RCUK Review of e-Science 2009
Town Meeting Tuesday 9th February 2010
RSA, 8 John Adam Street, London WC2N 6EZ

Talk 1 – Professor Adrian Smith (Director General of Science and Research)

At the front of the class a silence descended on the room and it's tremendous that you still remember these things.

This says who I am, for those who don't know me. I'm Director General for Science and Research in the Department for Business Innovation and Skills. My job in part is the oversight of all the public investment in science and research in the UK that goes directly into the universities, and through the Research Councils. I therefore have a huge interest in this area and this review, which just as a preamble I should say is really timely. We are in the UK at an interesting point both in our electoral cycles, and after the electoral cycle, the spending decisions and investments for the next few years in general, and in particular in Science and Research, and so bringing together at this time a serious review and thinking in this extraordinary and interesting and important domain, is very important for me and for the department as part of agenda setting and investment discussions in the period ahead.

I think virtually everybody in the audience knows who the UK Research Councils are, but we have run the first stages of this e-Science Review through the Research Councils so let me start just by saying, about two thirds of the total spend on research goes through the research councils, the rest directly into the universities. About a half of what we spend through the research councils finds its way back into the universities, competitively bid for, and so the universities, the university infrastructure, and the health and the sustainability of the research base in the universities is also fundamental to this agenda even though today we're hosting this and talking about it in the context of the research councils. And because of the nature of the research councils as arms length public bodies but accountable through the Government departments to parliament, it is in that more public domain that the debates have to be held in terms of what are the priorities going forward and what are the relative investment opportunities and the priorities among them. So, the research councils are a very important part of the landscape going forward, and again, virtually everybody here would know this but we run the system through seven separate Research Councils, the terms are there and you see they cover all the disciplines, my title is Science and Research. This is not just science and technology, it is the whole gamut right through the Social Sciences, Arts and Humanities and the Research Councils. Also, of course, in particular, the Science and Technology Facilities Council, looks after the major facilities, the Synchrotrons, it also looks after our International reach out, our memberships of CERN, our activities in the European Space Agencies, and so on. So the Research Councils cover the whole landscape. The mission, I use words like basic, strategic and applied research, 'if you want to get into a debate in a bar', I don't think they are as meaningful as we think they are but it is sometimes helpful, the Research Councils are supporting and funding the research base of the UK and, in addition, it is through the Research Councils that we direct the public money that goes into postgraduate training. So, various forms of supporting Phd students, to some limited extent Masters students, and that, in the wider political domain of the importance of the research base is of course an ingredient that's important over and beyond the production of science itself. It's the

production of people with advance knowledge and skills that go into the whole of society and economy and the health economy, not just the narrowly scientific and research, and as I said, the managing and developing of large facilities. So, why do we do things like commission International Reviews of which what we are going to hear today is one? Clearly, both as a scientific community, and also if you are in government as the funders of tax payers money, you want to know in some detail and some depth the relative strength and competitive positioning of different disciplines, different areas of activity in the UK, compared with our competitors however we identify those.

We are competing in a global, international environment and so to have the perspective from an International Panel of where we have serious gaps, or where we have missed opportunities, or where the structures that we are using to try and deliver are perhaps not the right ones, to do those kind of comparisons is totally invaluable both for the health of our own understanding of the sciences base but also in debating, arguing and persuading politician's and the Treasury of the importance of investment, and so as a basis it says at the bottom there in some sense for future planning, this is invaluable. As I said at the beginning, the timeliness of this it just spot on, because over the next few months we will be having quite radical debates in this country as to what the investment priorities are and whether we have the right structures in place to deliver.

A little bit of history for those who don't know and because there are some people sitting in the second row who know all this, because they where there and party to the start of all this way back in 2000, with the investment bumped up a couple of years later we have been running the e-Science programme and today the seven Research Councils, although they are separate, through Research Councils UK, which if you like is the collective of the Research Councils, a huge amount is done in common and I will mention some of that in a moment, when the e-Science programme was launched it was not necessarily the case that the individual Research Councils worked together on a whole swathe of common activities. This was one of the first. It was a serious investment at the time, and in some sense it was a bit of a prototype of how to try and bring together the different research councils and the different disciplines and the different cultures into something that identified a common approach to a problem. So what has the programme done? Clearly the driver is generic. Its core technologies, which are of use or available across all the disciplines, the specifics in terms of grid and middleware, and all the rest of it, most people here will know those words and be familiar. What it also did however, and this is something increasingly important for us in the UK and in the future, is to see all these activities, all these investments not as a UK silo (remote and separate in itself) but all the time to realise we are part of international communities, whether cooperatively or competitively, but actually to have that international dimension clearly in view.

The programme itself formally, went through to 2006, although there are aspects of it that continued to be funded, but in some sense this is the timeliness issue. The programme ran through 2000 – 2006. We now have this major review and this will be the time to take a breath and think 'where do we go next', but there had been continuing investments in the core and we branched out into some specific investment s for example: e-Social Science, and of course the investment in Grid activities.

In terms of what I said just now this was one of the first things that brought the research councils together collaboratively. I will mention in a minute that actually now something like 15% of the total research council budget is spent collaboratively on Grand Challenges of various kinds, but what they all have in common and the e-Science programme had right from the beginning, collaborations across disciplines, but not only across disciplines but between academe and industry. All those certainly 10 years ago, I hope decreasingly so now, but all those 10 years ago threw up new challenges about ways of working across

different cultural and other barriers. What has also changed in the last 10 years is a much more overt requirement and realisation that in difficult times, if we are to continue to compete for substantial tax payer investment in the research base, we have to take every opportunity to demonstrate the economic and social impact of those activities, not as is often mischievously paraded that every research grant has to demonstrate or predict in advance what its impact is, but simply to have a culture and awareness of mechanisms that wherever possible and wherever appropriate, we harvest the social and economic benefits of our research investments. So this review will partly help us as to how we move forward with the programme itself, but also perhaps our positioning in that wider environment of social and economic impact.

Just to say, this was one of the first things that Research Councils did together. If you now look at the current Cross Council research programmes, they are exactly the Grand Challenges you would expect. I think shortly we will be probably adding to these things like Food Security, but if you take something like Digital Economy, the words are carefully chosen to be interpretable almost however you wish, you will see that in addition to the e-Science programme per se, actually there's a more pervasive interaction with some of these Grand challenges.

So, what we are going to do this afternoon, we had the Panel itself, of which Dan Atkins has chaired, in which we are infinitely grateful to him and the members. Dave Snelling has chaired the Steering Committee, which has overseen the process, so we are going to have a major discussion of the main findings and recommendations. Dave Delpy from EPSRC is then going to mention the possible next steps. We've also got a parallel but not parallel (because that would mean it wouldn't meet), a non parallel activity in looking at e-infrastructure which Carole Goble will talk about. You will then mingle and your programme says at the end there will be a summary and a drawing together from Keith Mason from (STFC). Unfortunately, Keith is not well and so Dave Delpy has nobly stepped into that breach so that's the programme of how we want to take this forward this afternoon. Use this to receive the main messages and recommendations. Do interact with that and lets see what we see as the main issues to debate, how we take all this forward, and at this point I'll hand over to Dave Snelling who has Chaired the Steering Committee and thanks to him and everybody who has contributed to all this.

Talk 2 – Dr Dave Snelling (Chair of Review Steering Committee)

Just a little thank you for letting me do this. There was a Board Meeting of the OMIII UK Board and I vaguely remember saying something about having participated in an International Programme Review once, and I thought it was a lot of fun, and then for my sins I'm now standing in front of you with my second review of the day. My laboratory is being reviewed in Japan this morning between midnight and six, so I've asked to chair the discussion session so that I stay awake. So if anybody sees me falling asleep, please do respond accordingly.

So, as you see from the first slide, I am from the Fujitsu Laboratory of Europe. When they look for a Steering Group Chair they know that the Review Panel has to come from outside the community and that the review panel cannot come from inside the community. I'm a little bit close to the inside of the community that has actually been on the Review Panel because I know a lot of you rather too well to be acting as a reviewer, and while at the same time I'm a little bit more neutral than say members of the Research Councils, so I think as a position space I feel quite comfortable being the Chairman of the Steering Committee.

So what I want to tell you a little bit about is the Steering Committee as you see here came from a variety of different sources with a little bit of a remit to put together this review, and I must say that I'm the one who has done the least amount of work of everybody in this room, and in the tentacles that stretch out beyond it, so I feel quite lucky to be here with my one day of hard labour.

So, the Steering Committee role was basically to assist with the development and preparation of the review process. We needed to put together the International Review Panel, set up their Terms of Reference and so forth. We will go into a little bit more detail on how we put that together, and then the work starts from now for some of us to continue disseminating this information to the rest of the communities, so that starting with today of course as part of the dissemination process to pass this information back to the community and then to spread it into the wider community as we go forward.

So what did we do? The Steering Committee has been meeting a little over a year now and time flew, and I was quite surprised to find out when we started this process. So we sort a variety of nominations, first of all for Chair, and then for Panel members, and we selected, as you know we picked Dan Atkins as our Panel Chair and he has been absolutely stupendous and I will come a little bit to him in a minute.

So the next thing we did was to put together the criteria, some areas of expertise for the panel, tried to get an International balance, address the gender representation, and the international representation, to try and build a panel that would be representative of the community outside the UK. We went around and selected which projects from the e-Science programme would be the most interesting ones, or the most informative ones for the Panel to be able to visit during the week long session in the UK.

One of the most amazing things to watch was the evolution of the evidence framework, which started from 4 short questions, which I will show you in a minute, and grew into an enormous document framework that sits on the web for access by the Panel, and then Dan's job of course was to take this great big morass and distil it back down into the report that's been published, along with other information that they draw from their background and experiences. Then of course we wanted to build and approve the whole context for the data provided to the review panel, and then get the secretariat and responsible organisations to run the planning, with the EPSRC for which we owe a great debt of gratitude for an enormous amount of work to pull the whole process together.

So our top 4 levels of questions, I think Dan will go into these a bit more, so I'll just flash them up briefly. To say that we started from this very fundamental question as to what we were asking and I think they are important to know that the thing for me personally, what I was looking for was, did the programme change the way in which science and research was done? And I think you will find as a result of the report that Dan's put together, the answer to that basic question was yes and that we need to move forward on that information.

So at this point I will end my very brief introduction and turn over to Dan. At the end of this session you will notice from the agenda that we have a set of questions and answers. So we will have a bit of a session where we will do questions and answers and I will ask Dan to come and have a seat at that point. I'll join him on the podium along with Dave and Adrian, if you will come up in case there is a little bit of a wider framework of questions to ask, and then we will go from there with Dave who is next up on the agenda and then Carole will give us our closing comments before we go downstairs for tea.

Talk 3 – Professor Daniel Atkins (Chair of Review Panel)

This is a word cloud that I generated on the report using a web based application and it is simply a histogram of the occurrence translated into font size, I will come back to it in a moment.

Good afternoon. I am pleased to have this opportunity to share with you the work of this International Panel for the 2009 Review of the RCUK e-Science Programme. I assume that you have already, or soon will, read the written draft report, and at some point also have access to the extensive Evidence Document that was assembled by the Review Steering Committee. While my talk will highlight the key findings of the report, it is actually intended to be supplemental to the report - not an exact oral replay of the text.

These are the Panel members selected by the Steering Committee in concert with the Chair. They are all based outside the UK and represent a mix of international researchers spanning the RCUK disciplines and with extensive personal experience in e-Science. You will find brief academic bios of all the panellists included in Appendix A of the Report. I'm pleased that Professor Dieter Heermann, from the University of Heidelberg, a member of the Panel, is here today. [Prof Heermann, would you please stand up a second]. I will certainly invite him after my talk to add any addendums to what I have said.

So we are anxious to convert this draft report into a final report quickly. If there are any comments, particularly factual corrections that need to be considered, I would like to get them from you but I need to get them from you soon and in writing. If you would send them to me at this address atkins@umich.edu, not later than this Saturday, I would appreciate that.

Also, I believe that the EPSRC will make a PDF version of this presentation available on the web. If you want a keynote of the application that I use or a MS PowerPoint conversion of this presentation, send me an email and I will send you a URL that will allow you to download any of those three formats.

Now the next series of slides may be preaching to the choir but I will go through them quickly with the intent of reminding us that e-Science, under a variety of names around the world, is a major initiative in research communities globally, and that there is a strong and building consensus that it represents a major shift in the how, the what, and the who participates in scientific research. I want to underscore the point that what we are discussing today and what our Panel hopes our report will help you do is very important to the future of the UK and to the world at large. The UK has been a pioneer in launching e-Science movement but now has many followers, potentially many collaborators and certainly many competitors.

I obtained the blue part of this slide from Sir John Taylor, when he was DG of the Research Councils, about 2001. It is the definition of e-Science used to launch the programme in the UK. It stressed distributed global collaboration, use of large data sets, and computing data and resource sharing through grid architectures. This definition requires no major adjustment going forward, although the Panel did suggest that it should be made more agnostic with respect to the technology, feeling that grid architecture and terascale will not persist indefinitely.

This is another slide from the past, one I used in discussing the origins of the so called cyber-infrastructure enabled research activities supported by the US National Science Foundation. You'll see that the UK e-Science was featured prominently as a driver for the US programme, which was formally initiated 3 years after your programme was initiated here. As part of the response to the UK initiatives, a Blue Ribbon Panel was established

by the NSF, and after a year of studies and testimony, including testimony from John Taylor and Tony Hey in Feb 2003, issued a final report asserting in part that quote:

"a new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology, and pulled by the expanding complexity, scope, and scale of today's challenges. The capacity of this technology has crossed thresholds that now make possible a comprehensive "cyber-infrastructure" on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways with increased efficacy."

This report in turn stimulated several dozen other workshops and studies in most all the disciplines supported by NSF and most of these reports are available on the NSF website at the URL shown a the bottom of this slide.

This and the next slide summarize primary generic research drivers for e-Science. ICT enabled science is not optional. It is increasingly essential for meeting 21st century challenges, particularly Grand Challenges such as Dr Smith's showed us earlier, in scientific discovery and learning. This is due to the inherent complexity; the multi-scale and multi-science nature of today's frontier science challenges; and to the accompanying requirement for multi-disciplinary, multi-investigator, multi-institutional approach (often international in collaboration); the high and growing data intensity and heterogeneity from simulations, digital instruments, sensor nets, and observatories; the increased scale and value of data and the demand for semantic federation, active curation and the preservation of long-term access; and the need for engaging more students in high quality, authentic, passion-building science and engineering education.

In response to the Blue Ribbon Panel, the NSF in 2007 issued a document entitled "Cyber-infrastructure Vision for 21st Century discovery" describing the potential to transformation the conduct of science and engineering. Chapter one is a call for action and is followed by four other chapters covering a vision and an integrative and systematic framework for action in the intersecting areas of HPC; data and data visualization; virtual organizations, and related learning and workforce issues, both learning about cyber-infrastructure as well as learning on a platform of cyber-infrastructure.

The EU, as you likely know better than I, is also pursuing an e-Science agenda. Here are a few slides I borrowed from Mario Campolargo at the European commission, asserting a "new vision for science" with potential high societal impact; extracting knowledge from data deluge; improving scientific processes, working across disciplines increasingly in the context of virtual research communities. He also acknowledges the push of technology coupled with the pull of scientific need.

The next slides very consistent with the UK vision, stresses building science through collaboration on a global scale, drawing upon the potential of virtual communities.

And this final slide is used by Mario as he discusses the strategic importance of e-Science in providing the EU competitive advantage in knowledge-based global economy. The hope is to connect the finest minds and to share and federate the best scientific resources.

The UK e-Science community recognises perhaps better than many, that research is now both computationally and data intensive, at least some of you are strong advocates of what is being called a fourth paradigm of science, with the other three (as shown on the left hand slide from a the lecture of the late Jim Grey) being empirical, theoretical, computational and now data exploration. This paradigm is manifest in a growing number of ex-informatics fields, as in bio-informatics. Your own Tony Hey recently provided leadership and support for a compelling collection of essays on the 4th paradigm available

in paper and digital form from Amazon. The UK e-Science programme has created leadership capacity to continue leadership in data-intensive e-Science and I would encourage you to pursue that option.

Here is a slide based on a recent article in Science magazine by Francis Collins, a former Michigan colleague, who is now heading the US National Institute of Health. He does not use the term e-Science in this article, but as you can see in reading the underlined text in the abstract shown here on the left, he is clearly talking about e-Science as a fundamental to pursuing five special and very important opportunities for biomedical research.

I won't go into the details but briefly these are high-throughput technologies for comprehensive studies, with the revolution being the ability to be comprehensive, for example, to define all the genes of the human or a model organism, all of the human proteins and their structures etc. The other four special opportunities are translational medicine, focusing on global health, benefiting health care reform, and reinvigorating and empowering the biomedical research community to be more innovative. All of these having a strong relationship to success with e-Science.

The UK Research Councils have developed sets of grand challenge research initiatives of great societal significance. The grand challenges demand alignment of multidisciplinary expertise and resources facilitated by e-infrastructure and science methods. The same platform could also be made relevant to rapidly bringing together expertise and resources needed in response to unexpected, natural or man-made disaster, and also could be approached more systematically as a platform for new forms of any time, anyplace, life-long, and life wide learning, and I would encourage you to further explore these opportunities.

Now some of us, including myself, believe that we are talking about nothing less than the future of the research university in the digital age. As illustrated by these reports and book covers, we are starting to see a convergence of 'e-' type activities that will ultimately, I believe, have a profound impact on how the mission of research university (research; learning/teaching; and societal engagement) is carried out and how universities will cooperate and compete on the worlds stage. But this is a talk for another day and I can give you fuller references to these reports if you contact me.

I mentioned a few minutes ago the potential for e-Science to inform investments in e-learning and to share common e-infrastructure. The Obama administration is trying to do just that through the Department of Education and will be issuing a report soon from a task force I have also been serving on entitled 'Transforming American Education: Learning Powered by Technology'. This is quite an out of the box report which will define, hopefully for the Department of Education, policy for the allocation of hundreds of millions of dollars in technology grants to the state /public education systems.

The most important part of the word cyber or e-infrastructure is infrastructure. As the UK has clearly recognized, ICT based systems have now achieved the high status of infrastructure, in fact critical infrastructure. Infrastructure is often taken for granted unless it fails, but when you think about it is the most complex and expensive systems that society creates for itself. But Infrastructure itself, I learnt, is a complex topic with history and theory and academic following. This slide points to an excellent workshop report you may find useful entitled 'History and theory of infrastructure: Lessons for New Scientific Cyber-infrastructure'. Actually while at NSF I learned myself another definition of infrastructure "it is something that everyone wants, but wants someone else to pay for".

I also read the UK's OSI e-infrastructure framework document that Carole will be talking about in a few moments, and I believe that it has the right vision and that it aligns well with our Panel's vision and recommendations. I hope that the two together will provide useful documents and that they will be synergistic to you as you move forward.

Now to turn more specifically to the report. Let's look at some background and creation and what we actually did.

We where given terms of reference. The reason for conducting the review were provided by the Steering Committee and the role of the Panel was to assess impact, assess and compare quality, comment on added values, and present findings and recommendations about the strength, weakness and opportunities for the future.

Input to the process included a 200 page evidence document compiled by the Steering Committee and the Secretariat, some additional information that we requested in writing during the week, and we appreciate the response that the community gave us to that request, the presentations and conversations during an intense review week, the panel's expertise and an evidence framework I'll describe in a moment. We worked face to face in and around Oxford for about a week and then continued the report writing asynchronously. You now have the draft document for discussion at this town hall meeting and an invitation to send written comments to me by Saturday. We will then rather quickly prepare the final report which we hope will contribute to positive decisions and actions for the future of e-Science in the UK.

This 'evidence framework' consists of the five topic areas shown here with questions and sub-questions plus an "other category". We tagged these areas of the framework as Future, Other, Globally, Impact, and Enables leading to the acronym suggested on the first day by Stu Feldman on the first day as FOGIES.

Members of the community, many here today I expect, also contributed their responses to the questions in the evidence document as well as other data. This was very useful to the Panel and we are in substitutive agreement with the self-assessment that you provided.

So these FOGIES, or old fogies if you prefer, formed teams to process the sources of information: presentations, field trips, the evidence and so forth in response to the questions in the evidence framework. The report actually does address all the questions raised within the framework but is not organized completely around the framework. The report intermixes findings and recommendations in a narrative way but does in section 4 attempt to summarize within the framework structure, and then to call out some primary recommendations in section 5. There is, what we hope, constructive redundancy between the sections.

This is a mosaic of pictures to represent a week of hard work by many people. Thanks to the Steering Committee and EPSRC staff who provided wonderful support for the process from take-off to touch down. Also thanks to you the community who put in enormous effort into providing data, delivering excellent presentations, and poster sessions. Your accomplishments and enthusiasm were infectious and motivated the Panel to take their assignment very seriously and intensely.

We'll turn now to a discussion of some of the findings and recommendations from the Panel.

The bottom line on our report is that the UK e-Science Programme is in a world-leading position. Investments to presence are already empowering significant contributions to the UK and beyond, but the UK must now decide, and decide quickly we suggest, whether to create the necessary combinations of financial, organisational, and policy commitments to

capitalise on prior investments and to move to the next phase of building capacity, adoption, and competitive advantage. e-Science is not something you do once and move away from. There is an organic, emergent process, requiring ongoing, coordinated investment from multiple funders and coordinated action by multiple research and infrastructure communities. Such multi-dimensional coordination will not happen by accident. The UK should continue to nurture a robust infrastructure that couples and balances research, application development, and training processes. None of this is easy, but done well could achieve enormous reward. You'll note that as part of my jewel metaphor I added a picture of the Golden Jubilee diamond, currently the largest faceted diamond in the world at 755 carats. Shortly before leaving, some colleagues were reviewing my slides and suggested that I should more appropriately compare your science programme, e-Science programme to the Cosmic Diamond described in this BBC story a few years ago and weighing-in at 10 billion, trillion, trillion carats. This article contains the enormous understatement that the diamond star completely outclasses the largest diamond on earth. Well I'll let you decide which jewel you want to be.

At the end of the review period we were sequestered in a lovely estate near Heathrow to collect our thoughts. I don't know if any of you have visited Alcatraz prison outside of San Francisco, but you go in one of the cells and you can see the beautiful city in the distance but you can't get there, that's the way we felt. What I will show you and read to you now is the summary of significant strengths and weakness that stood out in the Panel's minds immediately after the review week.

So, on the strengths side:

- There was strong consensus that you're producing competent people for both academia and industry, creating enriched interdisciplinary collaborations including (faculty & students) that are increasingly important to the frontiers of scientific discovery.
- Creating interdisciplinary doctoral training programmes
- Stimulated industry to take up e-Science.
- Situated the UK reputation more firmly among the top nations.
- Accelerated the penetration of the e-Science into the UK and Europe.
- Contributed significantly to establishing standards and tools for National and European consortia network science projects.
- Stimulated university leaders to establish e-Science buildings and organizations.
- Promoted recognition of digital data as an asset and the need for greater attention to stewardship, although with that there is still a caveat lacking adequate repository capability and train human capacity and that's the case everywhere.
- Supported directly and indirectly scientific international collaborations, but believe that there was surprise that there was not much going on with developing countries, well at least we didn't see any.
- Enabled science not otherwise possible was being enabled
- That you initiate a national framework for sharing large-scale resources that will be increasingly important to both large and small scale science research and education.
- Supporting important and interesting work in the humanities and social sciences inclusion of both of those fields was viewed as an asset.

- Promoted increasing standardization to support data interoperability and aggregation.
- Promoted interdisciplinary work and provided mechanisms to link projects to projects on an on going way (All-hands Meetings; community building activities)
- Leveraged investments from other sources (regional, industrial, international)
- Stimulated local economies.
- Accelerated the productivity of researchers and accomplished some knowledge transfer, although there could be more.

On the weakness side by far the dominant concern was:

- Too early and rapid reduction of core funding and high level leadership for the programme resulting in sense of abandonment by some researchers and in fact career shifts.
- Failure to reap the benefits of prior investments.
- Reduced momentum of an important movement in which the UK had established a global leadership and a perception by some that the RC's did not really appreciate the strategic importance of e-Science and the special handling that it still needs.
- As everywhere there is still the lack of models and funding for sustaining and maintaining software, platform/infrastructure operations, and data repositories. If this is truly an e-infrastructure it has to be supported in a sustained way. Faculty researchers and so forth will not get their tenure promotion or their Phd graduation on an infrastructure that is volatile in coming and going.
- There were missed opportunities to transfer successful software tools/systems and best practices to other fields and lacked regularized processes and organizations to do so.
- Lack of adequate structure, leadership, and resources to promote constructive interplay and achieving balance between the generic and specific e-infrastructure and between e-Science core and disciplinary research (I'll come back to that in a moment).
- Some people on the committee felt that there was an over focussed, particularly going forward on 'grid' architecture, that it was a good fit perhaps for the particle physics community but not for all domains. But then is was also recognised that there were variations in what people mean when they used "grid". It can be narrowly computational sharing, it can include data sharing sometimes used ominously with all types of resources as in a collaboratory. Knowledge Transfer (KT) potentially higher than was actually achieved. Need more systematic and staffed KT processes.
- Finally there was noted a shortage of women participants (as judged by data in evidence document and gender balance during review). It was noted that there was some important areas of e-Science that did not seem to appear at least within the review process: Developments around sensor networks; more emphasis on usability human-computer-interaction; and the understanding of social/behavioural barriers to technology mediate science collaboration and ways to design systems and processes to reduce barriers, in other words social science playing a role in synthetic design in these new organisational structures, not less users.

A panel member from industry observed that a useful model for understanding the state of the UK e-Science programme comes from the high-tech marketing literature, particularly Geoffrey Moore's 1991 business classic '*Crossing the Chasm',* which uses the standard

description of the Technology Adoption Life-Cycle. Moore notes that "... the point of greatest peril in the development of a high-tech market lies in making the transition from an early market dominated by a few visionary customers to a mainstream market dominated by a large block of customers who are predominantly pragmatists in orientation." The visionaries are willing to adopt pieces of technology that will allow them to do things they have never done before, despite the risks and difficulty. The pragmatists on the other hand want a reasonably complete package and the ability to solve problems without expending undo amounts of effort.

Also coming out of the post-Oxford panel meeting was a set of recommendations for actions/ priorities over the coming 5 years and informed by a vision of approximately the next 10 years of evolutionary change in the conduct of science particularly enabled by e-infrastructure.

On the 5 years theme of research through sustainability for e-infrastructure:

- Suggestion of maintaining critical-size centres was already established but dramatically trying to increase the adoption and the involvement in these size centres.
- Provide mid-term career paths for current e-Science personnel. A lot of concern about providing the right kind of sanctioning, incentives and reward structures for particularly mid-career people working within the e-Science framework.
- Build stronger ties/bridges between the HPC community (e-Science should include modelling simulation prediction, as well as data mining and activities.) I think for historical reasons these communities are kind of separate in ways that need to be addressed going forward.
- Developed increasingly shared infrastructure that is reliable, mature and sustainable, a theme that will repeat itself.
- Seek and establish strong national leadership and stable cross-council coordination with real authority.
- Community building and training.
- Systematic dissemination of best practice.
- Emphasise packaged and hosted service-based e-Science, part of this crossing the chasm strategy.
- Keep up, but at the same time, when does that you have to keep up with emerging/ evolving new technologies including cloud computing graphical process units (GPUs) and so forth.

On the ten year time frame we are predicting transformation different disciplines but certainly not all occurring at the same time.

- Continuous evolution in underlying technologies: Grid, SOA, migration through the cloud, increased innovative intelligent sensors and so forth, data rates and resolutions temporarily and spatially produced by those sensors.
- To stabilise a hierarchy of distributed resources, with large national or international scale facilities at the top and increased emphasis on shared leverage adages at the national and international level for very expensive high end resources such as Pedi scale or potentially ecta scale computational resources.
- Data sets it's believed are in the spirit of the 4th paradigm, I mentioned, earlier becoming new types of instruments from many fields. We will experience a self-

amplification of data and that this data becomes easier to use and to extract more knowledge from data, more data will be created and the demand for sharing will increase. But simulations together with data mining will be adopted by more and more disciplines and that's one of the reasons that both the computational and the data intensive side and the appropriate infrastructure to support both those activities need to be more effectively brought together, and believe that data growth will occur beyond the current imagination. If you want some more compelling arguments for that you can refer back to that 4th paradigm book that I mentioned earlier.

- Also recognition of the barriers or the challenges of sociological change that go with the technology change, pursuit of cultural changes because e-Science becomes "socially" more accepted and more and more disciplined with increasingly the pressures adopted to stay competitive. e-Science ("computational") thinking as is called in the UK becomes an integral part of the everyday curriculum at all levels of education and it would be hoped that a substantial fraction of the research community becomes exposed to e-Science, in some sense the mark of success would be when the 'e' goes away.

We ended with a dozen recommendations to kind of summarise our thinking and recommendations and I'll now conclude by quickly running over these. These came after the process of writing the report and reflecting on both the meetings at Oxford and a more careful reading of the evidence document.

In the area of structure and leadership, as mentioned several times, the highest priority we believe is for you to quickly establish an organisation and management structures that continues to treat e-Science as a designated strategic initiative spanning all Research Councils and having ongoing designated funding. We realise that we are recommending this under conditions of severe financial constraint, but would argue that this makes it even more imperative to have better coordination to leverage the scarce resources from all parties to minimize redundancy and waste.

Provide high-quality dedicated leadership for a strategic e-Science Programme, and provide this leader with adequate authority at a high enough level in the organisation, and resources to catalyse real synergy within and between funder, research, and service provider communities. The leader needs resources to co-fund with specific projects funded by the individual Councils.

This slide illustrates (this is a slide that I developed while at NSF, I had similar challenges to what I am describing here) it illustrates one of the most important dimensions of the many balancing acts that are required for skilful management of an e-Science programme. The graph shows four quadrants of research funding. The left side is funding to create intellectual assets (knowledge) and the right half is funding to create e-infrastructure assets as broadly defined in the report to include equipment, institutions, and human capital. The upper half corresponds to discipline or field specific funding and the lower half corresponds to funding of sharing, either shared interdisciplinary intellectual activity or shared e-infrastructure creation and use. Now research funders like the NSF and the Research Councils are based and do a good job typically at funding the first quadrant. The domain specific research programmes, and in fact organised around disciplinary boundaries, and usually a pretty good job at funding the specific e-infrastructure requirements of that domain, although we all have this challenge of the balances between funding the research and funding the supporting infrastructure and not letting that balance get out of whack. But a successful e-Science programme requires attention to funding in all of these quadrants and in the Panel's opinion, to being productive in moving more emphasis on funding to quadrants three and four. Ideally you want to create the

conditions for best practices, software, and data flow across these quadrants so we're talking again about a balance and a synergy between funding in all of these quadrants. We need to realise in distinguishing good intentions for cooperation, when the realities of traditional budget processes come in to play, competition between the disciplines comes into play and e-Science rapidly shifts to me-science.

So we suggest in the report consideration of a hierarchy of e-Science management structures, starting from e-Science centres situated in academic institutions and regions that coordinate within their local community, a network of e-Science centres that coordinated across the country, a coordinating mechanism across the Research Councils, and we even go on to suggest that you have a somewhat unique opportunity certainly compared with the situation we have in the US, to have greater coordination between components that are now all housed within your BIS ministry, namely the Research Councils, JISC, Higher Education Councils and various Industrial Innovation and Funding agencies.

Establish more systematic and better supported mechanisms, including targeted funding, to nurture collaboration and bi-directional knowledge transfer between academic and industry in the creation, provisioning, and application of e-Science, with at least 3 goals in mind:

- To accelerate transfer of research outputs into beneficial innovation and economical advantage;
- To enlist industry in the creation and provisioning of the e-infrastructure, perhaps even provisioning, and;
- To help industry adopt and tailor best practices and services from e-Science to enhance their own productivity.

I want to share with you some information about some unique, at least in the US, partnerships now recently underway between the NSF and Google and Microsoft and perhaps this is happening here too (if its not you may want to explore it), that are providing the US e-Science community access to enormous clusters of computers and novel software provided by industry at no cost, that are beyond the means of universities or even the NSF to fund. The most recent, this started under an initiative called "Clue" between NSF and Google, and just last week there was an announcement of a similar partnership occurring between the NSF and Microsoft, to enable e-Science researchers to experiment with the use of massive cloud computing resources for research, that would be provided by Microsoft, and the URLs and this slide will give you access to various press releases and solicitations.

The various e-Science Centres now in place, some supported by the Research Councils and some not, are recognized in the aggregate as a tremendous resource for the UK going forward. Just as we are calling for the RCs and even BIS to coordinate the many moving parts and goals of e-Science programmes, we are suggesting that the e-Science centre network do the same on the front lines of science, where the rubber meets the road. We're recommending that this be established remit of complementary expertise sharing, not just be copies of the same thing, that they emphasise expectations, that the centres be proactive and engaging with each other, with industry and other countries, and that we establish the correct balance between sustaining the network but in a way that periodically, lets say every 5 years, requires re-competition to enable new entries into the field and to retire less effective activities and that balance within infrastructure is particularly a tricky one.

Sustaining the operational e-infrastructure for e-Science created to the present informed by an ongoing review of future needs and evolving in several directions to higher capacity of computing, to more complete functionality and to leading-edge, distributed system architecture.

In particular the UK needs to invest in e-infrastructure in ways that anticipates the continuing exponential growth in scientific data and the increasing ability to extract knowledge from it. That it provides the UK research community with access to petascale computing and anticipates the future needs for access to exascale computing (again I would suggest exploring doing this in a consortia way internationally); it continues to build on and strengthen the grid model of distributed computing, but also explore the adoption of emerging models of cloud computing and more centralised forms of computing.

That it recognise and programme calls and funding policies, that success in e-Science requires people working together in several complimentary roles that need to be funded and rewarded appropriately. There are people seeking to innovate in the application of e-Science to the methods of their field to their domain, but there are also people seeking to innovate better e-Science methods, practises, and services. I should say I hope that its recognised that e-Science as I'm using it is both a means of supporting research and is an object of research itself. There are people who design and build reliable production-grade systems and these are not computer science researchers in general they are specialised system builders and there are people who administer and operate in a reliable way supporting e-infrastructure.

We need to better define and reward new professional identities and job types within academia particularly those that span role two and three mentioned above.

This balance of complementary roles and creating mutual benefit working relationships is extremely important and many years ago I adopted this topological construct known as **Borromean Ring** to try to indicate this balance. The Borromean ring, three rings that are taken together or are inseparable, removing one destroys the whole construct, it's a peer to peer structure put together by mutual benefit and destroying the overall effectiveness if any of the three rings are removed, and in this case I am associating the rings with those that are seeking transformative application through e-Science and e-infrastructure to their scientific domain, to those that are concerned with the creation and the provisioning, and to those that are concerned with research both social and technical research related to deeper understanding and enhancement of future e-Science environments.

A continued focus and provision of incentive and funding to promote the sharing of e-infrastructure to move from the top part of that quadrant to the lower part of the quadrants of the graph I showed you a moment ago. Important not only from a cost-effective and now increasingly energy efficient use and environmental-impact use at least in the US, there is a growing awareness of the enormous amount of energy that is going into computing, but also perhaps even more importantly for facilitating intellectual interoperability, avoiding balkanisation between fields, institutions, facilities, and data resources particularly in the presence for the many grand-challenge research challenges that are intrinsically and interdisciplinary.

Since scientific research is intrinsically global, place great emphasis on creating UK e-infrastructure that harmonises with the e-infrastructure in other countries, particularly around data sharing.

Encourage and support even more participation of the arts and humanities. We think that you have some very good start in that area and that that's very important for them to be

included (and I talk in the report a bit about emerging of “corpus computing” as a new important field).

Encourage and support even greater leadership by the social science research communities. We are pleased to see that the council seems to be taking a leadership role here, but not only as a user of e-Science but as a contributor, particularly to deeper understanding of the human social behavioural dimensions, particularly working and distributed of global scale collaborations.

In crossing the chasm, again the call to address that and find ways to accelerate adoption of e-Science methods into the mainstream markets of researchers but at the same time we’re faced with the challenge, refreshes the investments in the “early market” to produce the next wave of innovation in e-Science services and application. This involves training and tailoring current services to more specific needs, and this process needs to be informed by formative assessment, by continuous monitoring, and by a culture of participatory design by those creating and those using e-Science in e-infrastructure.

Data stewardship recurring theme of data continued the strong focus on creating practices and services; complement and broaden the activities of Digital Curation Centre to deal with not only coordination and research, and about preservation actual provisioning of services for the community, and at least consider a highly centralised, large data centre model for the storing of information keeping the bits alive, with a distributed model of curation by disciplinary specialists, and seek and promote international cooperation.

We make just a broad statement that openness everywhere, and I threw in here the thing you can’t read but may want to look at more carefully, a graphic that I prepared some years ago to help people at NSF understand the broad range of openness. Openness means many things and I’m suggesting here openness in many different dimensions needs to be a general policy within the e-Science programme.

I threw in something that I think is probably too cryptic and needs to be illuminated more fully in the final version of the report, but I called for pursuing what I called ‘functionally complete, four-quadrant research environments’ and this is basically a call for more serious attention to virtual research environments and to what I would call high performance collaboration as opposed to just high performance computation. The origin of this term four-quadrant just comes from this two by two of place and time, four different quadrants of interaction between people, information and facilities, same in different time and place. The problem that I encountered when I used the term ‘virtual environments‘ sometimes is that people think we are consciously excluding the same time same place quadrant, the upper left quadrant, and consider the collaboration had been some how second class. What I’m calling for, the reason I am using kind of non-standard language, is for a more systematic look at how you use all four quadrants and how knowledge flow and knowledge creation process is to be mapped more effectively and to a systematic way of traversing all four of these quadrants including the most precious the same time and same place. For more elaboration on some opportunities and research agendas associated with this I refer you to this report ‘Beyond Being there: A Blue Print for Advancing the Design, Development, and Evaluation of Virtual Organisations’. And again what I am calling for is a theme of high performance collaboration, which I claim is a kind of an overarching theme that would pull together all of the other recommendations that we have put in place.

So one of the recurring themes in our report is that creating a transformative e-Science programme is a very complex multidimensional balancing act. It’s important and it’s

complex and tricky. When I generated the word cloud for this report, just for fun, I was surprised at the relatively occurrence of the connective word “also”, actually it is surprisingly big in the cloud and I think that may be indicative of many co-dependencies that we talk about in the report. But more to the point, while I was strolling doing one of the rare breaks at the Panel met in Oxford, I captured this street performer with my iPhone. Let me play this for you. So this struck me as a perfect metaphor for the balancing act theme that we recurred to in this report. It also could be thought as the representation of the crossing the chasm challenge that we talked about, but I sincerely hope that the analogy does not go any further to include “fiddling while UK e-Science burns.” Thank you very much.

Question and Answer discussion

Dr Dave Snelling (Chair of Review Steering Committee)

The floor is open at this point, any questions for anyone present? Not only questions, comments, whatever? Doesn’t have to be question. I would ask you state your name and which institution you are representing.

John Brooke, The University of Manchester

I’m very interested in your recommendation about the career path for the people in categories 2 and 3 producing e-Science, innovative e-Science, infrastructure who are not catered for under the current academic structure. I happen to notice people have left the e-Science programme precisely because they couldn’t get anywhere within their institution and in one or 2 particular cases it was an immense loss. Do we have any pointers that the UK can look to, maybe in the US or in other places, where people who start off working with these large scale infrastructure, developing new software, new ideas, and new research methods really, but outside of the classic subject discipline in academia can actually get positions and get promotions within the academic structure?

Dan Atkins:

We have in many research universities in the US, we have several tracks, we have the normal professorial track, we have a research professorial track, which is typically characterised by the expectation that the person brings in their extra support to which extent they do that, they’re kind of tolerated. And so that fills some of the bill. There has been some success in establishing a clinical research position kind of by analogy to the medical field that are actually rewarded for competency and practice as opposed to original research.

I introduced that track when I created the school of Information in Michigan. We do have some large centres such as the NCSA, the InCar centre, and others that have regularised staff members of the sort you are talking about. But it continues to be a problem a problem, its also very common when a budget gets cut by the NSF – that those are the first to go with the expectation that graduate students, or the professors in their spare time is going to do that. It’s actually very inefficient to have people that are ill suited to do those things, expected to do it but, I think also, I didn’t mention that, but I also suspect that here, as other places; there are certain impediments to incentive structures and rewards because of the way you do counting and accounting. You have this kind of highly numerical based assessment activity which I gather requires contributions to be kind of put in one bin or the other and that people who span multiple bins sometimes end up in either and that might be something else you need to address as to what counts and how its counted.

Brian Collins, Chief Scientific Adviser, Department of Transport at BIS.

As Chief Scientific Adviser I pick up some of the co-ordination things that you were talking about earlier on. I'm also Professor of Information systems at Cranfield. In the Department of Transport we've actually sponsored the development of a sensor network, measuring air quality in collaboration with Imperial, Newcastle and the Cambridge e-Science community. The Brits in the room will be pleased to know that that is likely to be deployed around Heathrow for measuring air quality in support of policies for development of aviation in this country.

But what I'd like to explore is, sparing John Taylor's blushes sitting next to me, this is one of the very few national scale initiatives that I've seen in my lifetime as a scientist in this country. And one of the things I don't want to loose and I maybe able to influence I'm told looking backwards at everyone in the room, is how do we maintain national scale in the exploitation of what we are doing – I'm more interested in exploiting in the instrumentation – you talked about instrumenting through sensors as one of the neglected areas, that we could actually with our smart infrastructure, whether its energy, transport, waste, water – we could instrument a lot more of what we've got, make much better use of what we've got as we go forward. We have the science and we have the engineering. We perhaps don't have the data manipulation and understanding of how to draw conclusions from what we will instrument, but it is something we can do at a national scale. So, I will be looking for expressions of interest, not necessarily for money, expressions of interest, but I do wonder whether, in your experience perhaps in other countries, given we have 2 members from other countries on the panel, whether that's something you have observed in other places around the world because you talked about international collaboration as well. All countries, all developed countries are going to face the problem, developing countries as well, so instrumenting our society to make better use of our assets seems a self evident thing to do, this is a national scale initiative that provides us with a spring board to do it, and how do we get that done?

Dan Atkins:

First I certainly commend your ambition there. One charity that we are using at the NSF is, we have a separate budget for major facilities and we've now, you know that was set up to fund large instruments for physicists and for light sources and so forth, but now the notion of facility is being broadened to include distributed things and sensor networks and so on and that's causing…that's making fairly large amounts of money available on a competitive way for a community to come together like the Ocean Observatory project or the Neon project and so forth to put in a large sensor, a data repository strategy and so forth that would then serve a wide community of research. And so part of the answer to your question is bound up in broadening the definition of what a facility is and how you go about creating and supporting it.

Malcolm Atkinson, University of Edinburgh

I really am delighted with the report and very impressed with the huge amount of effort that the panel has put in and I think we've got a lot to build on. But I'm slightly worried that your balancing act is too easy. It seems to me that you have an octet to balance because as well as those views there is another critical one which I think, partly through leadership and partly through I think the right time, worked well in the e-Science programme and that is the balance between bottom up effects and top down effects. So I completely endorse the notion of having an organised structure, but one of the real challenges is to find ways of stimulating bottom up effects as well, managing the scale up at the same time. And I think we've seen for example in networks where we have something like Jeone in Europe

connecting the countries, then country networks connecting to universities, then universities doing their own thing but still innovating in the way they do it…but we need something similar in the models for developing at least infrastructure and also we need an environment which encourages the innovation from the bottom as well as the top. And I'd like to know if you manage to get that balance in the NSF?

Dan Atkins:

I didn't mean to imply that the only balancing act is that optimal placement of funding and that two dimensional place. There are many, many dimensions of balance which is implied which I didn't make explicit but let me reply briefly to what you just said.

First off, the style of leadership which I am calling for is an altruistic leadership and one leadership with resources to facilitate the collective good and capture and vector and herd the cats of all the competencies you have in some more optimal way. Secondly, of course we all know that at the extreme technology can be used in prescriptive ways or in permissive ways, I mean banks use it in very prescriptive ways so that you go to a bank and a teller can't really do much more for you than you can do for yourself, that's built into the system. The approach to provision of ICT for science in education and learning needs to be more on the permissive side, its to permit people to do what they do better and so forth and so that's an important factor. Having said all that though, when you get down into the infrastructure layer, sometimes somebody has to break some ties about which of the many standards get used and so forth to achieve the collective common good of economies of scale of interoperability of intellectual flow and so forth and so on. And so that's another dimension of the balancing act that we're talking about but I'm certainly not, in fact when I started, when I wrote that, chaired that cyber report I was called to the Whitehouse by the presidential science adviser saying 'was I going to go to NSF and tell the physicist what they had to do and couldn't do if with technology'? Of course I said no, I was there to try and help them realise their aspirations and so definitely not calling for a top down, but I am calling for a reasonable balance between mission authority and resource to guide the collective good.

Sally Jane Norman, Newcastle University

Just a question about the gaps in programme conceptualisation you referred to, the sensor networks has already been picked up on but I was curious as to what kinds of gaps you were spotting in usability HCI? Whether these were coming from the conceptualisation scientific side or collaboration?

Dan Atkins:

Several of the panel felt that there wasn't enough systematic analysis of the software from a usability perspective and I guess I added the HCI because I associate that with the community and that maybe there needs to be more emphasis on a more human centred approach or a more participatory design process between the user communities. Its quite common for example in the HPC arena for the people to go out, that run those machines, to go out and buy those machines without necessarily asking the user community whether the architecture meets their needs or not. I think that in the case of the UK that's one of the reasons that HPC here largely means modelling and simulation, it doesn't include data, but it shouldn't be that way and there's much more nuance versions of what I'm talking about

Marina Jirotka, Oxford e-Science Centre

My question, comment really, is to ask you what your thoughts are concerning the next generation of e-Science researchers. I know for example at my own establishment with

DPhil students that I have, they're very excited about the whole notion of doing interdisciplinary work, multi-collaboration, crossing disciplinary boundaries, and yet they are constrained by a reward system, I'm going back to that merit/reward system that does reward them for individual effort and it goes to individuals rather than the team collaboration that we're seeking to promote in the e-Science programme. I wonder whether you have any comments on that. Can we envisage a doctoral programme where you're actually rewarding collaboration as opposed to individuals?

Dan Atkins:

So you're asking about, in the context of promotion in tenure kinds of considerations?

Marina Jirotka

Well, just in terms of individual doctoral students that are looking to make a career in e-Science. We still in some ways don't practice what we preach. I mean we are not promoting collaboration at that very early level where you're training students to actually know what it means to do collaborative work at that level.

Dan Atkins:

Yes, well I think that probably varies by field and institution. I guess, we have the realities of current disciplinary taxonomy and ultimately the need for doctoral students to convince a set of more senior people of the merits of what they're doing, so I think exposure to inter-disciplinarity, well, lets separate, the tools of e-Science will increasingly become necessary to be on the leading edge of doing research and I think that developing the skill and the knowledge and the access to that technology, doing that within an inter-disciplinarity research context maybe a somewhat different thing, although ideally e-Science platforms, e-infrastructure can facilitate interdisciplinary research and sharing and so forth. There are many people, including myself that advocate that most of the exciting frontiers of science are in the white spaces between fields. There are some people in medical areas, for example running around saying that disciplinary research is dead and interdisciplinary, and so forth, so I think this will be an evolutionary process.

Where I thought you were headed was about, back to this issue about reward structures and how do pre-tenure faculty get tenure and so forth and that's a very tricky issue. I generally recommend that you the challenge that a junior faculty member faces is establishing personal identity in some field but also some balance of showing that they can be members of interdisciplinary teams and achieve something in the collective. The School of Information that I helped create in the university of Michigan is intrinsically an interdisciplinary school and so people are rewarded for being interdisciplinary and we may be seeing more of those kinds of organisations evolving perhaps from the stuff what Anne's trying to do at Oxford and others will try, that would be the first class norm within that particular culture of that rewards structure and so that would argue that we need to get more autonomous academic units that can control their own destiny and that regard but that could happen as well.

Dieter Heermann

We do have a programme running now for actually about 20 years for interdisciplinary scientific computing where doctoral students are being trained and the young researchers do make a career so it actually is working.

Dan Atkins

So there may be some other models not what I'm aware of.

John Darlington, Imperial College

Thank you for a brilliant report I have never seen such a clear vision of what's happening and how it was organised, many of the musing of the e-Science Programme are very clearly set out there. Thank you very much, and if you're looking for a job there's a post for you here.

Can I just ask you one of your main observations was that the e-Science programme was multidisciplinary and broke the barriers between disciplines and applied research. The observation is now are that services have gone internet, that services have gone to the internet have gone to cloud computing and now you have the internet with several billion people collecting and adding notes and that is a gigantic resource. Isn't it the case that now the next silo is broken down, is the silo between academia and the general public looking at some very wide open space where transformational activities can occur, these computational paradigms and collaborative paradigms apply just as much in that arena as they do in the scientific arena so there's a lot to be learnt and applied there?

Dan Atkins

Thank you, I use this occasion to say that you'll recall earlier I talked about e-Science changing the what, the how, and who participates, and in who participates I include greater collaboration between citizen scientists and professional scientists. There is a lot of it going on within the astronomy community but that kind of collaboration is broadening and enabling students in middle school or even elementary school to actually participate in authentic science and to develop interest and passion.

Neil Geddes, STFC

You already hinted that there is a role and opportunity for BIS and expands a whole area. I wanted to pick on many of the things in the full report that are areas that you recommend are sustained or even grown, are areas which are either infrastructural or are either collaborative in the sense that John was hinting at, and therefore have no natural home at present. So given the constraints and especially the economic constraints we currently find ourselves, I wonder whether you have anything else to say, to give BIS some ideas for example since you suggested that they were in a unique position to tackle these problems or how we do develop and support some of these infrastructural or cross activity opportunities?

Dan Atkins

Well I think you, part of what were recommending is a more regularised cross council mechanism with appropriate leadership and some what analogous to the office of cyber infrastructure I created at the National Science Foundation that has a seat at the table. You know I sat at the table with the equivalent of all the research councils CEOs. I could have the status to go talk to the high level representatives at the NIH or the Department of Energy and so forth and do deals with them. I had about 25% of the total budget that was going into e-Science e-infrastructure in the NFS. That gave me enough to do deals with the others and get them to invest in ways that satisfied their upper quadrant needs, so for example I discovered there were 19 different workflow projects going on being funded by the NSF and I was able thorough persuasion and co-investment to move some of those into convergence. I discovered there were 100s of millions of dollars in these major various facilities that were going into data repositories. I was able to bring some of that together and so forth. So I'm not talking about a huge organisation, I didn't say in the report, but I'll say it now, what you've managed to achieve with, well the total money that

went into the core programme in the 5 year period was considerably less than the money I invested in one pediscale computer at the University at Illinois and the return on what you've got is just incredible, so if you had the appropriate structure and the appropriate leader and they had 30, 40, 50 m pounds to do deals with, I think that can make a huge difference.

Dave Snelling

Before moving on to our next question, I'm going to give Dan a short break and open up the floor to anyone who would like to answer. We had a comment earlier about the possibility of instrumenting society. Is this something we might want to do for one of our cross research council themes after we finish with energy and health and all the other easy ones?

Dan Atkins

I actually touched on that in a draft of the report and it was severely rebuked – they didn't want to instrument society!

Dave Delpy

Should I comment, or make a point about the research at the RCUK cross council themes? In particular, responding to Brian on this one. I think the cross council themes have been extremely successful and this was obviously a very early exemplar of that. The point that was made was how do we translate this from a national scale research activity to a national scale activity of translation and I think one of the things the research councils are going to have to look at is how they transition the existing cross council themes into something which then works with the delivery arms of government whether that is a government department, whether its Technology Strategy Board or whatever, because some of the research council themes will come to a natural end in terms of pump priming the basic research but we don't want to just run into the sand. We have to find a way of transitioning them into that next stage which is what I think Brian was hinting at, and that's where this sensor array activity would be one logical extension.

Dan Atkins

If I could briefly comment on that example, there are ongoing efforts by the NSF to work with the mission agencies, the weather service or the others, to kind of adopt it so there is some proactive attempt to migrate there and you appear to do similar things.

Malcolm Atkinson, University of Edinburgh

So I think these things are being done at the interface to translate for example in Scotland there is an area where the houses are being instrumented to explore how much you can extend independent living.

I think the challenge is really to make a transition from the scale of a pilot project, such as the Message project in transport at present, to something which moved up to a real national resource, because as you make that transition, you depend on being really competent at e-Science. Judging the emergencies from the false alarms, as we're particularly bad at that in our intensive care units at the moment, but there are a relatively small number of people in intensive care so 90% false alarms doesn't matter so much, but 90% false alarms when you instrument the homes, or you instrument the sewerage system or the transport network, might be rather painful. So I think we have got to do a lot of foundational work to become really competent on doing this on a larger scale – we've

got to move up from the pilot projects of a few 10,000s house to a few yards or miles of sewerage system to something that is really learning the trade to do it seriously.

Sir John Taylor

A couple of comments if I may, I think on what you're saying there, it is very important to try and draw in the operators, whether they are companies or public authorities or undertakings or whatever, to really stress this for real because there is a whole raft of problems of scale which you've really got to get at and exercise and solve. Just one example, if you Google 'smart grids pilots' at the moment and just see how many different pilot programmes are going on between big companies and public undertakings, to try and see if you can actually deliver smart grids, electricity grids not computing grids. Its just one example of the kind of area where this programme might well make some huge contributions in helping people grapple with the problems of scale.

Just a couple of observations if I may from my time there, I think BIS has a tremendous opportunity in this infrastructure area, I don't know if Carole's going to touch on this, I would be surprised if she didn't, but one of the things we really had trouble with in the early days was the fact that all of the educational infrastructure for universities was dealt with by HEFCE and JISC and so on, and the interface to the infrastructure that was needed for the research councils and research groups was kind of tricky. And you might have an opportunity to revisit some of that now in the next phase and say how do we really get some clearer focus on the infrastructure for both sides, because as you point out so rightly, learning and teaching is a very important area where the use of these technologies and approaches is important.

The other thing was the social sciences and psychology and user studies and so on. In the early days I think we had tremendous fun engaging with many of the social science community, who let's say were fairly sceptical in the early days and began to realise that there was a tremendous amount in this for their subject. But lately over the last 5 years or so its given me quite a bit of pleasure to tease some of those researchers again and say you realise that if you look at social networking and face book and You tube and Wicki and all of those things, we have social/technical doing things faster than you know how to write a grant proposal to study them! The dynamics at the rate at which these are changing and evolving is completely out of whack with the way we usually study these areas. So I think there's a tremendous opportunity for the social science research community to think about serious new methodologies for dealing with the kind of phenomena going on out there.

Dave Snelling

In a sense society has already instrumented!

Ellen Collins, Research Information Network

I was really interested in what you had to say about crossing chasm and trying to move from those early adopters to wider audience. We are currently in the process of finalising a report that we have been doing a study on, 'use of web 2.0 among researchers' and one the most striking findings for me was that, even though a large number of people have not adopted these technologies yet, see them as the future of scholarly education yet they're still not moving to engage with them and start using them even though they believe that that is the way that academics will communicate in future. So I was just wondering whether you could say a bit about how…if there's any ways you've observed of actually crossing the gap and if so what they might be?

Dan Atkins

Well first, don't expect a wave of adoption of a community all uniformly adopting this at the same rate but rather a wedge adoption strategy where there will be people out front and the wedge will bring more people along, particularly as they discover they simply cannot compete without the adoption of this new technology. Secondly I do want to acknowledge something that Dr Delpy kind of alluded to a minute ago; that I'm solving this chasm problem is not going to be solved by taking all the resources of the research councils and moving it from funding of basic research to adoption strategies and hardening of codes and so forth. So throughout the entire report we talked about multi-funders, multi-agents, multi-performers, multi-everything coming together in kind of complementary mutually beneficial ways. So the adoption crossing the chasm strategy is a problem that needs to be addressed by perhaps shifting resources within universities, analogous to the things that Malcolm has been dealing with for years….the libraries are perfectly happy to do digital and paper, but when you start to try and confront trade offs it becomes a little bit tricky, or a lot tricky. So part of the adoption strategy has to be a replacement, a reallocation from the old to the new. It has to be having codes and interfaces that are useable and that meet the real needs and even the issue of identifying what real needs is a tricky thing because those of you that do this, I'm sure David and others, you have this tricky issue of the technologist and the user and you sit down and have a conversation and you say what do you need well what can you give me. So that's why the process so much needs to be one of participatory design, spiral design and not a strategy of give me a £1m in 5 years and I'll give you the greatest system in the world and trust me till then, but rather one of incremental stair steps and that has the advantage of both you start seeing a return on value sooner, so it keeps your confidence, but sometimes even more importantly it helps broaden the vision space of the user about what the possibilities are. So there's all this borromean ring stuff, all this working together stuff, I've been trying to talk about and the whole process for doing this is very critical and something we didn't go into in depth, but pure technology determinism with rare exceptions is probably not going to accomplish it.

John Blower, University of Reading

I was just interested in one particular entry in your report about agility and the idea that in the future we might need the capability to be able to put up and tear down collaborative environments quite quickly in response to opportunities and threats and so forth, I was just wondering if you could say a little bit about how we might get to that state of agility?

Dan Atkins

Partly that's in there because it's been my kind of primary research area for many years and we started out, we did some of the early pioneering collaborative projects at the NSF with space-Science communities and built what I call hard wire collaboratories. But the real challenges for the future are the ability to agile and quickly bring together the complimentary expertise that's needed for some problem and so we played some role in the Sars outbreak a few years ago of actually using technology to bring together expertise that had never actually needed to talk to each other in new ways and that kind of wetted my appetite for this being a good possibility. And I think it is conceivably more possible with the whole mash up service oriented kind of way of working. I think it could be an interesting correlation of migration more to the cloud model, so a typical example I talk about is the collabortory which says, studies combustion as its basic science but then when we have one of these disasters wild fires out in the west that we have every year in the States, then that expertise and those computational models conjunction with satellite remote sensing gets redeployed to monitoring that fire doing predictive modelling that

predicts that a blow out is going to occur in the next 30 seconds and getting humans out of harms way before that happens. The main point I'm making is to view this e-infrastructure as a multi use environment to support research to support learning and to support perhaps response to emergency situations and conceivably to do that in a way that builds synergy between those 3 activities.

Peter Ainsworth, University of Sheffield

I'm now I think sitting on a cloud over Michigan, Illinois, Sheffield and JISC. I'm an early adopter. My question really is perhaps addressed to Professor Smith. Its about the diamond, we started with the Diamond, this phenomenal achievement that has been brought about by this initiative that started in 2000, which was consolidated and further launched in 2006, and one senses the urgency of where we are at the moment. I think one of the most exciting things in my own modest little career has been finding myself funded by AHRC, then the EPSRC, goodness me, as a medievalist and now by an e-Science initiative with JISC to dig into data and talking to image analysts at ICHAS.

What's going to happen after May? I know its not right or appropriate to speculate about the Mandlesonian politics or Cameron or Brown or the rest of them, but I worry about the extent to which this crucial report about this diamond - the extent to which it is actually going to meet with the audience it really needs to meet - How are we going to effect the right kind of advocacy not necessarily with politicians but with civil servants? In other words how do we carry this message forward in such a way that it gets beyond a circular argument amongst the converted and begins to break out and shake up the people who really do need to be shaken up higher up the pecking order. Is that clear?

Adrian Smith

Well you told me all the things you wouldn't expect me to speculate on, so let me take refuge in a purely factual answer. In this stage of the spending cycle, let alone the electoral cycle, the commitments to public spending cross the board, but in particular in science and research, run through until April 2011. So by around September 2010, whatever else the world holds for us, there has to be a spending review which will re-look at and prioritise overall size of science and research spend, the allocation of that spend and the prioritisation within that spend. The process by which that will happen, there is already a commitment on my part, through the previous Secretary of State, John Denham, when we were DIUS rather than BIS, that one part of that would be a formal consultation with the Royal Society, the Royal Academy of Engineering the British Academy, the CBI, the Council for Science and Technology, and the gang of chief scientists in Whitehall, constant dialogue with the Research Councils, and I have no way of stopping everybody else joining in. So, there is infinite space and opportunity between now and September for you to make your case.

Dave Snelling

So I would say you have a nice tool to use courtesy of Dan and company at this point.

Carol Goble, University of Manchester

I hesitate to follow such a profound question. One of the key points that you raised was a notion of openness. You mention it quite a bit in your report, open data, open source, software and so on. How will BIS balance the requirement for openness, which we see as a foundation for science innovation, and the desire for exploitation which tends to drive intellectual property, land grabs by universities in particular? This question really goes to Adrian and David as much to Dan.

Adrian Smith

We had 20 years of kind of cultural incentivisation to universities to be very competitive and to grab hold of IP and to hold it, and there were very positive aspects to that. People's consciousness of the values that they produced. There is now an ongoing debate about whether the balance in the exact form of the culture induced was right and that debate will continue its obviously very relevant to the tension that you're talking about and there are out in the open major debates – is it called the Manchester Manifesto?, John Soulston and co. which is one end of the spectrum in an argument about what you do with IP. So I think that's an ongoing debate, with no easy answer.

Dave Delpy

Let me comment. I can't add a great deal more than Adrian has said. I'm a convinced open source academic so let me declare my bias right at the outset.

I think it's a discussion and an argument where probably the last people who need to be converted are the Treasury. I think all the evidence that we're not seeing is industry, in fact, is very much on side with this idea of open access in general and it sees in fact that it enables it to be more agile and in fact to gain greater benefit by being selective, identifying its niche and then having in effect, access to that data or that software or whatever. So I think we've got industry coming on our side, GSK have of course gone down that route considerably. The universities used to be driven by HEFCE and the metrics which HEFCE put in place to retain their IP. I think they're being a bit more sensible in their higher education framework makes some explicit statements about them looking at national good as opposed to local financial gain. So I think the argument is actually swinging that way, as I say the only people I've had arguments with where the market force still seems to retain some sways with Treasury but perhaps we can, Brian's nodding and shaking at the same time, it's a very live subject.

Dan Atkins

It's a peripheral question but I think you'll find interesting, the open course where movement that started at MIT is certainly flourished at the university all over the world now. But now in the US its been embraced by the K12 and in fact one of the prime recommendations from this Obama policy thing I mentioned earlier is, that the Federal government fund the development of basic open course textbooks, the best algebra 1 book in the world, and make that freely available as a public good and the State of California has now sanctioned at least 12 open course textbooks for use within the K12 system.

Dave Snelling

I'll close down the question as the industry guy here. I will concur that there has been a trend in terms of increasing the amount of acceptance of open source within the industrial community. Some of my worst enemies are quite a fan of open source which was quite a surprise to me because of the things we used to be fighting over in the past, so there is the shift in change towards a more open approach to the whole process.

Michael Foreman, university of Edinburgh

I just actually want to come in on the same thing. The openness, I actually believe that the open data will be critical in crossing the chasm. If you make the data open, then other people will come in and show people what could have been done with the data and that will pull people along. That certainly a view I have and I'd be interested in hearing your comments on that way of crossing the chasm.

Dave Snelling
My guess is the answers yes - it is a good way to do it.

Michael Foreman, University of Edinburgh
I do have a question – in the report you talk about the 'not invented here syndrome' and you didn't expand upon that at all but I thought it was worth comment and perhaps you could elaborate a bit on what you saw and what you think we should be doing differently.

Dan Atkins
The issue of peoples, particularly in academia, willingness to use other peoples things and in the whole grid work, for example there have been these instances of modules needing to be rewritten for nationalistic reasons as opposed to technical and scientific reasons, I guess we were just raising the sensitivity to that kind of conduct. And we see counter examples in traverner and other things which are now being broadly used. But that also relates to the comment I made when I was showing that two by two thing of the flow of those things in other words if some biology or chemistry field has come up with a great workflow environment that serves them. There should be some ways in this cyber office that could add the money that could make that a more generalisable, tailorable environment that other people could use, or could put money over into the other domain that could help with the adoption of that. That's the kind of value added that this entity could bring to the party.

Michael Foreman, University of Edinburgh
Just to add to that how could we structure it so the flow of methods between research councils works better?

Dan Atkins
I'm not going to comment on that.

David Delpy
Can I throw that back and ask for examples where it doesn't work because I think in fact behind the scenes, the flow of information between the research councils works really well.

Michael Foreman, Edinburgh University
Methodology in researchers supported by different research councils.

Dave Delpy
That's a different matter.

Jonathan Tedds, University of Leicester
One of the great things about the report I think, from my astronomical research background, is how you've clearly identified this difficulty of funding infrastructure through research councils and the questions that ensue from that. But I have another question because I think its related, which is I'm now working with the universities across disciplines to help apply some of this expertise in different areas, and really my question is, how can…what places the institute alongside the report you've made? How do we enable institutes to work with the e-Science community and perhaps that might be part of the solution, to not just relying on the research councils but we need to involve the institute

because they need to measure what they do in terms of the ref and other things much more than they have in the past?

Dan Atkins

I don't really know much about your institute strategy, but in the US if you take, for example, the National Centre for Atmospheric Research, NCAR, that's a very good instance of an organisation that does span the research through the provisioning of infrastructure in this case largely for data repositories and it's a consortia model and so I think we need to explore more consortia models. Again the balancing act of infrastructure of all sorts, not just ICT infrastructure, but telescopes and ocean going vehicles and all of that, is a very tricky issue for a research funder, and the NSF for example, about 30% of the budget now is going into the infrastructure and at some point you start having the infrastructure but no money to fund the people to use it. I would recommend though that the e-infrastructure needs have a chance to compete with the bricks and mortar infrastructure that comes from the astronomy and the physics and the other light source communities and so forth.

Dave Delpy

Can I just add one other comment, which is I think the communities, and I include the Research Councils as well as the individual academics and universities, need to also take heed of the examples that Dan gave of working with industry. I thought those two exemplars that he gave were a real idea of how we can move forward, not just reliant upon what is going to come from government or from the research councils, in effect from the tax payer, there are other ways of working. I think those were great examples.

Matthew Dovey, JISC

It's really a follow up to that question. A number of institutions have been working on better ways to support the researchers, better ways of liaising between the ICT services and the academics in what the universities need to do to support the research community, and there are various models emerging from, in Oxford their e-Science centre has transformed into, and I hope I don't offend by saying this, but a hybrid between a research department in their own right but also supporting other departments in research across the university so its somewhere in between. Other universities have begun to strengthen their library services, digital library services and outreaching to the researchers that way. Some universities now have a liaison role and what we just commissioned, a piece of work we just commissioned from the JISC, is to survey the various models that are beginning to emerge, to see whether we can extract some good practice there. This is the start of the process not the solution to the process and the big overhanging question is where the funding going to come from to help support this amongst all the other pressures on budget, and I'm afraid I don't have an answer to that but its something were trying to engage with.

Dave Wallam, University of Oxford

With the next generation of researchers coming through, being much more IT literate in all areas, do you think at this point really its time for institutions to be looking at their IT services, to actually be moving away from providing basic business functions, email etc that can be bought from any and all providers, to be really specialist support services that are actually use their business advantage in terms of research communities as much as possible?

Dan Atkins

Yes, and that's what I'm trying to do at the university of Michigan. I've taken a part time job as associate advice president and to move the enormous investment we have supporting machinery to supporting people to use the machinery and the reasons that we're in close consult with Google and Microsoft and others about outsourcing the fundamental generic services, so that we can concentrate on the values, using our scarce resources for value adding, which gives us competitive advantage. That's a whole other story we can talk about another day but that's definitely a trend and there's a version of that that needs to be adopted within the e-Science were talking about.

Dave Wallam

So yes, just very quickly very, interesting to give your competitive advantage and it was mentioned earlier we're looking here with, I think the Manchester document, I cant remember exactly how it was termed, about this different method of whether competition between institutions is really the way forward or as competitive as we have been. So that's very interesting…using our IT services to support competitive advantage or not being competitive.

Dan Atkins

Well one of the balancing acts is to figure out where you should compete and where you should collaborate, so you clearly want to cooperate on the provision of network infrastructure right, because you want to share costs and more importantly you want to be able to talk to each other over the networks but then you are going to compete for funding, that's why the mutual self interest, mutual self advantage, I think we all know that economist, certainly tenure faculty, cooperate for mutual self advantage and that's the kind of things you need to try to construct the conditions for that which will occur. I think that one of the reasons I'm so passionate about collaboration and interdisciplinary work is that early in my career I had the experience through this upper atmosphere research collaboratory to work with the leaders of the space physics community to work with top flight computers, social scientists and we together accomplished something that we could never have done individually and we took enormous pleasure and pride from that. I think once you've had that experience you want more of it.

Dave Snelling

Well I think that's a very nice crowning speech there. I think I will draw the session to a close at this point, two seconds breather but don't try and leave the hall unless you have something to go downstairs and set up for us or other emergency appointments to take off at. David, I think you're next off up here.

Dave Delpy

Well I won't keep you long because we have a much more important speaker after me. What I've been asked to do is to talk about very briefly about the process that we will now be going through with the next steps following this e-Science review.

So, what will these next steps involved? Well you've already heard from Dan about the fact that at the moment this is still a draft report, but it isn't going to be a draft report for long. You've been given, as is usual in academia, an incredibly short timescale in which to respond. You have the opportunity to feed in to the report and to make sure we correct any errors of fact or misperceptions and you've got to roughly the end of the week in which to do that. Atkins@umich.edu, but it's probably in the pack, so there's an element of speed to do that. The report itself, together with any additional comments you may wish to

make which are not necessarily relevant to be incorporated into the report, but which will advise us on the whole of e-Science research that we are funding, all of these will feed into the e-infrastructure report, and you are going to hear in a minute from Carole an update on that, together, obviously with a range of input and comments which we will get from a range of other stakeholders whether they be departments, universities, the research council institute and so on.

We will then, as RCUK, obviously have to consider what our next steps will be, both separately as in individual research councils and EPSRC will go through its consultation with its ICT SATs, its TOP and UP panels, with its strategic partners in industry, which it works closely with, so there will be a variety of individual consultations but these will then be brought back together and it will be RCUK who own this programme who will then consider the next steps jointly. We will be using this report, your comments that feed into it, and obviously the e-infrastructure report to inform our future activities, but as Adrian Smith said at the outset, there is a health warning, we will be identifying future priorities but those that we can actually implement will depend on our budget in 2011. We are essentially in the final year of our current three year spending round. My budget runs up to the end of March 2011 and it will be the bids we make this year that will provide us with the budget that will enable us to carry forward the recommendations of the report and the strength of the case this report has identified will really help us in arguing the case with government for an increase and a continued funding for research base in general, but obviously in the e-Science element. The Digital Britain Report, the fact there are government departments and government ministers that are focussed on the development of the digital and e-Science element of the economy will help us, but this report, its very strong recommendation of the academic base really will be very helpful in arguing the case for additional funding.

Once we do have our budget then obviously we will start to act on certainly the major commitments. There are some elements in the report that don't require a major commitment, and where individual councils or councils coming together in a bilateral or trilateral movement, can actually start to action these within the existing budget then I think we would try to do that as soon as we can, but the worst thing that can happen to anything like this is planning blight, that we delay in implementing things because we're uncertain about what our overall future budget will be. If we can afford to do some of the things that are recommended and we agree with then we should get on and do them. But then, finally, having got a budget and presumably allocated some priority funding, I'm sure you will want us to identify some priority funding in this area, we will publish an action plan as RCUK because its extremely important that you the community, and in particular those of you that were involved in the review, can actually see the way we've taken onboard, not just the general messages, but also the specific recommendations. So there will be a follow up action plan which will be published both probably through a series of meetings like this but also obviously on the web.

So that's the next steps a lot depends upon the budget and we will have to wait and see what happens after May 6.

I'm now going to hand on to Carole, Carole Goble who's going to give you an update on the cross council review of e-infrastructure, which is obviously very strongly linked to this and then when Carols finished will just quickly close this session.

Carole Goble

So I'm a computer scientist so I only ever use my own laptop – don't trust any of this other e-infrastructure.

[Trouble with her computer. Putting on a memory stick.]

David do you want to fill in?

Dave Delpy

My last slide is in fact a repeat of what David showed at the outset so I don't need to display it. My last slide was going to show what we are going to do when Carole finished, which is, I was going to close and I'll close in fact now by thanking you all for coming, for those of you that were involved in inputting to this panel visit and providing some of the raw data that they used. Thank you for the questions that you provided Dan with during the course of the afternoon, and to invite you at the end of Carole's talk, to join us back downstairs to the room where you registered and had lunch, where you can ask the questions that you wouldn't want to ask in public of Dan or other members of the panel and the other members of the research councils team who will be around. So I want to come back up after Carole finishes to support her at the end of her talk and then we'll go downstairs have some refreshments.

Transcript ends here.

Carole Goble's presentation was, unfortunately, not recorded due to a technical fault, however, Carole's presentation slides can be found via the RCUK e-Science review page at http://www.epsrc.ac.uk/research/intrevs/escience/.