AstroGrid

progress report

for PPARC Astronomy Committee
March 1st 2001

EVENTS

The AstroGrid project arose in early 2000 as a response to PPARC's Long Term Science Reviews, and accelerated during summer 2000 as part of PPARC's upward bid in the CSR process. A formal proposal was presented to Astronomy Committee in October 2000. This report summarises progress in developing the project since October. The key developments have been as follows :

(i) MSSL has joined the list of consortium institutions (with L.Harra as Lead Investigator), and D.Pike (RAL) and R.Bentley (MSSL) have joined the list of key staff. These additions have considerably strengthened the solar physics side. It was always the intention that solar physics would be fully included, but the new additions give us the skills base to have confidence this will be fulfilled.

(ii) The results of the CSR have been announced, including considerable new "e-science" money for PPARC. The budget for AstroGrid has still to be resolved however, as on the one hand, there are other potential bids into this area, and on the other hand there are further additional sources of money, and uncertainties over which existing areas of activity should properly be labelled "e-science". PPARC has circulated an Announcement of Opportunity for outline bids in addition to the LHC Grid, AstroGrid, and a coupled models project developing within the STP community.

(iii) PPARC have announced the recruitment of a new e-science Director, and the creation of an e-science steering committee. This will presumably be the body which will set our budget, and oversee detailed progress, but at this stage it still seems important for Astronomy Committee to give a strategic steer.

(iv) We have circulated a "call for comments" to begin the process of consulting the community. The text is at Annex-H, and a summary of reponses at Annex-I. In addition the October proposal was used as a position paper, and placed on a public web-page at www.AstroGrid.ac.uk. The reponse has been considerable and extremely useful, although there are difficult issues arising (see below).

(v) We held our first workshop, in Belfast in January. A report from the workshop is attached at Annex-J.

(vi) Together with ESO, ESA, Jodrell Bank, TeraPix, and CDS Strasbourg, we have submitted an EU RTD proposal referred to as "AVO" (Astrophysical Virtual Observatory). If successful, this will fund 2 additional staff years per year for 3 years within the AstroGrid consortium. In any case, it has placed us on a firm footing with major international partners. The proposal is available at the AstroGrid website.

(vii) We have begun the process of detailed planning of the project, as indicated in Annexes A-E. This planning is not complete, and the comments of Astronomy Committee at this stage would be very welcome before completing the process for the e-science steering committee.

(viii) There has been considerable pressure from the community to widen our remit, and to closely involve more individuals and groups. This has been particularly strong in the case of radio astronomy.

REQUIREMENTS ANALYSIS : TWO PHASE PLAN

The October proposal deliberately put forward an ambitious vision. We make no apology for this, as it was necessary to make it clear how important and exciting the subject is, and to get a feeling for what can be achieved. However as the project moves towards reality, we need now to be very careful about the goals, and about the realistic achievables within three years. There are several reasons for this caution :

(a) We need a far more detailed analysis of the scientific requirements before we construct the functionality to meet them. As well as long careful thought, this requires detailed interaction with the community. We have begun this process, but the response in itself makes it clear that extensive consultation is needed. Our intention is to develop a series of blow-by-blow "use-cases", and to analyse these to produce a Science Requirements Document. We expect this process to take a year.

(b) Pressure from the community is inevitably towards including everything possible in our programme. However it would be a pipe-dream to imagine the UK building an all-encompassing "Virtual Observatory". In practice this concept will emerge into reality on a global scale on a timescale of perhaps 5-6 years. A better idea is for the UK (i) to deliver some specific facilities on a short timescale that match its prime opportunities and needs, and (ii) to establish itself as a key player within the Virtual Observatory game, with real product to offer. This strongly argues for selecting key datasets and limited goals.

(c) This programme will be complex to design and manage. Unless we keep it reasonably focused, it will fail.

(d) Politically, PPARC having been given new money for this work, it is very important to visibly succeed.

We have therefore structured our programme into two distinct Phases. Phase A is a one-year intensive R&D phase, with two main components - requirements analysis, and early experimentation with hardware and software, to bring us rapidly up the learning curve. There are two main outputs - the Science Requirements Document, and a Phase B plan. At Annex-K we describe our current understanding of the scope of our whole programme, divided into "Activity Areas". We have deliberately avoided casting these as "work-packages" in order to indicate that the precise work and deliverables remain undecided. For Phase-A however, we have developed outlines of concrete workpackages. If Astronomy Committee are happy with the direction these are taking, they will be developed in more detail quite rapidly.

The two-phase plan also sits well with a cautious approach to committing the money (see Annex-B).

ISSUES

· community pressure is towards widening our goals, but pragmatism suggests the opposite.

· the community remain unclear about when to try to bring their goals inside AstroGrid, and when to consider a separate bid to e-science funds. We have had some pressure to consider additional membership as well as widened goals.

· the definition of e-science remains unclear, and there are worries about "displacement" funding. Our stance is that AstroGrid begins with funded databases in place, adding value. So for example, much of SOHO post-launch support may be considered e-science, but most of the existing activities are not part of AstroGrid, which adds goals beyond those of the current remit.

· financial caution suggests releasing money slowly, but we need a minimum committment to start recruitments. In particular we believe recruiting the Project Manager and Project Scientist as soon as possible is vital.

· Optical, IR, X-ray and solar astronomy are well to the forefront, but concerns have been voiced that radio astronomy has not been sufficiently considered. For solar-terrestrial physics, the AstroGrid project always intended prominence, but the community concerned has not yet gelled behind AstroGrid in the same way as in the other areas.

List of Annexed material

ANNEX-A : Management Plan
ANNEX-B : Whole Life Cost Estimate
ANNEX-C : Phase-A workplan
ANNEX-D : Project Manager Job Description
ANNEX-E : Project Scientist Job Description
ANNEX-F : International Perspective
ANNEX-G : Cross-Disciplinary Perspective
ANNEX-H : Text of "Call for Comments"
ANNEX-I : Summary of responses to "call for comments"
ANNEX-J : Report on Belfast Workshop
ANNEX-K : Description of AstroGrid Activity Areas.

ANNEX-A : Management Plan

PHILOSOPHY

The management philosophy of the AstroGrid project is that the overall aspirations should emerge from the desires of the community, but that the project in practice should have finite specific goals, and should be run as a tightly defined project by a relatively small consortium, equivalent to building an instrument. There are two reasons for this approach. First, we believe that if the project is allowed to become too ambitious, or has too diffuse a structure, it will fail. Second, the grandest aspirations of a "Virtual Observatory" like environment will certainly not be achieved by the UK in isolation, but may be achieved on a global scale over five years or more. Seen in this context, the UK AstroGrid project needs to make clear concrete achievements seen as contributions to the world-wide "VO" agenda, which will place us centrally on that stage.

Although a small number of institutions retain management responsibility for AstroGrid, a much larger number of institutions are likely to be involved, as (a) a large fraction of the work will be outsourced, either as grants or commercial contracts, and (b) many individuals will participate in the advisory structure, and (c) the community as a whole will be extensively consulted.

PPARC E-SCIENCE STEERING COMMITTEE (PESC)

AstroGrid will be almost entirely a PPARC funded project. (Some HEFCE/SHEFC/DENI funded effort is of course included, and EU funds are hoped for). AstroGrid activities will therefore be subject to the usual grant conditions and management constraints imposed by PPARC. In particular, PPARC has announced the creation of an e-science director and e-science steering committee, covering the whole e-science programme and not just AstroGrid. The steering committee will monitor the progress of AstroGrid, control its budget allocation, and oversee its goals and match to PPARC requirements. For convenience we refer below to the combination of e-science Director and Steering Committee as PESC.

ASTROGRID LEAD INVESTIGATORS (AGLI)

Responsibility for the goals, design, and implementation of the project rests with the AstroGrid Lead Investigators (AGLI). The individuals concerned are A.Lawrence, R.McMahon, M.Watson, F.Murtagh, L.Harra, P.Allan, and M.Lockwood, although this list may change by agreement of the members. The AGLI also direct the project and set policy, subject to the constraints and oversight of the PESC. There is no formal Project Director - policy and direction are achieved by mutual agreement. However there at any one time there is an agreed Project Spokesperson and figurehead. Currently this is A.Lawrence. Normally the AGLI meet within the context of Consortium meetings (see below) but may arrange extra meetings and teleconferences as necessary.

ASTROGRID WORKING CONSORTIUM (AGWC)

A considerable number of people will be employed towards the ends of the AstroGrid project, either within the consortium organisations, or in other organisations, or through commercial contracts and secondments. However a number of core staff have already been extremely active in both technical work and in the design and goals of AstroGrid, and it will remain useful to identify these "key staff" as having a special role. The current list is M.Irwin, J.Sherman, R.Mann, D.Pike, C.Page, C.Davenhall, G.Rixon, D.Giaretta, and R.Bentley. The list may change by agreement. On the other hand it would not be appropriate to place top-level responsibility on such a large group of people, especially as many of them will have their own salary dependent on AstroGrid. This is why we have separated the smaller AGLI group as taking reponsibility for direction. The concept is that the AGWC is the body through which debate concerning AstroGrid policy and implementation and technicalities takes place, but that formal responsibility rests with the AGLI. The AGWC maintains a continous email discussion including complete email archive. It should meet approximately quarterly, and has indeed done more than this so far. It will be expected that further staff will normally be welcome at AGWC meetings as requirements suggest, but that the formal membership of the AGWC (in effect the default circulation list) will only evolve by agreement.

PROJECT MANAGER, PROJECT SCIENTIST, and ALLOCATION OF WORK

The project will appoint a full time Project Scientist (PS) and a full time Project Manager (PM). The PM will be an open recruitment. The Project Scientist may also be an open recruitment, but may be selected from within consortium institutions. The draft job descriptions for these two posts are attached. Both postholders report to the AGLI, normally through documents and reports presented to AGWC meetings. The PM and the current AGLI spokesperson have the additional reponsibility of being the principal liaison points with the PESC. The PM will expect to make regular reports to the PESC. The PS has prime responsibility for seeing that AstroGrid meets its science goals. The PM has prime responsibility for the budget and schedule of the project. It is intended that the AstroGrid workpackages will be fairly clearly devolved to particular indiividuals and organisations. The PM will allocate the work, but in close interaction with the AGLI and the PESC. It is not yet clear whether there will be a distinct "Project Office" (as with e.g. Gemini or VISTA) or simply a distributed programme (as e.g. with XMM) . We wish to leave PM candidates the freedom to indicate their preferred structure. Our intention is to recruit the PM as soon as possible. In the meanwhile, we will not appoint an interim PM, but will appoint one or more of the re-deployed staff to undertake the administrative side of the PM responsibilities.

ASTROGRID ADVISORY BOARD (AGAB)

We are undertaking a programme of community consultation in a variety of ways, for example by meetings and by an open "call for comment". This is crucial in developing the Science Requirements Document. However we do not see this as simply a once-for-all process. Furthermore, there are considerable skills and experience on both scientific and technical matters in the wider community that we wish to benefit from. Finally, we wish to strike a balance between creating a wide sense of ownership on the one hand, and keeping a manageable project structure on the other hand. Our intention to strike this balance is to create an Advisory Board with invited members. Around ten members may be large enough to be representative but still small enough to be useful. We intend that the AGB will include a mixture of ordinary astronomers, those with special skills and interest in astronomical software or data mining research, those with key future project interests (e.g. VISTA, GAIA, ALMA, WASP, the Liverpool Telescope), and finally computer scientists and particle physicists. The Advisory Board will normally meet immediately before AGWC meetings, and formally provides advice to the AGLI.

ANNEX-B : Whole Life Cost Estimate

This is a simple cost model for planning purposes. Below we explain the basis of the model.

(1) ABBREVIATIONS

Y1=April 2001-April 2002 Y2=02-03 Y3=03-04
HEFC = HEFCE, SHEFC, or DENI as appropriate

(2) TOTAL vs ADDITIONAL COST

Note that the total project cost, the cost to PPARC, and the additional cost to PPARC, may all be different. The total cost may include the HEFC funded staff cost, and non-PPARC external funds such as EU funding, or commercial subsidy. The cost to PPARC includes all activity/equipment required to achieve the AstroGrid goals. It is recognised that some of these activities may already be underway, funded under existing lines. In this case the *additional* cost to PPARC may be smaller. Our aim here is to estimate the total cost to PPARC, regardless of what is considered new or not. HEFC staff effort is listed but at zero cost. Our intention is that AstroGrid starts with databases in place, adding value. We therefore currently expect that the "displacement" in staff effort funding will be relatively small. For the storage hardware we have costed however, it is not clear how much is already assumed in existing lines, so a substantial fraction of this may be not additional.

(3) HARDWARE COSTS

The hardware we actually procure will depend sensitively on the result of Phase A studies. For simplicity we have modelled this in two parts - mass storage, assumed to be RAID-like systems, and datamining machines, assumed to be PC clusters. These asssumptions may turn out to be incorrect - for instance, we may decide that SMP machines are better suited to the datamining research that users actually want to undertake, or we may decide that hanging storage off the back of cluster-nodes makes more sense than monolithic RAID systems. Or of course events may get overtaken by technological developments, such as the promised FMDs.

(3a) MASS STORAGE HARDWARE

In the October 2000 proposal we estimated UK on-line data growth across all areas (OIR, X, solar, STP) to be +20TB, +30TB, +35TB in Y1,2,3. (Note that the full raw data is considerably larger). We have taken on-line storage costs to be £30K/TB, £20K/TB, £15K/TB in Y1,2,3. This represents fairly robust upper RAID-level SCSI storage, and is meant to be an effective price including maintenance, DBMS support, associated servers, and tape robot back-up systems. It is quite possible that there will be cheaper mass storage options may be available but it is not yet clear what the best choice will be. We may not be able to commit very much early money, so we have chosen to slip the first two years requirements, buying nothing in Y1, 20TB in Y2, and 65TB in Y3.
Funds needed are therefore 0K, 400K, 975K.

(3b) DATAMINING MACHINES

Our immediate priority is for prototype data-mining machines for optical/IR, for XMM, for solar work, and for grid-experimentation - we assume four 16-node clusters. In Y3 the WFCAM project will need a much faster machine, assumed to be 200 nodes. (Other later projects may also need high-throughput machines, but are outside our window). We assume the use of PC clusters, and use a cost of 2K/node, 1K/node, 1K/node in Y1,2,3. This includes a 50GB disk hanging off the back of each node. We need four 16-node machines in Y1, one 200-node machine in Y3. Funds needed £128K, 0K, £200K.

(4) COMMERCIAL LICENSES

We are likely to require public access use of commercial software, for example DBMS systems. An example is the Objectivity license costing of the order £20K/site if being used for web access. We will need at least a couple of copies in Phase A, plus maybe similar items for evaluation. Hard to estimate total need. We have allowed £50K/year.

(5) STAFF RATE

We are assuming £60K/staff year including a travel allowance and personal computing allowance. This corresponds to a senior PDRA salary, say 30K + 22% NIS + 46% overhead = 54K, plus 3K per year travel and 3K per year towards workstation/laptop provision. This is also reasonably similar to the RAL dsy rate. The actual spend will vary wildly, but this is a reasonable average. This staff rate is assumed to apply whether staff are employed within an AstroGrid consortium institution, or as a grant to another university. We also expect however to use commercial effort. For purchased external programmer effort, a budget of more like £90K/yr would be expected, and sometimes we will certainly pay rates like these. However a promising alternative is that software companies may second staff to University groups for finite periods, charging actual salary cost. (The University would receive a grant-like overhead). For this method, £60K/yr is again a reasonable cost.

(6) PROJECT MANAGEMENT

We wish to hire a Project Manager (PM), Project Scientist (PS), and Project Assistant (PA) as soon as possible. Our working assumption is that this means staff in post in October 2001. The PM will be an open recruitment. The PS may also be an open recruitment, but could be internal selection. Project Assistance will probably in reality be several bodies - for example one whole office assistant co-located with the PM, and distributed clerical assistance across our institutions. For simplicity we model this as 1.0sy at the standard staff rate. The total staff cost is therefore 3sy/yr , but only for half the first year.

(7) HEFC FUNDED EFFORT

We assume that the six academic/senior establishment staff listed as Lead Investigators will each contribute 0.1sy/yr. In the table below we list the staff effort but use zero cost.

(8) RE-DEPLOYMENT OF EXISTING STAFF

We hope to begin some recruitment immediately, but want to start real work as of April 1st. A number of staff have already been active, and are committed to begin dedicating a large fraction of their effort to AstroGrid. These staff are all currently funded through other programmes, so are re-deployments. The level of deployment is an interim working arrangement but may be revisited as we begin our recruitment programme. The individuals are :

70%	Page, Rixon, Mann	
50%	Davenhall, Bentley, Giaretta, Pike	TOTAL 4.4 sy/yr
20%	Sherman	
10%	Irwin	

(9) PDRA RECRUITMENTS

To provide the total staff effort needed to complete the Phase-A workplan, we need to recruit two further PDRAs/programmers in Y1. We assume we will achieve staff in post by October 2001, thus costing 1.0sy total in Y1, continuing the same staff on three year contracts, and so committing 2sy in each of Y2 and Y3. Beyond this we do not have a concrete workplan, but do have a preliminary model. We assume the total staff effort as in the October 2000 proposal, and assume that half of this is in-house. To achieve this, we then make a preliminary assumption of three further PDRAs in April 02 (two-year contracts), and two more in October 02 (eighteen month contracts).

(10) EXTERNAL STAFF EFFORT

We are unlikely to make external contracts until Phase-B, so the estimate is very preliminary. We model this as 11sy/yr at the standard staff rate, starting in Y2. (If substantial commercial contracts are used, the number of staff years of effort returned for the same money will be less.

COST PROFILE and BREAKDOWN

	Y1	Y2	Y3	total

REQUISITIONS (k£)				
mass storage	0	400	975	1375
datamining	128	0	200	328
licenses	50	50	50	150
TOTAL REQUISITIONS	*178*	*450*	*1225*	*1853*
STAFF EFFORT (sy)				
HEFC	0.6	0.6	0.6	1.8
re-deployment	4.4	4.4	4.4	13.2
PM/PS/PA	1.5	3.0	3.0	7.5
P1,P2 (Oct 01)	1.0	2.0	2.0	5.0
P3,P4,P5 (April 02)	0.0	3.0	3.0	6.0
P6,P7 (October 02)	0.0	1.0	2.0	3.0
External effort	0.0	11.0	11.0	22.0
TOTAL STAFF	*7.5*	*25.0*	*26.0*	*58.5*
STAFF COSTS (k£)	414	1464	1524	3402
REQUISITIONS (k£)	178	450	1225	1853
TOTAL COSTS (k£)	*592*	*1914*	*2749*	*5255*
Proposed commitment	*592*	*1014*	*564*	*2170*
Proposed hold-back	*0*	*900*	*2185*	*3085*

Proposal on committment of funds.

Our proposal is that we be given permission to begin recruitment immediately for PM, PS, PA, and two PDRAs. In addition, we need some immediate equipment and license procurement for Phase-A. The rest of the estimated funds required could be held back. In other words the proposed committment = Y1+Y2 requisitions, staff obligations to 4.4sy from April 01, and 5.0sy from October 01).

ANNEX-C : Phase-A workplan

The philosophy of the Phase A Plan is "get stuck in". A top-down debate on standards and so on will be going on internationally, but we cannot afford to wait. The prime aims are (i) to do a thorough and sceptical requirements analysis so we know what we really want, and (b) to get stuck in and get experience and learn lessons and develop staff skills as soon as possible. Terms are defined in Annex-K.

WP-A0 ESTABLISHMENT OF PROJECT INFRASTRUCTURE

TASKS	Set up project web pages, FTP areas, and software repositories, and automate information sharing. Decide document classes and formats, set up templates. Decide software standards and set up libraries and toolkits. Set up document and email repositories, e-mail exploders, diaries, and schedules.
DELIVERABLES	Handbook of project procedures. Public and consortium web pages. Working project information system
RESOURCE	3 staff months

WP-A1 REQUIREMENTS ANALYSIS

TASKS	Consult community; circulars, public meetings, key committees, and private discussion visits. Commission and develop use-cases and deduce requirements. Organise public meetings and invited workshops.
DELIVERABLES	Science Requirements Document, including set of use-cases. Functional Requirements Document. Public meetings. Reports on meetings.
RESOURCE	12 staff months

WP-A2 FUNCTIONALITY MARKET SURVEY

TASKS	Investigate options for commercial software and assess capabilities (applications, DBMS, etc). Investigate options for academic software and assess capabilities (IRAF, Starlink, IDL; rival middleware toolkits). Likewise for options in data/metadata standard, interfaces etc - FITS, XML, etc. Investigate capability for new s/w construction within UK astronomy community. Investigate progress and working assumptions being made in other disciplines and other countries
DELIVERABLES	Technical Reports on applications/products etc. Functionality Market Survey Report. Decisions on route forward
RESOURCE	9 staff months

WP-A3 EXPERIMENTAL PROGRAMME.

TASKS	Procure and deploy 16-node Beowulf clusters at selected sites. Make arrangements for borrowed use of other machines, eg. EPCC SMP machine. Install and test middleware packages (Globus, Legion, CORBA). Deploy two or more clusters as test data-grid. Design benchmark problems for data access, database searching, and data analysis problems. Quantify performance of various machines, configurations, and packages on the benchmark problems, using version-0 tools.

DELIVERABLES	Working data grid (for experimental purpose only). Grid-enabled versions of selected applications packages. Demonstration of multi-site browsing and database searching. Documented performance tests of various machines/packages. Technical reports on lessons learned from experiments. Decisions on route forward.
RESOURCE	24 staff months

WP-A4 DEMONSTRATION FEDERATION-1 : SOLAR

TASKS	Federate SOHO database (RAL) with Yohkoh database (MSSL). Agree criteria for federation success. Define agreed data, metadata and database standards as necessary for the pilot federation (i.e. not necessary to use "final" standards. Construct simple user interface for interrogation of databases simultaneously, using version-0 tools.
DELIVERABLES	Successful pilot federation. Technical report on lessons learned.
RESOURCE	6 staff months

WP-A5 DEMONSTRATION FEDERATION-2 : OPTICAL-IR

TASKS	Federate SuperCOSMOS and early-release SDSS databases (US via Edinburgh) with INT-WFC and INT-CIRSI databases (Cambridge). Agree criteria for federation success. Define agreed data, metadata and database standards as necessary for the pilot federation (i.e. not necessary to use "final" standards. Construct simple user interface for interrogation of databases simultaneously, using version-0 tools.
DELIVERABLES	Successful pilot federation. Technical report on lessons learned.
RESOURCE	6 staff months

WP-A6 DEMONSTRATION FEDERATION-3 : X-RAY

TASKS	Federate XMM database (Leicester) with Chandra database (US via Leicester). Agree criteria for federation success. Define agreed data, metadata and database standards as necessary for the pilot federation (i.e. not necessary to use "final" standards. Construct simple user interface for interrogation of databases simultaneously, using version-0 tools.
DELIVERABLES	Successful pilot federation. Technical report on lessons learned.
RESOURCE	6 staff months

WP-A7 DEMONSTRATION FEDERATION-2 : STP

TASKS	Federate CLUSTER and EISCAT databases. Agree criteria for federation success. Define agreed data, metadata and database standards as necessary for the pilot federation (i.e. not necessary to use "final" standards. Construct simple user interface for interrogation of databases simultaneously, using version-0 tools.
DELIVERABLES	Successful pilot federation. Technical report on lessons learned.
RESOURCE	6 staff months

WP-A8 VERSION ZERO VISUALISATION TOOL.

TASKS	Construct simple image viewer and/or source catalogue viewer for use in the demonstration federations. Not necessarily intended to be final visualisation tool - just sufficient functionality to make the federation test possible. Probably choose, upgrade and deploy existing package (e.g. GAIA) .
DELIVERABLES	Working visualisation package. Report on lessons learned.
RESOURCE	6 staff months

WP-A9 VERSION ZERO DATABASE SYSTEM.

TASKS	Construct simple database management system, and simple data access tools, observation catalogue browsing tools, and exploration tools for use in the demonstration federation. Not necessarily intended to be development towards final DBMS, or data-mining tools, just working code with sufficient functionality to make the federation test possible. Probably choose, upgrade and deploy existing packages (e.g. SYBASE, SolarSurf, Objectivity, CURSA) .
DELIVERABLES	Working database management system capable of addressing two physically separate databases. Simple data exploration tools. Report on lessons learned.
RESOURCE	6 staff months

WP-A10 CONSTRUCT PHASE-B PLAN.

TASKS	Monitor progress of Grid work across all disciplines. Monitor progress of international projects, and begin contributions to AVO project. Digest results from all other work-packages. Assess political scene and financial prospects and make technology forecast. In the light of all the above, set realistic goals for two year programme and design workpackages to achieve them.
DELIVERABLES	Phase-A completion report. Phase-B Plan (project goals; whole life cost estimates; detailed workpackage definitions; management plan; operational plan.) Agreed division of activities with international partners. Agreed stance with cross-disciplinary partners.
RESOURCE	6 staff months

ANNEX-D : Project Manager Job Description

The purpose of this job is to manage the development of the AstroGrid project, which is intended to design and implement a distributed data access architecture for astronomy over a three-year period. A consortium consisting of the major astronomical datacentres will undertake the work. Currently the members of the consortium are the universities of Edinburgh, Leicester and Cambridge, the Rutherford Appleton Laboratory, Queen's University Belfast and the Mullard Space Science Laboratory. This list may change during the lifetime of the project. In addition, work outside the consortium may be funded where this is appropriate.

The specific responsibilities of the post are:

- To maintain and update the schedule of the whole project.
- To develop the details of the work programme for the second two years of the project.
- To monitor the progress of individual work packages in order to ensure the project is keeping to schedule and to indicate where corrective action is needed.
- Where appropriate, to agree changes to work packages with those undertaking specific tasks.
- To monitor the budget of the project.
- To allocate funds to consortium members, or other agreed parties, in order that specific tasks may be accomplished.
- To organise regular consortium meetings to review progress.
- To provide regular reports on the progress and finance of the project to the consortium members and to PPARC.
- to liaise with international and cross-disciplinary partners
- to liaise with commercial partnerrs and to place and monitor contracts

The project manager will report to the Lead Investigators of the project, and will probably also report to PPARC's e-science Director.

ANNEX-E : Project Scientist Job Description

The purpose of this job is to ensure that the AstroGrid project delivers the agreed facilities to the scientific community, thereby providing the ability to extract new science from existing and future data resources. The project is intending to design and implement a distributed data access architecture for astronomy over a three-year period. A consortium consisting of the major astronomical datacentres will undertake the work. Currently the members of the consortium are the universities of Edinburgh, Leicester and Cambridge, the Rutherford Appleton Laboratory, Queen's University Belfast and the Mullard Space Science Laboratory. This list may change during the lifetime of the project. In addition, work outside the consortium may be funded where this is appropriate.

The specific responsibilities of the post are:

- To develop and maintain the science requirements for AstroGrid.
- to liaise closely with the UK astronomical community and to lead a process of consultation.
- To codify the science requirements as use-cases.
- To develop and maintain an active use of all of the tools developed by AstroGrid so as to be the system's 'test pilot'.
- To monitor progress to ensure that the science requirements will be met and to agree changes to the requirements with the consortium where appropriate.
- To develop tests by which we can demonstrate that AstroGrid has met it goals.
- To maintain contact with other e-science projects within the UK to ensure that common tools are developed wherever possible. AstroGrid should both contribute to a common set of tools and use those developed by others where appropriate.
- To maintain contact with related projects in other countries to ensure that we use tools developed abroad where appropriate and that AstroGrid is interoperable with related systems in other countries, or at least that gateways between different systems can be provided.
- To present the results of the AstroGrid developments to PPARC, to the UK community and to the international community.

The project scientist will report to the Lead Investigators of the Project.

ANNEX-F : International Perspective

The idea of a "Virtual Observatory" has been building worldwide over the last year or so, with several conferences and workshops devoted to this idea. The US has the strongest track record of developments in this area in recent years (eg NED, the HEASARC website, NASA SkyView, and the Astrophysical Data Service). However the CDS in Strasbourg, responsible for SIMBAD and ALADIN, also occupies a central niche. Two major projects have arisen.

The first is the US "National Virtual Observatory (NVO)" project. This was given a boost by being highlighted in the recent report of the Decadal Survey Committee as the top priority medium sized project, with an anticipated budget of around $60M over ten years. It is not yet clear whether this initiative will develop primarily through NSF funding, or as a NASA project. In November a "pre-proposal" was submitted to the NSF for a five year programme, headed by Messina and Szalay. The final proposal is in preparation. A paragraph in the NSF pre-proposal describes the AstroGrid project, and A.Lawrence and F.Murtagh are listed as international collaborators (along with other AVO principals - Quinn, Genova, and Benvenuti).

The second major project is the "Astrophysical Virtual Observatory (AVO)". This has developed out of the OPTICON working group on archive interoperability. A proposal to the EU Framework V RTD programme was submitted on February 15th. The partners are ESO, ESA, CDS, Terapix, AstroGrid, and Jodrell Bank. Each partner commits 2 staff years per year for three years to the AVO programme, and requests a further 2 staff years per year from the EU. The goals of the AVO programme are similar to that of AstroGrid, but without solar physics and space plasma physics. The key archives highlighted are those of ST-ECF and the VLT. The initial three year programme is seen as a development project , with an expected second three year programme to follow establishing a Europe-wide working system and possibly a physical user support centre. Like AstroGrid, the AVO plan has a strong emphasis on requirements analysis, but this is seen as extending over the whole three years. Within AVO, AstroGrid has agreed a lead responsibility in the area of grid computing developments and their application.

A possible third major project is EGSO, the European Grid of Solar Observations. Organisations across Europe active in solar physics archives are starting to come together with the intention of an EU bid analagous to the AVO project.

NVO, AVO, AstroGrid, and related developments in Canada led by CADC, represent a kind of fluid jigsaw. It is not even quite clear what the pieces are, let alone how they fit together. There has been no suggestion so far to develop a coherent "world project", but rather to keep the various projects in dialogue. Some duplication of work is inevitable and indeed desirable, as we explore alternative solutions. We obviously must work towards common data, metadata and interface standards, but these may evolve by both competition and co-operation. Our relationship with the US project is likely to remain informal. With AVO however we are committed to a much closer relationship, with part of AstroGrid inside AVO and part outside. We must therefore work towards more closely defined complementary tasks. For now, such close definition is not practicable, but one of AstroGrid's key deliverables from Phase A is a Phase B plan, and this should include agreed division of tasks with both AVO and NVO.

We cannot expect to *dominate* the construction of a world-wide Virtual Observatory. However by making clear and simple well recognised contributions, we can become a *leader* in this area. This points very strongly to AstroGrid (a) getting off theground fast, and (b) having limited rather than ambitious goals.

ANNEX-G : Cross-Disciplinary Perspective

The work of the AstroGrid consortium will not take place in isolation and will need to be well connected with similar programmes being undertaken in other scientific disciplines. The obvious connection is with developments in Particle Physics as this area has been at the forefront of the building of the GRID as a whole and has a common funding source through PPARC, as well as a common oversight mechanism through the e-science Director and the e-science steering committee. Astronomy will benefit from the development of toolkits that are being driven by Particle Physics. We will organise specific collaborative meetings between Astrogrid partners and Particle Physics groups at the Universities and RAL. In addition, there will be a specific focus on working with the UK Particle Physics Tier 1 GRID node.

We will also need to have strong ties with other areas of science as they have particular strengths and requirements that will complement those of astronomy. In the area of climate studies, a consortium is planning to develop the necessary infrastructure for building coupled models that can communicate over the Internet. This mode of operation is directly applicable to problems that exist in the area of Solar Terrestrial Physics, where there is a desire to link models that cover different physical regimes. (Strictly speaking this area of coupled models is outside the AstroGrid remit but well inside the astro e-science remit, so we mention it here for completeness). In the area of bio-sciences, the requirements for handling the burgeoning amounts of data that are coming out of the human genome project, which will be dwarfed by the human brain project, have strong parallels with the requirements from astronomical data and metadata. The heterogeneity of biological data is most unlike that of Particle Physics, and even worse than that of Astronomy. When searching for data on the Internet, the Earth Observation community already has sophisticated facilities available to them that could be used more widely. Additionally, with the growing need to access telescopes at remote sites with great ease via the network, astronomy will benefit from development of control systems for large-scale instruments such as synchrotron light sources and neutron sources that include the processing chain as part of the overall system. Astronomy will benefit from many external developments, but we expect it be a net contributor of tools for the storage, access and processing of heterogeneous data. We expect that there will be collaborative generic projects in the area of coupled models.

In addition to these interactions with researchers in other sciences which are facing similar problems to those of AstroGrid, we shall also seek collaborative links with computer scientists. This will be led through the group at QUB, which is a partner in AstroGrid. We also have close working connections with both the RAL e-science department, and the Edinburgh Parallel Computer Centre, and will approach other computer science groups, such as the database group at Manchester, in order to make use of their specific expertise. Much of the expertise that AstroGrid will require in a number of key areas already exists in academic computer science, where researchers are keen to see their work put into practice on challenging applications, as provided by the large databases to be federated by AstroGrid. For example, there exists a mature and active field of computational geometry concerned with the description of multi-dimensional datasets, which informs both the choice of indexing schemes to use in databases for efficient querying and design of methods for analysing the data they contain. Computer scientists developing generic Grid tools are also seeking realistic examples of distributed processing upon which to test their protocols, and are eager to contribute effort to the development of such applications.

Collaborative relationships with the telecommunications and information technologies industries (both hardware and software) will also be pursued. The industry will be aware of the likely demands from commercial users and thus the potential market. The largest commercial databases are growing at a rate (TB/yr) quite similar to that of astronomy. Their desire for database access distributed across sites, correlation hunting among object fields, and resource discovery also has striking similarity. Thus, although Particle Physics will undoubtedly be leading the way in development of GRID toolkits, astronomy is probably closer to the commercial problem in nature and scale. Software vendors can be willing to work closely with demanding users of their products, as this can help them further develop the functionality of their products, and both software and hardware companies will provide expertise or products at a discount, in order to use their association with prestigious research projects for PR purposes. Initial conversations with some companies suggests however that their horizons are short and they will not invest in their own R&D programmes. Rather than simply waiting for us to deliver the R&D, a suggestion that has arisen is to second commercial programmers into academic groups, working to our tasks, but returning to their companies with new knowledge and skills. The development of these relationships may be fruitfully sought through the bodies coordinating e-science at the OST and PPARC level, as well as by AstroGrid itself.

ANNEX-H : Text of "Call for Comments"

The AstroGrid Project : call for comment

INTRODUCTION

One of the good pieces of news in the recent announcement of the science budget allocations was that money is available for "e-science", understood as computing grid developments, scientific software infrastructure, and the new style of science that this empowers. A substantial fraction of the extra money in PPARC's budget is earmarked for activities of this kind. In particular, a specific project known as "AstroGrid" is under review. Many people are already aware of the project, but this circular is intended to alert the astronomical community in general, and to invite comments (see below).

AstroGrid started as astronomers became aware of the daunting data volumes expected from UKIRT WFCAM and VISTA and the technical problems implied. Meanwhile X-ray and solar astronomers were also concerned with large (if not quite so terrifying) databases and the problems of how the community gets science out of them. All kinds of astronomers world-wide have become increasingly concerned with the "inter-operability" of the key database holdings, and the dream of a "Virtual Observatory" unifying such databases has arisen. PPARC's Long Term Science Reviews, starting in mid-1999 and reporting in mid-2000, highlighted IT infrastructure in general and large database initiatives in particular as being of key importance, placing it the "Priority 1" shoppping list.

Agreement is emerging that database access, searching and even analysis tools, need to be services physically based around the data holdings in a distributed grid-like fashion. Just as the Web is distributed information, the idea of a "computational grid" involves distributed CPU power, by analogy with the electrical power grid. The scientist has the power of a supercomputer at her fingertips, submitting jobs via a simple interface without even needing to know where they run. For astronomy, we need further layers known loosely as a "data grid" and a "services grid". All these ideas are closely paralleled in other science areas, and in particular have been driven by the needs and desires of Particle Physicists, who have the scariest data rates and data volumes of all. (Astronomers however have more diverse, heterogeneous, and highly structured data, bringing extra problems). Through the summer of 2000, a series of inter-research-council meetings were held, which led to a fascinating atmosphere of both collaboration and competition. At this stage, the AstroGrid concept became formalised and a consortium formed and proposal written, as we felt strongly that astronomy had to have a coherent project in order for PPARC to bid upward with. This strategy has largely worked, but the whole story is much larger, as a large fraction of the "e-science" funds have been kept centrally by the OST, still to be bid for, giving a much larger opportunity for the astronomical community.

A formal proposal was put to Astronomy Committee in October 2000 and was very well received. Since that time developments have included (i) substantial strengthening of the solar component, (ii) formal links with the US NVO project, (iii) an agreement to make an EU RTD proposal along with ESO, ESA, Jodrell Bank, Terapix, and CDS Strasbourg, (iv) a first AstroGrid workshop, to be held in Belfast Jan 29-30. (v) Plans for a session at the 2001 NAM. The project is now required to provide further plans and costings to Astronomy Committee on March 1st. It is in preparation for this Astronomy Committee review that we request community input.

ASTROGRID POSITION PAPER

The October 2000 proposal to Astronomy Committee can be taken as a position paper for the community, and we encourage all interested to obtain and read this document. It can be downloaded from the preliminary AstroGrid web page at www.AstroGrid.ac.uk

ADVISORY ARRANGEMENTS

AstroGrid is not an astronomical research project, but a project to deliver the infrastructure needed to do research. We see it as equivalent to building an instrument. A small number of groups will build the instrument, but everybody will use it. However we are extremely keen that the community of end-users is closely involved in advising and guiding the project, and in determining the science requirements. The first year will involve an intensive R&D phase, an assessment of current functionality and requirements, and consultation exercise. This is intended to include open calls for comment such this one, specialised workshops such as the upcoming Belfast workshop, and occasional open meetings. An early aim will be to complete a Science Requirements Document.

An overall "Grid-czar" is being appointed by the OST to oversee the whole programme, especially the generic work. PPARC is also appointing its own "e-science Director" and is setting up a steering committee which will cover both Particle Physics and Astronomical activity (including work outside AstroGrid). AstroGrid itself will have a Project Manager who will liaise with the steering committee. Community oversight of AstroGrid will therefore be through the e-science steering committee. However we do not feel this will be enough to provide community input on determining science requirements, or to tap into the large variety of both scientific and technical expertise spread through the community. We are therefore inclined to establish our own AstroGrid Science Advisory Group.

WHAT ASTROGRID IS NOT.

(1) AstroGrid is not research. It is infrastructure that should enable us to do more and better research.

(2) AstroGrid is not for theoretical modelling - it is a datagrid project. The computational needs of theoretical astronomers were also highlighted in the LTSR, but these should be pursued and funded separately. However many of the technical issues are closely related of course, so we should stay closely in touch.

(3) AstroGrid is not intended to swallow all of astronomical e-science. Although a large fraction of the new PPARC funds will undoubtedly go towards the LHC-Grid and AstroGrid projects, there will be opportunities for more diverse small proposals, and a far larger uncommitted pot of money (30-45M) will be held by EPSRC for bids across all subject areas. An example is that PPPARC will be funding 10 studentships per year in this area.

(4) AstroGrid is not just another name for existing or expected activities, eg Starlink, the XMM SSC, the SOHO archive, or the VISTA pipeline. Rather, it should be delivering clear added value in each of the related areas.

CALL FOR COMMENT.

We invite interested individuals to read the Astronomy Committee proposal and send suggestions and comments to any of the PIs. As well as any open-ended comments, we are particularly interested in the following :

(i) We are aware that a danger may lurk in being too ambitious. What should be the top priority concrete goals ? What can we really achieve in three years ?

(ii) We are interested in "use-cases" - i.e. examples of scientific projects you could achieve if AstroGrid were in place. (i.e. the "Design Reference Mission" in NASA speak)

(iii) Do the arrangements for community consultation sound satisfactory ? Do you have any further suggestions ?

(iv) Where do you believe the UK is strong, and where weak ? Ditto astronomy versus other science areas.

(v) Alongside the software developments we have considered a funded assisted archival research programme, similar to "Astrovirtel". Any comment or further similar suggestions ?

ANNEX-I : Summary of responses to Call for Comments

Following a Call for Comments announcement via the PPARC Astronews email exploder (Jan 22nd), a number of responses concerning the AstroGrid proposal and, more generally, the PPARC E-Science budget, were received by the consortium. Some of these responses concerned proposals that have been, or will be, submitted independently to PPARC. The number and diversity of responses was highly encouraging, showing both the strength of community interest and the timeliness and relevance of the E-Science initiative. It is clear that there is overlap between the requirements of some of the responses and that those which remain outside the remit of the AstroGrid proposal require coordination.

The responses are summarised below. The AC is asked to comment on whether any specific areas below should be considered for inclusion in the AstroGrid proposal. This is of some urgency, since some of the groups concerned need to know how to respond to the PPARC Call for Proposals. An alternative approach would be to wait until after the results come in from the PPARC AO, since there is no way of knowing if this set of responses is representative of the community's needs.

1: Atomic Physics Databases: Keenan(QUB)

Atomic data are a crucial element of many areas of astrophysics, including spectroscopy and plasma modelling. The current AstroGrid proposal is mainly concerned with observational data from ground-- and space--based astronomical observatories. Laboratory and theoretical atomic physics data are not mentioned.

Atomic physics data are, of course, important not just for astrophysics plasma modelling, but also in many areas of laboratory physics relevant to the EPSRC remit. Therefore this may be a potential bid through the EPSRC route, as a joint EPSRC/PPARC programme.

2: Gravitational Wave Astrophysics: B. Sathyaprakash (Cardiff)

Gravitational wave data analysis can greatly benefit from Grid development. The Grid will help not only in data transfer among different antenna projects in Europe but also across the Atlantic. Distributed computing in a Grid environment greatly enhances the volume of parameter space that one can search to match model and observed gravitational wave data.

The Cardiff group have developed a graphical programming language (Triana) that allows one to execute and monitor analysis of data on a distributed system. It is proposed to develop Triana as an API to run application software on a network of grid computers and secondly to develop software to enable AstroGrid to carry out distributed computing, aimed at harnessing wasted CPU cycles on idle machines.

3: Federation of Astronomical Specctra Archives and databases of theoretical spectra and in silico generation of models and fitting: Jeffery (Armagh)

An important e-Science requirement is the ability to interface archives of astronomical spectra, databases containing theoretical spectra, codes for generating new spectra and tools for finding optimal fits. The second requirement is to be able to share distributed computing resources effectively.

Key requirements for such a system are:

1) Federation of key spectroscopic archives (INES, 2dF, 6dF, WYFOS)?

2) Tools for interfacing archives of theoretical spectra to observations (eg simply overlaying a model on top) ?

4: Merlin data and access methods for uv-data; Garrington et al (Jodrell Bank)

This response focused on the requirement for AstroGrid to support provision to UV visibility data as well as radio images and source catalogues. The focus of the proposal was on data from the MERLIN/VLBI National Facility, however, the requirement to support access to UV visibility data is also relevant to more general VLBI and to ALMA.

The following issues were raised:

(a) Inclusion of items for interoperability of radio data, including access methods to uv-data.

(b) Consideration be given to exploringg remote on-the-fly processing for extraction of small sub-images from large wide-field visibility data-sets.

5: Interferometric imaging: Richer (Cambridge) et al

The response emphasised the diversity and differences in the types of data that exist in astronomy. These range from simple 2-D scalar datasets i.e. images and catalogues through multi-dimensional scalar data sets (spectral cubes, polarisation data, etc) and non-scalar data (e.g. complex visibility data sampled at random points).

Points raised included:

(a) Requirement for data mining tools to access and manipulate visibility data e.g. combine interferometric data sets, make images from them, etc.

(b) Data mining tools (eg source extraction) must cope with incomplete uv coverage and effect on point spread function

(c) Full polarization data (I Q U V) may be available from these telescopes and needs taking account of in data structures.

(d) New image processing algorithms are needed.

(e) Highlighted requirements of future facilities such as PLANCK/FIRST, and optical interferometers (VLTI, LOA)

6: Apply LHC Technology to Astronomical Archives; Carter(LivJM) etal

This is a costed proposal to develop a data archive and analysis facility based upon the MAP architecture developed for the LHC project by the University of Liverpool HEP group and deploy it as the archive facility for the Liverpool Telescope on La Palma. The proposal is complementary to the AstroGrid proposal and focuses on a single archive and to take technology already developed and currently in development for the LHC project, and enable it for use in an astronomical context. The resultant tools could be probably deployed within the context of the AstroGrid programme.

7: The UK Wide-field Automated Survey Programme (WASP); Wheatley (Leic) et al

WASP is a recently-funded PPARC programme to build and operate a small aperture wide-field telescope that will image the whole sky each night. The experiment will generate 200GB of data per night and this must be processed in real time to search for time variable and/or moving sources.

8: Needs of GAIA mission ; Wynn Evans (Oxford) et al

These respondents made a number of detailed and useful general comments and suggestions. They specifically stressed however the unique IT needs of GAIA and its strategic importance on the UK scene, and proposed a close involvement of GAIA workers within AstroGrid. GAIA is certainly very important but seems rather a long way downstream compared to the three-year AstroGrid timescale so our instinct is to suggest that GAIA simply keeps a watching brief.

9: Further statements

Supporting statements, expressions of interest, and many more technical suggestions were also received from:

Clowes (Lancs: Chairperson of the Starlink Information Services and Databases Software Strategy Group)
Edmunds (Cardiff: Chairperson of the VISTA Executive Board)
Walton, Lennon, Rutten (Isaac Newton Group)

Walker (Cardiff Computer Science Department)

Replies to respondents

We have made brief informal responses to most of the above but would like to make more formal responses once we have seen Astronomy Committee's reactions.

ANNEX-J : Report on the first AstroGrid Workshop

Hosted by Queen's University Belfast, 29 & 30 Jan 2001

Purpose of meeting

The purpose of the meeting was twofold:

(i) to provide members of the UK astronomical community with information on the AstroGrid programme, and allow open discussion of it amongst them;

(ii) start to identify the areas of existing activity with the UK in the context of the rest of Europe and North America.

The specific scientific topics advertised as the aim of the meeting were:

1. Data mining.

The Grid will be used for the development of innovative data mining methods: important concepts here are self-organisation, multiple resolution, and progressive refinement. Closely associated with this work will be the development of new tools for ingest of data into data archives and data centres.

2. Information Discovery.

The Grid will help the astronomer face the tsunamis of data resulting from current and near-future observing facilities. Themes here are dealing with structured and unstructured data, search and discovery tools, smart information agents.

3. Visualisation.

Observed data and simulated data (from cosmological models, and instrument and detector models) will be used. Approaches will include interactive visual user interfaces, 3D representations, and innovative new techniques aiming at support for distributed, collaborative work.

Attendance

The workshop was attended by over 37 participants (see Appendix below) including three senior staff from the Strasbourg Data Centre, plus Schade from the Canadian Astronomy Data Centre and Thakar from the Sloan Digital Sky Survey Science Archive group. In addition Rickett (PPARC) and Fleming (EPSRC) attended and were able to provide useful up to date 'official' information on the PPARC E-Science programme.

Day 1 Programme:

This consisted of sessions devoted to presentations on:

General Assessments:

This section included an objective assessment of the currently available and competing technologies with an emphasis on existing standards and commerical database systems. Presentations covered comparative analysis of Relational Database Management Systems(RDMS) and Object Oriented Databases Management Systems(OODMS) and the CORBA networking application communication protocol.

The General Context:

Virtual Observatory initiatives in the UK, across Europe and in North America were discussed. There was a consensus that the AstroGrid goal of firm science-driven deliverables in a 3 year time frame was preferable to other, more grandiose schemes which promise more but have more risky goals on a longer timescale. The contributions from Strasbourg were of particular value since they focused on real solutions to known problems. For example, the 19 character Bibliographic Code (e.g 2000AAS...197.7802M) for uniquely identifying bibliographic material was presented as an illustration of a simple and effective standard. The complexity of the VO problem was exemplified in the case of the HESSI Solar Satellite which identified the requirement to access data from 29 different Solar datasets all at different sites. The ALMA project was presented as an example of a single project producing a diverse set of data, with particular emphasis on multi-polarisation, multi-channel, Fourier--domain visibility data.

Tools and Techniques:

Here the focus was on the type of architecture and software tools that the AstroGrid programme will need, ranging from a discussion of catalogue formats, through data compression techniques that are needed for the display of remote image data, to a summary of recent research on visual user interfaces to information spaces.

Needs and Requirements:

The final session focused on a number of specific scientific applications and the relationship between the data providers, the archives, distributed datasets and the scientific user.

Day 2 Programme:

This was a morning sesssion devoted to a round--table discussion. The topics covered included:

1. User scenarios (led by Steve Schwartz)
2. Data curation (David Giaretta)
3. Data centres (Francoise Genova)
4. International aspects (Clive Page)
5. Model and observed data (Peter Allan)

Conclusions:

The meeting satisfied a number of different needs and, as a result, a number of well formulated responses to the AstroGrid Call for Comments have been received, as well as suggestions for widening the brief of the AstroGrid programme. One clear concern that was voiced was over the method by which the community could provide input into the AstroGrid programme, and how to identify which things the AstroGrid programme would not be delivering. Such concerns are to be expected in any IT programme.

Electronic versions of almost all the workshop presentations can be found http://main.cs.qub.ac.uk/~fmurtagh/astro-grid-papers/astro-grid-papers.html.

Appendix: Workshop Participants

Allen, Gabrielle (Albert-Einstein-Institut, Golm)
Allan, Peter (RAL)
Bentley, Bob (MSSL)
Boyd, David (RAL)
Butler, Ray (Galway)
Coghlan, Brian (Trinity College Dublin)
Crookes, Danny (Queen's Univ, Belfast)
Csillaghy, Andre (SSL, Berkeley)
Davenhall, Clive (IfA, Edinburgh)
Diamond, Philip (Jodrell Bank)
Fleming, Jim (EPSRC)
Garrington, Simon (Jodrell Bank)
Genova, Francoise(CDS, Strasbourg)
Giaretta, David (RAL)
Goldin, Aaron (Galway)
Holloway, Anthony (Jodrell Bank)
Jeffery, Simon (Armagh)
Lennon, Danny (ING)
Mann, Bob (IfA, Edinburgh)
McMahon, Richard(IoA, Cambridge)
Murtagh, Fionn (Queen's Univ, Belfast)
Noble, Roger (Jodrell Bank)
Page, Clive(Leicester)
Pike, Dave (RAL)
Richer, John (Cavendish, Cambridge)
Rickett, Guy (PPARC)
Rixon, Guy (IoA, Cambridge)
Sathyaprakash, B.S. (Cardiff)
Schade, David (CADC, Victoria)
Schwartz, Steven (QM, Univ. London)
Shearer, Andy (Galway)
Sherman, John (RAL)
Smartt, Stephen (IoA, Cambridge)
Taylor, Ian (Cardiff)
Thakar, Aniruddha (Johns Hopkins)
Trew, Arthur (EPCC, Edinburgh)

ANNEX-K : AstroGrid Activity Areas.

Separate postscript document