

## CASE FOR SUPPORT: AUSTRALIA-UK COLLABORATION FOR THE EXPLOITATION OF GRID AND GEOSPATIAL STANDARDS (AUKEGGS)

### PART 1: PREVIOUS RESEARCH TRACK RECORD

The UK e-Science pilot project NERC DataGrid (NDG) was funded for three years from September 2002 to develop a Grid infrastructure providing uniform discovery and access to a range of environmental data across the UK. The prototype is focussed on the curated archives of the British Atmospheric Data Centre (BADC) and the British Oceanographic Data Centre (BODC). The middleware developed, however, will enable other managed archives and individual research groups to federate their data resources through NDG services.

The project has so far developed a number of key components:

- An overall metadata taxonomy ([i,ii,iii,iv]) providing a framework for decomposition of the NERC metadata domain. Key classes include usage metadata, domain metadata, and discovery metadata.
- A standards-based data model and markup, the Climate Science Modelling Language ([v]). This has been explicitly designed with a dual purpose – both as a semantically rich format-independent data representation language (when exposed through a service), and as a wrapper mechanism to encapsulate legacy file-based storage.
- A rich domain metadata model, or ontology ([i]) for representing and linking concepts around environmental datasets. This provides a means in NDG to navigate meaningfully between related datasets in a way hitherto impossible.
- A robust and scalable discovery federation mechanism based on the harvesting protocols of the Open Archives Initiative (<http://www.openarchives.org>).
- A formal software architecture based on the Reference Model for Open Distributed Processing (RM-ODP) that should capture requirements of the wider environmental community.
- The scoping of a scalable federated role-based authorisation framework that meets the requirements of the environmental community, and will interoperate with existing access control mechanisms. This is currently being implemented jointly with a partner project, the NERC Eco-Grid, extending the authorisation framework of the CCLRC DataPortal ([vi]).

A prototype harvesting and discovery portal has been implemented, with preliminary XML-based data extraction and plotting tools. The remainder of the project will focus on continued implementation and rollout of NDG middleware for data delivery and security, and systematic metadata population across the bulk of the BADC and BODC archives.

Standards for data, metadata and services are crucial to NDG, and considerable effort has been placed on following the developments of the ISO Technical Committee 211 for geographic information. NDG's data model is based on these standards (including the Geography Markup Language, [vii]), and the metadata model will support export of ISO 19115 discovery metadata. In addition, NDG delivery services will include the web service interfaces of the Open Geospatial Consortium (OGC). NDG has actively supported the move to establish a 'Grid working group' of the OGC.

A number of working links have been established between NDG and significant related projects. These include the US Earth System Grid (named collaborators on the NDG proposal), the EU MarineXML and forthcoming MOTIIVE (marine data harmonisation for GMES/INSPIRE) projects, and geospatial standards adoption projects of the World Meteorological Organisation (through the project lead, UK Metoffice) and the International Oceanographic Commission (through MarineXML and BODC).

#### The Australian Solid Earth and Environment Grid (SEEGrid)<sup>1</sup>

SEEGrid is an informal cross-disciplinary community of researchers in Australia. It has been established to bring together people in the earth, environmental and computing sciences to address the

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<sup>1</sup> <http://www.seegrid.csiro.au>

issues of “transparent access” to data and knowledge about the earth, and the available and potential technologies offered by the grid that enhance our ability to explore for and manage our natural and mineral resources. Its establishment followed a high-profile workshop<sup>2</sup> opened by the Australian government Chief Scientist. The key players in SEEGrid are all partners to this proposal (Cox, Atkinson, Wyborn, Woodcock, Müller). We list some key aspects of the work of SEEGrid members:

- Simon Cox has made extensive contributions to the development of international geospatial and metadata standards (Geography Markup Language co-editor, various OGC and ISO working committees, Dublin Core advisory committee, project lead for eXploration and Mining Markup Language)
- Rob Atkinson has driven much of the work of the EU MarineXML project, shepherding the proposed establishment by the International Oceanographic Commission of a marine standards registry including a standards-based ontology repository
- Dietmar Müller has co-ordinated the establishment of the Australian Earth and Ocean Network (AEON) to link Australia to a global effort dealing with large planetary-scale problems that can only be resolved by development of cross-disciplinary e-science for sharing data, concepts and designs, and at all scales

NDG has worked informally with SEEGrid in the past through MarineXML, a recent workshop ([viii]), and a joint submission to an OGC web services interoperability testbed ([ix]).

A widely deployed network data access mechanism for gridded climate science data is the OPeNDAP protocol. It has been suggested, however, that OPeNDAP is at variance with web service standards ([x]). SEEGrid is planning to work on harmonisation of OPeNDAP and geospatial data/web service standards, and have already commenced some discussion of the topic with the OPeNDAP development team. The work is highly relevant to NDG and will contribute to this collaboration. Rob Atkinson and Dietmar Müller are currently developing common semantic interoperability approaches across geosciences and marine sciences disciplines. This activity will directly support the dissemination of best practice and common approaches from the NERC Data Grid and SEEGrid collaboration into the broader scientific community.

#### The Tasmanian Partnership for Advanced Computing<sup>3</sup>

TPAC is one of the partners of the Australian national HPC facility, APAC, which has the mission “Providing the Advanced Computing and Grid Infrastructure for eResearch”. It functions as the APAC expertise centre for modelling oceans and atmospheres. In addition, it has set up the “Digital Library for Oceans and Climate” ([xi]), bringing together data resources of Bureau of Meteorology Research Centre, CSIRO Division of Marine Research, the University of Tasmania and the Australian Antarctic Division. The TPAC Director, Associate Professor Nathan Bindoff, was co-chair of the Data Products Committee of the global World Ocean Circulation Experiment ([xii]) – the largest coordinated global ocean observing experiment to date. APAC is affiliated to the Global Grid Forum and Australia’s next-generation advanced network<sup>4</sup> with a 10 Gigabit backbone. The Western Australian partner of APAC is IVEC, of which CSIRO (Cox, Woodcock) is a member.

#### National Oceans Office<sup>5</sup>

The National Oceans Office (NOO) of Australia is in the process of establishing a portal with very similar aims to NERC DataGrid. The Portal will allow users to research a marine data topic in one online location and pull together information from a number of participating Australian Government science and information agencies and museums. The system will be modelled on a web services, distributed architecture with three groups of components: a Marine Catalogue component, an Oceans Portal component and a number of contributing systems that provide web-service enabled content. In addition to the Oceans Portal, NOO is participating in a globally distributed bioinformatics network called OBIS (Ocean Biogeographical Information System).

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<sup>2</sup> <http://www.glassearth.com/seegrid.html>

<sup>3</sup> <http://www.antcrc.utas.edu.au/tpac/>

<sup>4</sup> GrangeNet (GRid And Next GEneration Network), <http://www.grangenet.net>

<sup>5</sup> <http://www.oceans.gov.au/home.jsp>

## PART 2: PROPOSED RESEARCH

This project aims to foster and exploit synergies between emerging developments in Grid computing, geospatial standards and the climate sciences through a formal collaboration across complementary projects in the UK and Australia. Specific outcomes will include a cross-equatorial resource-discovery and federated web services demonstrator, a framework report on integration of legacy geo-data resources, and standards proposals for geospatial data services.

### 1. BACKGROUND

A number of emerging developments within the interests of the UK e-Science pilot NERC DataGrid (NDG) provide a timely opportunity for their mutual benefit.

Through this project, a link will be established between NDG and a 'sister community' in Australia. In the absence of specific funded Grid infrastructure projects, informal collaborations are developing within the Australian 'e-Research' community. The partners to this project have established unfunded cross-domain and cross-organisation dialogue around the twin themes of Grid computing and geospatial standards. These themes are core to the NDG remit, and this project will bring these partners together in a synergistic coalition. The Australian partners participated in a high-profile workshop in July 2003 to develop the concept of an Australian 'Solid Earth and Environment Grid' (SEEGrid)<sup>6</sup>. The meeting was a rare confluence of geologists, oceanographers, computing researchers, government officials, and a UK e-Science ambassador<sup>7</sup>! The Solid Earth and Environment Grid currently exists as an informal "community" hosted by CSIRO. The most visible activity is a website which hosts workspaces for several earth- and environment-oriented communities, with a particular focus on the development of community vocabularies and their implementation in a standards-based framework. This project will build on the enthusiasm developed amongst the SEEGrid community and establish a formal collaboration among key players, aligned with NDG objectives.

The NERC DataGrid project will provide secure, integrated and uniform access to a wide variety of environmental data across the UK. The subject of this proposal is linking three areas of relevance to NDG - Grid technology, geospatial data standards, and climate science data. These are addressed in the following paragraphs.

During the course of the UK's national e-Science program investment since 2001, several significant changes have occurred in the middleware used to build Grids. First demonstrators used closed protocols such as the Globus Toolkit version 2, or UNICORE, to build bespoke 'hard-wired' Grids with limited flexibility. Specific interoperability projects, such as the EU-funded Grid Interoperability Project (GRIP), sought to develop mechanisms to enable such protocols to work together, and to propose standards for Grid middleware through the Global Grid Forum. Simultaneous developments for online services in the web community led to the definition of web services and standard protocols for so-called service-oriented architectures (the 'publish-find-bind' pattern of WSDL, UDDI and SOAP). Adoption of web service protocols as a basis for Grid interoperability was proposed in 2002 and endorsed as the Open Grid Service Architecture (OGSA) by the Global Grid Forum. The protocol-level implementation (the Open Grid Services Infrastructure, OGSi) applied extensions and conventions to standard web services, and represented a fundamental paradigm shift from the early grid demonstrators. A number of projects with significant investment in first-generation Grid middleware chose not to make a shift to OGSi. Just as other projects were coming to grips with the new web-service-based OGSi protocols and the Globus Toolkit version 3, it was announced (by IBM, HP and the Globus Alliance) in January 2004 that another major 'standard' middleware change was proposed - the Web Service Resource Framework (WSRF). This completes the convergence of Grid computing protocols and web services, with a number of specifications for adding statefulness to web services now on standards-track through OASIS.

The series of upheavals has made it difficult to steer a strategic path through the evolving landscape of Grid middleware. The response by many e-Science projects has been either to stick with the Globus Toolkit version 2 or to apply vanilla web services, handling state, where necessary, in an *ad-hoc* manner.

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<sup>6</sup> <http://www.seegrid.csiro.au>

<sup>7</sup> The workshop dinner speaker was Dr Anne Trefethen who presented the UK e-Science program.

Indeed, the UK e-Science Core Programme has recently published a policy document recommending an evolutionary approach to web service grids ([xiii]). This has left a significant deficit of opportunity for WSRF and associated WS-specifications as a Grid middleware, which this proposal seeks to address. One of the most rapidly-growing areas of web services deployment is in the geospatial data and GIS community. The Open Geospatial Consortium (OGC) is an industry forum developing open web service interface specifications for access to geo-data and services. A number of commercial vendors (including ESRI) now bundle OGC web services with their off-the-shelf products, and there are various examples of value-added integration of distributed geographic data and information using OGC services. Regular testbed exercises (through the OGC's Interoperability Program) provide the opportunity to evolve the technology base. NDG partnered with one of this proposal's collaborators (CSIRO) in an informal collaboration on a bid under an earlier such OGC testbed ([ix]). A specific deliverable from the present project will be an analysis report on the scope for 'Grid-enabling' OGC web services through profiling against WSRF specifications. This would provide a significant input to a future OGC testbed exercise and offer the opportunity for greater exposure of emergent Grid middleware standards. There is a growing interest amongst OGC members to explore Grid technology. The Earth-Observation working group hosted a Grid session at the most recent Technical Committee meeting, including a presentation by Tony Storey of IBM entitled "Bringing Grid and Web Services Together".

Related to the OGC implementation specifications are emerging standards for geospatial data, metadata, and services being developed by the ISO Technical Committee 211 (Geographic information and Geomatics). There is a fair degree of coordination between the two bodies - for instance, the OGC's flagship markup specification, Geography Markup Language (GML), is now on standards-track through TC211 as ISO standard 19136. Similarly, the OGC Web Map Service interface specification is being standardised as ISO 19128. The full suite of TC211 standards projects (there are now around 40 of them) present a formidable challenge to any project - such as NDG - concerned with interoperable geospatial data management. There is a natural synergy, nevertheless, between the ISO framework and Grid computing. An essential pattern of Grid computing is to virtualise networked resources. For computing resources this means encapsulating job queuing and operating systems, for instance. For data resources it means encapsulating storage location and format details. NDG has developed a data modelling and markup language - the Climate Science Modelling Language (CSML) - as a semantically-rich wrapper mechanism with which to virtualise file format details. This represents a novel approach to file-based data virtualisation on the Grid. Other data Grid technologies (SRB, RLS) virtualise file location, but not contents. CSML functions also as a data model, and has been based on a range of emerging standard conceptual models for spatial (ISO 19111) and temporal (ISO 19108) reference systems and geometry (ISO 19107), gridded 'coverage' data (ISO 19123), encoding (ISO 19118) etc. The knowledge base captured by these emerging standards represents a powerful implicit ontology for geographic data. Exposing legacy file-based data through a data model like CSML provides a generalisable pattern for virtualising data resources on the Grid. A deliverable of this project will be a framework report on such semantic integration of legacy data stores. Data structures based on generalised "maps" have a key role in managing observational data in many areas of earth science including geophysics as well as oceans and atmospheres. OPeNDAP and netCDF are well-known technologies in use by the oceans and atmospheres communities in this area, and these have also been considered for large-volume exploration geophysics data. These maps approximate with what OGC & ISO/TC 211 call "coverages" and serve through the Web Coverage Service (WCS). But ISO "coverages" are limited to spatio-temporal map domains, which are insufficiently general for many cases in earth observations. Cox, Atkinson, Müller and Bindoff are investigating this, and this work will also contribute to the data integration report.

CSML is an application schema of the Geography Markup Language and represents one of the first serious attempts at such a domain profile. Perhaps the most well-known, and considerably more mature, example is the eXploration and Mining Markup Language (XMML, [xiv]), developed by GML editor, Simon Cox - one of the partners to this proposal. XMML is the prototype for what is expected to be a set of standards ratified by the International Union of Geological Sciences "Commission for Geoscience Information" (CGI) - Dr Cox is on the governing Council of CGI. NDG's investment in GML and ongoing development of CSML will benefit enormously from this link. Dr Cox is also lead

author of the OGC markup language for Observations and Measurements, which has been incorporated in part into CSML.

The initial focus of NDG is on climate-science (atmospheric and oceanographic) data. These data communities have traditionally developed stovepipe data management and access infrastructures. With increasing awareness of the global nature of climate issues, there are increasing drivers to ensure interoperability. As part of the original proposal, NDG identified the US Earth System Grid (ESG) as an infrastructure with which to peer. Ongoing collaboration has led to prototypical NCAR data being discoverable through NDG, and to the establishment of the 'Global Organisation for Earth System Science Portal' (GO-ESSP)<sup>8</sup> as a forum to discuss community approaches to data management. Future work will extend to full peer-to-peer discovery with ESG and then mutual data access. This project seeks to extend NDG collaboration in a similar manner to climate-science partners in Australia. A demonstrator will allow cross-equatorial discovery of climate science data resources (the oceanographic digital library of the Tasmanian Partnership for Advanced Computing<sup>9</sup>), and demonstrate federated access to oceanographic data (with OGC web services deployed through the Australian Oceans Portal<sup>10</sup>).

## 2. PROGRAMME AND METHODOLOGY

### Aims

The overall aim of the AUKEGGS is to build on informal links already established between NDG and key groups in Australia in order to exploit synergies between emerging developments in Grid middleware, geospatial data standards and the climate sciences. These separate strands will be joined through an opportunistic collaboration to the benefit of the immediate partners, the UK, and the respective communities more broadly.

The collaboration builds on several exchanges that already have taken place, and may be seen as a concrete outcome from those discussions. A UK Core Programme delegation visited Australia on an N+N visit in March 2003. That visit established contact between NERC DataGrid (Kerstin Kleese van Dam) and the SEEGrid geo-sciences community (Lesley Wyborn). A return visit in April 2004 developed the contact, with dialogue between NDG and APAC/TPAC (Bryan Lawrence and John O'Callaghan). A further follow-up visit by an Australian Research Council-sponsored delegation (including Woodcock and Roberts) in May 2004 focussed on Grid data management issues and indicated an enthusiasm for ongoing collaboration.

Specific objectives of this project include:

1. A demonstration of a data Grid linking climate data resources in Australia and UK. There will be several components to this.
  - a. NDG has adopted the metadata harvesting protocols of the Open Archives Initiative for harvesting discovery metadata from data providers. The discovery metadata schema being used is the 'Directory Interchange Format' (DIF) of the Global Change Master Directory (GCMD). This simple technological approach has proven already a powerful mechanism for federating discovery between NDG and the US collaborators. As a first step in a UK-Australia data Grid, it will be deployed for the data holdings of the TPAC Digital Library for Oceans and Climate.
  - b. NDG is developing software to enable data providers easily to federate into it. Once released, it will be installed at TPAC to enable not only discovery but also access to TPAC data through NDG.
  - c. Also located in Tasmania, and a collaborator of TPAC, is the Australian National Oceans Office (NOO). NOO is currently deploying an Oceans Portal that will provide

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<sup>8</sup> <http://go-essp.gfdl.noaa.gov>

<sup>9</sup> <http://www.antrc.utas.edu.au/tpac/datasets/diglib.htm>

<sup>10</sup> [http://www.oceans.gov.au/oceans\\_portal.jsp](http://www.oceans.gov.au/oceans_portal.jsp)

web service access to a range of oceanographic data, via OGC geospatial web services. OGC services are amongst the data delivery options being implemented by NDG. A demonstrator will be developed showing integrated access to both NDG and NOO data made possible through a common web services framework.

2. An outcome of this project will be a framework report on semantic integration of legacy geospatial data. Both NDG and SEEGrid are developing techniques to integrate legacy data sources through a semantically-meaningful web service interface. NDG has developed the Climate Science Modelling Language as both a data model and wrapper for exposing file-based climate-science data. This is an application schema of the Geography Markup Language. A SEEGrid collaborator on this proposal (Cox) is one of the core editors of GML, and has a particular interest in development and governance frameworks for community languages and vocabularies, and their implementation in the web-services context. This project will provide an opportunity to work more closely on evolving it for climate science data. In addition, another SEEGrid collaborator (Atkinson) is involved in a significant refactoring of the 'geoserver' reference implementation of OGC web services in order to facilitate the wrapping of legacy relational data sources. Both approaches will be documented in the report. As well, work by SEEGrid members investigating the harmonisation of OPeNDAP and OGC/GML will contribute to the report.
3. A scoping report on the application of WSRF to 'Grid-enable' OGC services will be developed as input to a future OGC interoperability testbed. Particular aspects of OGC services that might benefit include: incorporating WS-security, formalising notification mechanisms, and incorporating 'progress' as service state for requests with latency.

## Methodology

The project is proposed to run for around 20 months from early 2005. The specific travel involved is summarised in a table and project Gantt chart at the end of this document. In more detail, the collaboration will proceed through the following milestones.

An initial kickoff meeting in Australia. All collaborators will present their work and agree a detailed work plan to meet the project objectives. A key aim of this meeting will be to identify specific overlaps of interest and complementarity – beyond the deliverables identified in this proposal – around which to focus additional collaborative effort. This will likely include, for instance, harmonisation of OPeNDAP and Grid-compatible web services.

TPAC will populate DIF-format discovery metadata for the Oceans and Climate Digital Library. An NDG researcher will assist with installation of OAI metadata harvesting software and ensure that federation with NDG works. The long experience of the Australian Antarctic Data Centre (a TPAC partner through the 'Antarctic Climate and Ecosystems' CRC) with discovery metadata will be applied here.

Once NDG data provider software is bundled, an NDG researcher will install this at TPAC, providing a first test of full NDG deployment outside UK.

An international workshop will be convened at the National e-Science Centre in Edinburgh on 'Grid middleware and geospatial standards for earth observations data'. This will be open and promoted beyond the project collaborators to the broader earth sciences community. It may be of interest, for instance, to EDINA and the edikt project. The workshop will be a major project milestone, and its timing will coincide with the end of the first phase of NDG funding.

With the implementation of the NOO Oceans Portal, a demonstrator will be constructed to show chaining of geospatial web services for adding value to ocean data resources

A visit to UK from Australia will enable two reports to be written – one on integrating legacy geo-data resources (both files and relational) with OGC web services, the other a scoping report for OGC adoption of WSRF.

A final project workshop will present and review project outcomes. The potential for further collaboration will be discussed, including a possible submission to an OGC interoperability testbed.

Between milestones, meetings will be held using teleconferences and, where possible, Access Grid.

The final three milestones are all timed past the end of the first phase of NDG funding. It should be noted that they do not depend critically on a successful second round of funding – they exploit the results of the first phase. However, these milestones (especially the analysis of WSRF for OGC services) would integrate well with a second phase and could, in that case, be developed further than this project allows.

### **3. RELEVANCE TO BENEFICIARIES**

This project will benefit the participants, the broader respective e-Science and e-Research communities, and the international geospatial community.

The collaboration will establish the first data provider node of NERC DataGrid outside the UK, and demonstrate transparent discovery and access to oceanographic data hosted in Australia. Internationalisation of NDG will be a high-profile deliverable. The project will provide only the second formal collaboration between SEEGrid partners themselves. The deployment of functioning Grid middleware will provide a concrete basis for ongoing e-Research activity in Australia.

The SEEGrid community will gain access to current thinking on Grid technology. This is particularly important for the research program being coordinated by CSIRO and GA on behalf of the Cooperative Research Centre on Predictive Mineral Discovery (pmd\*CRP), which focuses on combination of observations, interpretations and simulations concerning ore-forming systems. The simulations are typically very computationally demanding, so access to HPC through Grid infrastructure is critical; constraints for simulations are obtained from services from a variety of providers. The NDG work in this area has focussed on convergence of Grid and Web Services; SEEGrid has focussed on communities and semantics; these are clearly complementary and strengthen each other. NDG will gain access to some key individuals involved with developing important geospatial standards.

The framework report on web service integration of legacy geo-data resources will provide a useful reference for other projects within the respective Grid and geospatial data communities. It should identify practical patterns for exposing real-life data (both file-based and relational) through semantically meaningful services. The mid-project workshop will be of broad appeal to domain researchers internationally.

An analysis of the scope for 'Grid-enabling' OGC's web services through WSRF profiling will provide a highly constructive and strategic input to the work of this important standards body. It will enhance the opportunity for ongoing collaboration between the partners in an OGC interoperability testbed. A less immediate benefit would flow to vendors as any resulting service interface specifications were deployed in COTS products.

### **4. DISSEMINATION AND EXPLOITATION**

SEEGrid has an existing community consultation and briefing process, based around their collaborative website, longstanding research provision relationships particularly with the mineral exploration industry, and occasional forums reaching the broader community. SEEGrid is also involved with "technology diffusion" projects under the auspices of AusIndustry. A project web-site will be maintained by SEEGrid as the primary means for communication and dissemination of project results. It will link to the NDG portal and a web demonstration of the UK-Australia federated data resources. Reports sponsored by the collaboration will also be published at the web-site.

Opportunities for scholarly publishing will be sought wherever possible. In particular, an external publishing track will be sought in addition for the project reports. It is also envisaged that the establishment of the collaboration and formalised ongoing contact between partners will lead to opportunistic joint conference papers and other publications.

The standards work of the collaboration will be promoted both within the community and strategically through standards bodies themselves.

Finally, the project workshops will provide an opportunity for direct promotion of outcomes amongst peers and the public.

## 5. JUSTIFICATION OF RESOURCES

The project costings are provided in the table below. ‘Outwards’ travel is from the UK to Australia and *vice versa* for ‘inwards’. In addition to these costed resources, we have assumed the usual venue and support services of the National e-Science Centre in Edinburgh for the main project workshop.

Event	Travel	Costing
Kickoff meeting	3 x outwards for three days, plus 5 Australian domestic flights	£7.5k
OAI federation of TPAC metadata with NDG	1 x outwards for one week	£1.5k
NDG middleware federation with TPAC	1 x outwards for one week	£1.5k
Major project workshop	10 x inwards for three days, plus 10 x UK domestic flights	£14.5k
NDG/NOO web services demonstrator	1 x outwards for one week	£1.5k
OGC/WSRF and data integration report writing	1 x inwards for two weeks	£2k
Final project workshop	5 x outwards for three days, plus 5 Australian domestic flights	£9.5k
<i>Ad-hoc</i> opportunistic events		£2k
		£40k

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- [i] O'Neill, K. *et. al.* (2003), "[The Metadata Model of the NERC DataGrid](#)", Proceedings of the U.K. e-science All Hands Meeting. S.J.Cox (Ed) ISBN 1-904425-11-9
- [ii] Lawrence, B.N., *et. al.* (2003), "[The NERC DataGrid Prototype](#)", Proceedings of the U.K. e-science All Hands Meeting, 2003. S.J.Cox (Ed) ISBN 1-904425-11-9
- [iii] Lawrence B.N., *et. al.* (2004), "[Googling secure data](#)", Proceedings of the U.K. e-science All Hands Meeting, 2004. S.J.Cox (Ed) ISBN 1-904425-21-6
- [iv] O'Neill, K., *et. al.* (2004), "[A specialised metadata approach to discovery and use of data in the NERC DataGrid](#)", Proceedings of the U.K. e-science All Hands Meeting, 2004. S.J.Cox (Ed) ISBN 1-904425-21-6
- [v] Woolf, A., *et. al.* (2005), "Climate Science Modelling Language: standards-based markup for metocean data", 85<sup>th</sup> American Meteorological Society Annual Meeting, San Diego (accepted).
- [vi] Manandhar, A., *et. al.* (2003), "[GRID Authorization Framework for CCLRC Data Portal](#)", Proceedings of the U.K. e-science All Hands Meeting, 2003. S.J.Cox (Ed) ISBN 1-904425-11-9
- [vii] Cox, S.J.D., *et. al.* (2004), "[Geography Markup Language \(GML\) 3.1.0](#)", OpenGIS® Recommendation Paper (also: ISO 19136 Committee Draft), xxi + 580 pp
- [viii] Atkinson, R., S. Cox, B. Lawrence, A. Woolf, "[Next steps in interoperability - community managed GML application](#)", EOGeo 2004, University College London.
- [ix] CSIRO (2004), "Communities, classifications and catalogues, Proposed contribution to OGC Web Services Initiative", with Social Change Online and NDG.
- [x] Woolf, A., *et. al.* (2003), "A Web Service Model for Climate Data Access on the Grid", Int. J. HPC Apps, **17**(3), 281-295.
- [xi] Karsh, K.L., N.L. Bindoff, S.J. Phipps, I. Cummings, J.L. Roberts and P. Heil (2003), "Digital Libraries for Oceans and Climate", Bull. Aust. Met. Ocean. Soc., **16**.
- [xii] Bindoff, N.L., A. Woolf, J.L. Roberts, F. Sainsbury (2002), "Online Access to WOCE Global Data V3", WOCE and Beyond, Final WOCE conference, Texas.
- [xiii] Atkinson, M., *et. al.* (2004), "[Web Service Grids: An Evolutionary Approach](#)"
- [xiv] Cox, S.J.D. (2003), "XMML – A standards conformant XML language for geology features", Proceedings, Geological Society of America Technical Meeting, Seattle.

## AUKEGGS WORKPLAN

Milestone	Date	Travel/Participant(s)	Deliverable
Kickoff meeting in Australia	T0	3 NDG → Australia; 5 Australian domestic	Detailed objectives and plan for collaboration
OAI federation of TPAC	T0+2	1 NDG → Australia	TPAC data discoverable through NDG
NDG federation of TPAC	T0+5	1 NDG → Australia	TPAC data accessible through NDG
Workshop	T0+6	11 Australian collaborators → UK; 10 UK domestic	Workshop report
NOO/NDG web services demonstrator	T0+12	1 NDG → Australia	Value-added ocean data through portal
Inwards visit - report writing	T0+16	1 SEEGrid → UK	Report on WSRF applied to OGC; Report on integrating legacy geodata
Final workshop	T0+20	5 NDG → Australia; 5 Australian domestic	End-of-project report

ID	Task Name	Start	Finish	Duration	Timeline																							
					Q1 05	Q2 05	Q3 05	Q4 05	Q1 06	Q2 06	Q3 06	Q4 06	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Kickoff meeting	02/02/2005	04/02/2005	3d																								
2	OAI federation of TPAC	11/04/2005	15/04/2005	1w																								
3	NDG federation of TPAC	04/07/2005	08/07/2005	1w																								
4	First project workshop	17/08/2005	19/08/2005	3d																								
5	NOO/NDG web services demonstrator	16/01/2006	20/01/2006	1w																								
6	Report writing	12/06/2006	23/06/2006	2w																								
7	Final project workshop	16/10/2006	18/10/2006	3d																								
8	Project web-site	02/02/2005	18/10/2006	89w 1d																								