail, skype, VPN connections to remote servers.

Virtual reality.

Student interface WebCT course delivery.

Freely available data and software tools

The management and analysis of unstructured data for scholarly research in humanities

Access Grid as part of broadening participation of underrepresented groups in high performance computing

Developing shibboleth capability within uPortal and more recently Sakai (in connection with the Sakai VRE project).

Automatic digital library creation

Programme looked at a range of methods and tools including e-*

High performance computing, data management, data analytics, optimization, scaling

Initially, structured text encoding and enhanced searching afforded by encoding. Later, experimental text visualization algorithms and environments.

Bandwidth, databasing, searching

Grid technologies for data and job management

You do realize that this survey hasn't clearly laid out what eInfrastructures means. I'd like to relay a proposed project here - but it's not at all clear to me what you're referring to. It's a problem of jargon.

Both flashmeeting as well as Wikis (the main e-Infrastructure I am referring to) allow simple access from multiple sites through a web browser and do not require any additional software or hardware.

Notably, this project has less to do with technological advances but more to do with e-infrastrucutre resources and in silico research. The whole project is a JISC-funded scoping exercise for geospatial data repositories that could play a significant rol

The project integrates Digital Library and Grid technologies to deliver an infrastructure in which the building of digital library applications is an easy task. These 'Virtual Digital Libraries' are build by using and, if needed, dynamically deploying th

Open source software community, mailing list based

1990's--distributed records management with centralized metadata search and on-line retrieval

I wouldn't call the features particularly advanced. It was the collaborative nature of our work in the humanities, engineering, the arts, and sciences that is innovative.

Discussion threads. Email. Secure network storage for sharing files with collaborators.

Separating core features from locally modified and governed features allowing community based use and re-use of IP protected image data across multiple subject based institutions

2. Ease of sampling annotating sharing and integrating images

Meta data standards, virtualy distributed archive, multilingual access

Variety of features being investigated: Job submissions using different applications SRB, GridFTP, OGSA-DAI, GLobus commands Data integration and access Advanced videoconferencing Collaborative /VO tools Workflow Modelling Simulation

As a library service - primarily involved with supporting users in a networked environment with searching for, accessing, migrating, and analyzing data.

None. Just infrastructure. Very important though.

Standardized metadata format for publication (DDI-XML) Network of distributed servers Centralized search on distributed data

ICTs form the context for all work although not necessarily their primary focus. They are also inescapably involved in the functional aspects of research (such as submitting and refereeing articles).

GRID technology, common data elements, coordinated & distributed analysis

3d gis, webservice

Using OGSA-DAI on the NGS to grid enable an existing data service

Diary data collection through text-messaging; use of mobile phone, wifi system and computer network for data collection; online flash interface for both data coding and data visualization

Grid- and cluster-based computing. The university had a grid that it supported of 300+ computers. We used it to run thousands of simulations until recently when it was taken down. Now we're running the simulations on a cluster of computers; it isn't as

Archiving huge amounts of material (images, audio, texts) = storage

Analysing data = computing power

Videoconferencing

Replayer is being developed to support the understanding and development of mobile technology. It can be used by computer scientists, social scientists, or interdisciplinary groups engaged in studies into the use of mobile technology. Logged systemic data

Browser-based service access to data analysis tools. Integrating service remote procedure calls to services into desktop statistical packages.

We designed and developed an open source, free software library for building podcasting services. We used it to set up our own podcast for the students of the faculties of Humanities, Foreign languages and Educational sciences of our university.

Web Portal DataGRID

It is a citizen science project

This work, like most of my projects, makes use of behaviors of individuals and groups on the Internet. This project, in particular, makes use of a number of very large data sources that were provided from Internet services that were instrumented or craw

Grid technology etc. I cannot really describe it technically since I am not working with that aspect of the project. The goal is to set up a database about occupations that uses several other data resources on the internet.

Using off-the-shelf technology

ACESS GRID video conferencing and developing a national social science network

I can't comment - we didn't think it was particularly innovative but the humanities community apparently did. It brought together metadata from a range of sources for corss searching purposes as a pilot. Since we support a whole swathe of standards for

It is a R&D project to be realized in the future: Integrating often used instruments of work of social scientists (editor for shared work with texts, database, mail, bibliographic references and background database, web sources and services, statistical

Interoperability between aggregated online resources, using Grid technology.

The following is not about the project on the previous page but the main research project I've done in this field. My team used an Access Grid Node to conduct 'virtual fieldwork' - interviews and focus groups - with a student sample and then with UK and

On line distribution of data. Is it innovative?

Use of grid clusters to run massive simulation of an opinion dynamics model

Computer vision recognition systems for the analysis of the relationship between language and gesture with the analysis of language underpinned by corpus linguistic techniques

Use of the UK's National Grid Service

VOSON has features which are reasonably advanced or novel for social science-oriented research software. It isn't particularly advanced in the context of what is going on in the e-Science/grid portal development communities, but I'm not building it for

A logically-structured representation of conceptual metadata for social science data sources, built using ontology languages and tools.

MYSQL database, Flash animation, 3D rendering applications, and html-based website.

Efficient and scalable distributed computation

Shared dynamic data base for a scientific journal to be used by its editors (filemaker pro)

Advanced field based data gathering and offsite collation of data for a major archaeological excavation

The study of the social issues surrounding these advanced infrastructures

Generalogical approach coupled with text mining to represent relns between different texts

The innovation in this instance is less a technical one than a social one. It recognizes that senior decision-makers in government agencies and departments do not always learn about

emerging evidence by reading text. This project is testing learning ou

The Innovative Teacher project (I*Teach) develops such practical methodology, approaches and tools targeted at day-to-day utilization by the teacher trainers and teachers of these enhanced ICT skills in their work.

The deliverables comprise a suite of open source, open standards based, interoperable, RDF Web services with a graphical user interface including an embedded annotation tool that exploits fuzzy logic techniques to indicate associations between previously

User requirements gathering and piloting of demonstrators specifically for humanities (simply being an einfrastructure project in the humanities is innovative)

A method for automatic _conceptual_ analysis, retrieval, and browsing of natural language data.

GRID and interactive visualization.

The projects we are involved in use the grid for video seminars, meetings etc, enabling York to talk with Penn State University, Southampton, Manchester etc

We have a funded proposal that involves using the NZ GRID as a means of providing a data service for social scientists (exchanging and analysing information in particular)

Virtual reality on the web

Developing a professional reading interface for large databases of information required us to investigate web interface technologies, as well as techniques of professional reading. The test database was a PostGreSQL installation, with a wide variety of

Exchange of large data bases

JSR-168 compliant portlets Storage Resource Broker Apache Tomcat

Grid technologies for the qualitative analysis of digital video across the network for social science researchers

wikis videoconferencing Docushare (collaborative document editing) nVivo (qualitative data analysis)

The infrastructure is primarily used for secure data exchange.

Global grid connecting Edinburgh, Perth and Beijing, applied to the analysis of business data for customer relationship management

Integration of a data indexing service for specialist data resources, with a facility to allow access to those data resources and the merging of them with other data files, by non specialists.

Gray literature search engine, automated image analysis.

The project is to develop middleware to facilitate field research in conditions which lack the usual assumptions of pervasive or HP computing. That is, to enable field researchers to be able to tap into the cyberinfrastructure capacity asynchronously fro

Early adoption of XTF (http://xtf.sourceforge.net/), an open source digital library platform, based on Saxon and Lucene. Early adoption of advanced JavaScript/CSS rich internet application features. Experimental use of topic maps and other semantic web

Access Grid and related distributed services

WIKI

None are terrible innovative, but we are making use of cvs/sourceforge as the depository of code and results; we are using a local shared memory machine for computing purposes, which could benefit from grid type approaches

Used email to communicate and advanced editing features to develop survey instruments.

Web services, interface tracking systems using ultrasound, Anoto, various video streaming technologies

Support for real-time, collaborative and remote video analysis.

The project I was involved in in 2002, SAMD, was a pilot project the grid enabled a web based social science database. It was one of the first projects to do so. The project website is at:http://www.sve.man.ac.uk/Research/AtoZ/SAMD

Database, computing and web communication

Wiki, web pages, internet, web server, portal, Java, access grid, email

Use of Semantic Web, Grid & Web 2.0 technologies to faciliate mixed-method techniques for

policy appraisal.

GRID enabled individual based, dynamic demographic mirco-simulation for the whole UK which integrate datasets from different sources.

The eMasters programmes are wholy online and are delivered using a virtual learning environment. A key feature of the pedagogy is the use of asynchronous tutor-led discussion groups to support an international community of public service practitioners.

Collaborative databases for the whole project, data sharing,

Collaboratory

Semantic aspects using ontologies / thesauri differentiation between disciplines

Collaboration and development of Grid for spatial analysis

Semantic grid

Semantic annotation for live and retrospective video analysis Event history analysis Mulitmedia data collection

A fundamental aspect of our project was the ability to engage with the nonscientific community in the use ofe-Science. We took this principle to extremes by involving one of the most marginalised groups imaginable: the Makushi Amerindian tribe situated i

Moodle vle compendium mapping participatory gis

Argos is a flexible data query and analysis system based on the web services paradigm. As an application domain we will examine several goods movement planning problems and their effects on spatial urban structure. Many scientific problems can be mode

We are using geostatistical tools and advanzed visualization techniques for investigating archaeological data. Because archaeological data come from our own fieldwork in Patagonia (South America), we need advanced systems for data exchange and analysis

Collaborations across 3 continents

VoIP, web-surveying, web-based research and analysis, web-based simulation

Semantic Grid techniques

Nothing new, we use e-mail and internal documentation

This will be an empirical data archive for SSH in Lithuania with possibilities to analize data online

The g-Eclipse project builds an integrated workbench for e-Infrastructure end users, e-Infrastructure resource providers and e-Infrastructure application developers based on the industry compliant eco system of the Eclipse foundation. The g-Eclipse frame

In creating the Network Workbench Cyberinfrastructure, we drew upon our previous cyberinfrastructure work in the InfoVis Cyberinfrastructure (http://iv.slis.indiana.edu). We have developed some middleware for us to rapidly create CIs that is different fr

Integrating data and metadata across servers, with multi-lingual discovery tools.

Building an eScience network of researchers working with interlinked picture details. This comprises an editor, e repository, a wsdl interface and a publication environment for web based publication-

Coupling of scientific modeling with decision support capabilities looking at human costs, economic impacts, etc. of disasters (i.e. earthquakes), collaborative data and model scenario sharing, integrated provenance linking scenario with research literature

A low cost, computational cluster, that can be transported as checked baggage with no extra charges, and sets up quickly

3d telepresence

The software system supports the SRB federated storage system developed by the San Diego Supercomputer Center. It can also use the Video Pipeline compression and transcoding system developed by the Condor Project parallel computing project.

See http://www.ncess.ac.uk/research/nodes/DigitalRecord/

GIS mapping data mining placename extraction

The resource has developed over ten years, using a range of evolving technologies and standards, including DC metadata, on-line map-based interfaces, Z39.50 & OAI interoperability, facetted classification, web services, portal technologies, data mining,

Automatic acquiring and indexing of academic documents base on automated metadata extraction and indexing of metadata such as citation, author, title, acknowledgement and affiliations. Cocitation and active bibliography groupings are also listed.

Repositories technology for Social Science datasets produced as part of academic research. This technology will help dealing with storage, preservation and access issues.

Cross-university nationally exchange of materials and data, to support collaborative research. International incentives for the same.

We are using Sakai Virtual Research Environment as a collaboration space for research teams, but we also foster several teams that use the platform for other collaborative activities and, then research them.

This is not a good survey. You have not defined eInfrastructure and so I can't answer these questions correctly.

Use of integrated tabular and geopspatial data infrastructures

Meta-scheduling, interoperability, system integration, data and information management, data federation and replication

Real-time interaction at multiple sites

Many cameras, video projections, internet

We 'scraped' content from search results in legal databases, then mined each of those texts for external references (e.g., citations to other texts), which was used both to identify other relevant texts, and ultimately, to 'map' the network of links. To

Publication and citation of scientific data using persistent identifiers. Integration of literature and data. Architecture for continuous digital workflows in the geological sciences.

Geospatial presentation of cultural, social, linguistic, musicological information; effective archival of complex objects; linkage with Shibboleth is in design.

Collaboration spaces. Shared web-based information (not data) repository Grid-based communication Web email

We've custom-built the Collex tool (http://www.patacriticism.org/collex) to support federated archives, faceted browsing, search, collection, tagging, annotation, syndication, etc. in NINES.

Cooperative editing of medieval charters based on multilingual markp up tools.

A world congress about cibersociety multilinguial and ONLINE

Easy provides access to a large number of datasets in the humanities and the social sciences*. You can download most datasets directly, along with the accompanying documentation. For some datasets, however, you need special permission. As a researcher o

A computer based simulaton of a working economy in which students can buiild, populate and operate working online digital ebusinesses.

Standardised WS-based export/import facility from local databases (such as Filemaker) to repositoryt software (DSpace/Fedora) and import/export between repsoitories. Linguistic data-based representation models using onm-thr-fly vector diagrams to navi

Online virtual lab for languag acquisition research

Network of computers in Census/NSF RDC system

We are working to do query dependent, on-the-fly data integration and to incorporate use of incomplete and inconsistent ontologies in an interactive, concept oriented interface.

The development of metadata tools to generate and analyze the metadata describing variaous stages of the research life cycle. In particular, we are working to generate metadata that would replicate the analytic or working datasets used to produce the re

Develop database of images and 3D models of archaeological artifacts for search and retrieval

Past project - VICODI. - Ontology

Grid technologies, web services, semantic technologies, building a virtual research environment

Collaborative authoring and semantics based operations

Secure confidential remote access to patient records

Seamless synchronous/asynchronous collaborative editing of drawing, text, database, etc.

We were using current communication technology (MSN IM and conference phone calls) in new situations - introducing secondary level 11-16 year old science students to new situations of

learning through communicating with science experts and remote scienti

Datagrid and Service Oriented Architecture for Textprocessing and linguistic analysis. Based on Globus Toolkit 4, Web Services, LDAP, PKI and Shibboleth .

Collaboratory and expert referral system

Multi country analysis, communication, data gathering, using web, webbrowsers, spiders, neural networks, grid computing

Web portal (w/wiki, blog, and etc.) plus multipoint videoconferencing

In process: Mindquarry, Wiki, Digital Book (co-authored), Weblog, Digital Memory Bank etc.

This project, in particular, was a meta-level project examining how the social sciences and history, especially the STS field, can inform and be informed by the growing cyberinfrastructure agenda. The discussion heavily involved innovation and advanced i

Web services for providing synthetic social science data

Cross-searchable metadata from four existing web services, each with multiple online databases eventually, vision of integrated data access and tools across services

The workshop organizers set up a blog for participants that was active throughout the meeting.

ERIC is an internet-based digital library of education research and information sponsored by the Institute of Education Sciences (IES) of the U.S. Department of Education. It provides access to bibliographic records (citations, abstracts, and other perti

Access Grid for video and teleconferences. OGSA and Globus infrastructure modules. Deep storage Metadata. The project is available at www.earthsystemgrid.org. It provides all operations related to climate science data. The data itself is produced b

Ontologically-based data integration web portal for access to tools and workflows

The purpose of the project is to build a cyberinfrastructure for the humanities, arts, and social sciences that facilitates advanced research in these disciplines.

Laser scanning; 3D modeling of any entire ancient city

We began production of the Dynamic Backend Generator tool in the summer 2005 and have since successfully tested and refined it on over twelve of Vectors database-driven web sites. The DBG is a dynamically-generated middleware interface to a database

Communication in a virtual classroom/lecture room audio. video

Grid-based middleware, gLite, WSRF

Multiple attempts to make Virtual Organisation technologies work for us

Solving different problems by consulting different personalities of the worlds. Sending application without any cost. Involving in many discussion forums and participating in development of programme and policies. Involving in virtual learning environment.

Asset Action Packages Asset action packages are well labeled, actionable URLs that enable digital objects from various sources to be presented in a consistent manner to the content consumer. Asset action packages allow a functional view of a unit of c

The DILIGENT project is creating an advanced test-bed that will allow virtual e-Science communities to share knowledge and collaborate in a secure, coordinated, dynamic and cost-effective way. The DILIGENT test-bed will be built by integrating Grid a

Storage Resource Broker, Grid Computing, 3D digital artifacts, Datamining

Using GRID based infrastructures in clinical routine (not just research)

Integrating different aspects of work via a communal classification system of occupations, past and present, world wide; a coding module

I'm not sure of what you mean here. We are creating Distance Learning Courses, an internet tool for storing and analyzing language data, digital videos, etc.

One-of-a-kind middleware system for deploying simulation service across the internet

Web services as text analysis tools. Users of the portal define texts that are then processed by remote web services brokered by the portal through a common interface. It also has some social network features to allow sharing of documents, news, and tool

Development of user-targeted Grid technologies at Scale. Distributed development and user services team.

Planning stage for RECON. Need to organize an application for sharing verbatim data, and

other types of unstructured data types among researchers in the network (audio, video, pictures, etc)
Innovations in information storage, middleware, high performance computing and applications. Particularly, innovative database technology has been introduced for use in medical, biological, environment, maintenance, remote learning to name a few.
There is a web portal for participating countries to upload all of their data etc collected during each round of the ESS
All major areas of distributed computing
Collaborative database building
We seem to be one of the few organizations doing 3D work

Source: AVROSS WP2 survey.

Question B5: Sources of information and know-how important in the decision to begin using e-Infrastructure

Gut feeling
Immediate practical benefits
My research centre is, in part, developed to undertake this type of research feedback from users / also ideas from other contexts and sectors
Own research and developments for data service e-Science Core Programme
OSI Report on e-Infrastructure, eIRG White Paper
Other online information environments
Own efforts in metadata and data management
Available graduate student for assistance
International network
WWW - I couldn't have built or conceived of my project without Google as a source of information. The open-source development community and movement was also integral to the vision project
Student work and research
Industrial applications for data collection application of science to practical social science research
Research Funding
I was a computer scientists for HPC manufacturers for 30 years
Our project is on e-Infrastructure
Personal knowledge
Prior experience in natural resource sciences
Personal interest in e-Infrastructure
Mailing lists
My own responsibilities (self-created) are to provide e-Infrastructure
Use was required by the project leaders
Our organization, acts & events is entirely online
The use of e-Infrastructure is required for the goals of the project
Opportunity to bid for a major grant
Ideas
We develop and do research on cyber infrastructure. The Center I lead is called cyber center
My organization was instantiated as an e-Infrastructure.

Source: AVROSS WP2 survey.

Question C1: Other funding sources of the e-Infrastructure project(s)

Project's partners
Private donors
JISC funding (UK HE IT)
No funding for project
All voluntary, just the most central virtual place for developing statistical data analysis software
It is predominantly funded by our own institutions
JISC
Higher Education Funding Council for England & Wales
Microsoft
Tertiary Education Commission
BRCSS Network Project subscribers/publisher
WUN, Internal Affairs Ministry, Annenberg School at USC
Industry
International partners
SuperComputing (a la SC07-09)
JISC
Private companies
It is being reviewed for funding federal line agency
SBC (telecom company)
Numerous countries -national funding bodies
Funding ended in 2005
NSF
US Department of Energy
Participant institutions
Corporations
Foreign institutions of our partners
Industry
The governments of 26 countries

Source: AVROSS WP2 survey.

Question C5: Other main outcomes of the project

New summer program
Teaching historical demography methods
Growing scientific communities
Raising of consciousness about the importance of the digital humanities
A European Data Portal
New collaborations & engagements with early adopters
New disciplines of e-Infrastructure, and service providers
New data access methods
Innovations in teaching
Presentations
Public domain software we hope - the project hasn't started yet
Outputs to be produced
This project hasn’t yet started
The Australian Qualitative Data Archive (AQuA) pilot
Contributed to the establishment of a e-social science centre at Manchester Postgraduate programmes
New research questions
Official Eclipse project (www.eclipse.org/geclipse)
Part of platform for developments described in ESFRI roadmap reuse of architecture and components
Change in how computational science is taught (learning curve meant data had to be reproduced multiple times)
Publications currently pending
Follow on projects
Build research networks across Europe & America
We are just getting started
The exploration of international collaboration was an important starting point
Contribution to standard development led to new, follow-on research proposal being accepted
Hopefully new social policy
Improved search function and full-text access
Shared repository
New discoveries
New schema capacity building
Establishing a community or e-social scientists
Infrastructure
Old data now digitised.

Source: AVROSS WP2 survey.

Question C6b: Other type of data produced

Geospatial Implementations and software
GIS data
Community based VREs, VLEs hyperlink network data
Audio, Biological data
Talks and presentations to the social science community
Sensory data from computer logs
GIS data
Picture metadata interactive scenarios (3-D, GIS-based with add on reports, tables, filters, etc) that can be interrogated/explored map-based data
VR models
Geospatial cultural GIS-data
CAD-data
Spoken material
Dictionaries, bibliographies, metadata etc
3D spss recode jobs
Application results
Classified thematic fragments, thesauri structures
Scientific.

Source: AVROSS WP2 survey.

Question D2: Other potential barriers to the adoption of e-Infrastructure technology

The Old Guard who still control many funding streams and research directions who do not believe in e-Infrastructure as a catalyst for scholarship
Special case of all the 'usual' problems of sharing geospatial data
Had to be self-sufficient on technology, software, etc., hence open source
Lack of appropriate support mechanisms/services (e.g. training)
Locked into old conceptions of data publication
Pushback from mainstream social science publishers
Lack of understanding in the discipline of the project's contributions
The main problem is the university's firewall. It has sold its firewall to an outside company and we have to get it opened every time we use AG. Despite this being an engineering university there was low awareness of grid technology but this is improving
Two big problems for a social scientist doing e-research: getting e-scientists interested in your work (and collaborating)
Getting the respect of your discipline (e.g. economics/politics/sociology) where not much value is placed on tool development
Methodological warfare
Lack of standardised metadata in social science databases
Ethics and governance, cost
People's capacity to engage with the new technologies
Communication social - computer scientists
Pressure to produce flash rather than operational capabilities
Lack of community coordination (it's early)
Lack of technology and ICT support resources in schools (real context of use)
Not being taken seriously when coming from the humanities.

Source: AVROSS WP2 survey.

Appendix I.5: Code system for the positive and negative lessons (QD3 and QD4)

Code	Code label	Examples
1	Consider user and other participants perspectives and needs	Get and act on feedback from wide range of (real) users; e-Infrastructure should be considered as new support to existing functions; look beyond the technological capacities and at what you need to have done; fit new applications with the everyday tools that people use; identify your user base and understand their needs.
2	Benefits of e-Infrastructure regarding data	Abilities regarding data management and capture, dealing with complex information, makes data available, data access may reduce entry barriers,
3	Benefits of e-Infrastructure for communication and collaboration	Abilities in regard to connecting individuals with common interests; collaboration is enhanced; building virtual communities; collaboratories promote e-Infrastructure
4	Positive contribution of e-Infrastructure to scholarship, teaching and learning	Use advancements in teaching; involve graduate students
5	Research-related benefits of e-Infrastructure	Positive effects of e-Infrastructure on efficiency and effectiveness of research; positive impacts on the development of the field; positive effects of programming for social science research
6	Disadvantages of e-Infrastructure for communication and collaboration	
7	Don't place too high expectations on e-Infrastructure	Enjoy benefits as they come; patience helps; short-term projects may not be able to develop demonstrators
8	General positive effects of e-Infrastructure	E-infrastructure save time; powerful tool; involvement with new technologies shows their benefits; benefits of e-Infrastructure for workflows and processes, it can be a good way to get funding
9	General negative effects of e-Infrastructure	Complex to set up; takes commitment, time and financial resources
10	Proactiveness, bringing new tools to users a.s.a.p. brings success	Being proactive is better than waiting for institutional solutions; entrepreneurial approach; don't aim for perfection, be content with second best; use tools for generating research outcomes as soon as possible
11	Positive and negative influences of the field and institutional environment on e-Infrastructure are important	Supportive effects of the field, NCeSS, NSF; collaboration with university libraries; problems with getting e-Infrastructure ideas accepted; your local library is your friend; local administrative support is essential, but difficult to acquire for innovative projects; importance of organisational politics
12	Collaboration works and pays	International collaboration works, positive effects on research and scholarship, find collaborators
13	Problems with legal issues and finding solutions	Problems with copyrights, intellectual property rights (IPR), laws; difficulty in finding legal advisors; Don't use proprietary technologies if at all possible
14	Engage in community-building	A decentralised approach to e-Infrastructure is beneficial, involve local communities, attribute responsibility to local stakeholders, advantage of loosely coupled systems and web-2.0 style user-generated content

Code	Code label	Examples
15	Solving issues of data/metadata	Data/metadata connection is critical and tricky, data publication is as demanding as data creation, standard definitions of metadata and data structures & elements, do not replicate existing data infrastructures
16	Software & middleware elements and technological configuration of e-Infrastructure are important	Applications might be important for use; be open to software revisions; compatibility of software is important; substantial software development efforts; code quality
17	Connect to other projects, exemplars, frameworks, peers	Good results of pioneering e-Infrastructure projects; building on exemplar work in the field; keep an open eye on ongoing tool development; use frameworks, don't build new solutions from scratch; talk to other projects in e-Infrastructures; connect to peers; share the results with everyone
18	Supporting interdisciplinarity for e-Infrastructure	Creating incentives for inter-, multi-, cross-, transdisciplinarity; crossing disciplinary borders works, interdisciplinary collaboration
19	Technological limitations of e-Infrastructure	Unreliable, needs high level of technological expertise; social science problems are not suitable for e-Infrastructure; immature technology, lack of documentation and structured information
21	Disadvantages of standards	Not using Windows makes everything easier and more secure for web applications
22	Hardware issues	Improving hardware may be cheaper than restructuring software
23	Problems of tool development	Separation of tool development and research, choice of tools
24	Importance of human factor, problems with finding good staff and skills	Motivation for participants, enthusiasm is important; people are critical, skills; you need technology/domain translators; programmers from outside industries (search engine consultants, video game programmers) convinced through their work ethic; strong leadership
25	Problems of establishing and managing interdisciplinarity	Terminological problems: different understanding and definition of e-Infrastructure, e-research, e-science across disciplines; problems of interdisciplinary collaboration (social sciences – computer science)
26	Importance of funding, problems with funding, cost issues	Seek broad and sufficient funding base; development costs are significant; private foundations are a good alternative to conservative government granting agencies; estimate high project costs; lack of permanent funding for infrastructure; funding agencies lack appropriate tools to fund eInfrastructure
27	Care for sustainability after project completion	Lack of follow on - national closure around ideas for developing e-social science; sustainability is difficult but critical
28	Problems of collaboration and communication	Costs of collaboration; difficulties of finding the right partners; right degree of collaboration
30	Advantages of standards or open source	Use of standards prevents lock-in into specific projects, disadvantages of custom-made tools, use open source tools
31	Issues of timing	Everything always takes more time than expected, not enough time calculated for the whole project, timing is important
32	Composition of the research & project team	Success depends on open communication and dialogue among the team members
33	Importance of project design &	Good project design very important, design projects in

Code	Code label	Examples
	management	different phases, organize real meetings
35	Importance of flexibility	Project flexibility, flexible planning, flexible approach, flexible deployment, flexible ontologies
98	Other lessons (e-Infrastructure related)	Social science problems can drive worthwhile computer science research, involvement with firms through e-Infrastructure, distinguish your project from others (e.g. naming)
99	Other lessons (*not* e-Infrastructure related)	Improving discussion skills, improving the position within the organization, in regard to funding, goal orientation, project design, goal orientation is important
100	Duplicate code	Code already included for a different answer from this respondent.

Source: AVROSS WP2 survey.

Appendix II: Case studies

Appendix II.1: Criteria for rating the e-Infrastructure initiatives

	2 points	1 point	0 points
1 Technology	**Weight: 30%**		
a) Innovativeness of the technology	Very innovative, goes beyond the state of the art in e-science/Grid development	State of the art in e-science/Grid development	Below state of the art, just internet-based applications
b) Relevance for social sciences and humanities: this means first of all that the technology has to be relevant for SSH	Specific for SS/HUM, generic,	Adaptable to SS/HUM	Adaptability, transferability unclear or improbable
c) Replicability: Can the technology/tool be transferred to another setting?	Transfer to SS/HUM has been effected or under way	Transfer possible according to existing information	Transfer not possible
2 Success	**Weight: 30%**		
a) Long-term sustainability: Has the project secured long-term funding? Has it achieved an organizational status beyond the project level, secured an institutional affiliation?	Long-term funding secured, institutional affiliation achieved	Long-term funding and/or institutional affiliation still possible	Project terminated without successors, arrangement for continuation
b) Constituency of users involved? Size of the current (not the planned!) user community?	Active and growing community of users beyond the project level	Active community of users at project level	Nothing known about users, no user community defined
c) Outcomes: publications, patent applications, new methods, new data, new tools, follow-on collaborations	Several and significant outcomes documented	Some outcomes so far	No outcomes
3 Size	**Weight: 20%**		
a) Large or small potential user constituency	large (> 10'000)	medium (> 1'000)	small (< 1'000)
b) Broadness versus depth, i.e. domain-wide initiatives versus projects creating one specific source or solving one specific problem in a field	Several domains in SS/HUM	One domain or field	Below domain or field level
c) Countries included: multinational versus national or even local projects	multinational	national	below national level, local, univ.
4 Accessibility	**Weight: 20%**		
a) Timeframe	started more than 3 years ago and still ongoing	started more than 3 years ago and terminated, started 1-3 years ago	started less than a year ago
b) members and agency of the initiative (includes pragmatic issues, like willingness to participate)	access guaranteed	access not clear	access improbable

Source: AVROSS

Appendix II.2: Informants in case studies

Person interviewed	Affiliation	Remark	Interview duration
Access Grid Support Centre (AGSC)			
Manager/Researcher	Univ. of Manchester	computer scientist	105 min
Developer/Researcher	Univ. of Manchester	computer scientist	60 min
Institutional level (management)	Univ. of Manchester	Department of Research Computing Services	75 min
Access Grid Support Centre Officer	Univ. of Manchester	computer scientist	60 min
User (high level)/ collaborator/researcher	Univ. of Manchester	Manchester Visualization Centre	60 min
Modelling and Simulation for e-Social Science (MoSES)			
Researcher	Univ. of Leeds	geographer	95 min
Developer/researcher	Univ. of Leeds	computer scientist	72 min
PI/researcher	Univ. of Leeds	geographer	84 min
User/Co-PI	Univ. of Leeds	geographic modelling	45 min
User/Co-PI	Univ. of Leeds	health science	25 min
ComDAT Informants cannot be disclosed due to reasons of confidentiality.			
SPORT Informants cannot be disclosed due to reasons of confidentiality.			
Dokumentation Bedrohter Sprachen [Dokumentation of Endangered Languages] - DoBeS			
DoBeS archive manager	Max Planck Institute for Psycholinguistics		-
Understanding New Forms of Digital Records for e-Social Science (Digital Records – DreSS)			
Project Manager/Domain Advocate	University of Nottingham	Department of Computer Science	–
TextGrid			
Project Manager	Goettingen State and University Library		Joint interview of 90 min
Technical officer	Goettingen State and University Library		
FinGrid			
Technical manager	Non-university research	Computer scientist	Joint interview of 100 min
Site coordinator	Non-university research	Computational physicist	
Technical developer	Non-university research	Computer engineer	Written answers
User	University	Econo-Physicist, finance researcher	30 min (phone)
User	University	Statistician, finance researcher	45 min (phone)

Source: AVROSS case studies.

Appendix II.3: Contact letter for e-Science experts worldwide

AVROSS study on e-Infrastructures

Dear xxx, (ideally a contact person)

Under the acronym AVROSS we are conducting a study about the adoption and use of e-Infrastructure (cyberinfrastructure) in the social sciences and humanities for the European Commission (Information Society and Media Directorate General).

The purpose of this study is to provide the European Commission with a comprehensive overview of recent adoption of e-Infrastructure in the social sciences and humanities, to identify supportive factors as well as barriers and, last but not least, to develop recommendations for EC policy making in this area.

For the purposes of the AVROSS study, e-Infrastructure is defined as integrated ICT-based research and learning resources. It embraces networks, grids, large scale computing resources, data centres, advanced tools for data analysis, visualisation, collaborative environments, and can include supporting operations centres, service registries, single-sign on, certificate authorities, training and help-desk services. Most importantly, it is the integration of these that defines e-Infrastructure.

The analytical work includes a number of case studies on successful e-Infrastructure projects, i.e. projects or domain-wide initiatives which have been successful in rolling out e-Infrastructure tools and applications to user communities in science (in the widest sense including natural sciences, engineering, medicine and life sciences, social sciences and humanities).

We would need your support for identifying possible cases from your country. Please answer the following questions briefly and return the email to the sender (or print it and send it by mail to: xxxx name & address).

I. Please list a maximum of five successful eInfrastructure projects in your country (include the project name/acronym, the responsible organisation, and, if available, the name and/or email address of a contact person).

1.
2.
3.
4.
5.

II. Provide reasons for each project why you short listed it among the successful eInfrastructure projects in your country.

1.
2.
3.
4.
5.

III. Please attach or send by mail information material on any of the listed projects if it supports the process of case selection.

IV. If you feel that you are not the right person to answer these questions for your country and/or think that somebody else should be contacted who is particularly knowledgeable on this issue we are grateful if you provide this person's contact details, but at least the name and affiliation.

Send this query to:

Thank you for your help and cooperation. For further questions and to become member of a forum on the topic of the study visit our webpage at http://international.fhso.ch/avross/ or contact:

xxx replace with your address xxx

Appendix II.4: Interview Guideline

AVROSS Interview Guideline

Core Questions

1. Background and Involvement with CI/e-Infrastructure[33]
   1.1. Please tell me about your (academic) background and/or role in the project
   1.2. CI has been understood in various ways, could you describe your understanding of the CI framework?
   1.3. Please describe your involvement with CI
   Probe: How did you initially learn about CI? What motivated your participation?
   1.4. Background of the project: How was your project established?

2. Technology
   2.1. Many technologies have been associated with CI over the years. What technologies are used and/or developed by your project?
   Probe: Why have you selected those and not the others? (technological maturity, standards) What prompted the decision to develop and not use existing tools?
   2.2. Do you in any way support learning, training or documentation processes in your project?
   Probe: Do you use e-learning tools and which? Do you use the project CI in ways for learning, training or documentation (within the project)?
   2.3. What is the relationship between the project and CI technology stakeholders, such as infrastructure or middleware projects (i.e. Teragrid, Globus)?
   2.4. What were the technological constraints you have encountered during the project?

3. Community Structure and Mobilization
   3.1. What user and/or developer communities are involved in your project?
   Probe: Public research, business, governmental org.; geographical distribution?
   3.2. How are members of these communities recruited and how are they organized?
   Probe: To what extent are these preexisting ties (i.e. past collaborations), or new links? (If new links, how were these established—e.g. through outreach efforts, training)
   3.3. How do participants interact, and how do these interactions feed back to the work process?
   Probe: Were any of the efforts led by users? Did you encounter problems with user participation? Have these interactions been formalized: for example, as contracts or as institutionalized meetings? **If applicable:** Are any such interactions made public?
   3.4. How do project team members learn what happens elsewhere in the project?
   Probe: More generally, how is collaboration organised within the project? What would you say towards a notion of learning as part of the research process?

[33] CI = Cyberinfrastructure in the US, e-Infrastructure in Europe

3.5. In what ways are you or others in your project connected with other related efforts in the US/UK/Europe (country) or elsewhere?
3.6. In what ways did related developments - either in the US/UK/Europe (country) or elsewhere - influence the work done in project?
Probe: Ask for specific references to projects.

4. Adoption
4.1. Are the developed CI currently used today? Have they been adopted by others outside of the project?
4.2. What do you think are the major catalysts that are helpful to get the approach adopted by people in the wider community?
Probe: Networks, funding, publications
4.3. What are the obstacles to get the approach adopted by people in wider scientific community?
Probe: Technical, org boundaries, national interests, privacy/confidentiality concerns.

5. Impact
5.1. When you arrive to the office today how is your work different than it was prior to the project?
5.2. What do you think should be considered the major measures of success of your project?
Probe: Publications, new tools, workshops, widespread adoption etc.
5.3. What are the main innovations coming out of the project(s)?
Probe: What *new* problems/questions/theories are addressed? (If the focus is on tools then ask: how these tools help addressing *existing* problems/ questions/theories?)
5.4. What are the alternative paradigms in your field to these developments?
5.5. What in your opinion has been the impact of your project to date?
Probe: Who, aside from your collaborators, has picked up on the approach/tools developed in the project (software: please provide use references and/or download statistics)?
5.6. What do you think is going to be impact of CI in your field 5-10 years from now?
Probe: What might be the hurdles for accomplishing this vision?

6. Personnel and Resources
6.1. Is there a connection between research and teaching?
Probe: Are graduate students involved? Doctoral programs or apprenticeship schemes?
6.2. What is the project budget?
Probe: Who are the main sponsors?
6.3. What are the main costs associated with the project?
Probe: Were teaching, training, and outreach budgeted?
6.4. Have you assumed new approaches during the project for funding considerations?
Probe: Should you receive twice as much funding, how would you allocate it?
6.5. Some interviewees have indicated that funding for research related to CI has been gradually declining. How does this trend impact your project?

7. Change
7.1. What components of the projects have changed from the original planning over the course of the project?

Probe: In particular: technical components, research agenda, use and/or user focus. Why? Has this been/is this a problem? How did/does this affect the research process?

8. Policy Input
   8.1. What do you consider to be main successes and failures of your project?
   Probe: How would you do things differently if you had the opportunity?
   8.2. Do you have any recommendations to policymakers regarding funding, areas of interest, new calls, or other issues?
   Probe: Do you have recommendations towards fostering the uptake of e-Science in the social sciences and humanities?
   8.3. Do you have additional thoughts about the subjects discussed in this interview, or are there other issues you think that study should address?

9. References and follow up
   9.1. Could you please refer me to others associated with your project - other users or developers - who could contribute to this study?
   9.2. As the study continues would it be possible for me to follow up with you for questions and clarifications?

Thank you for taking the time to participate in our study. Your input is very much appreciated!