

Ground-Based Astronomy STFC Consultation Ad-hoc Advisory Panel Report to PPAN

May 13 2008

Contents

1. Executive Summary.....	2
2. Background: Assumptions and Constraints.....	2
3. Inputs and Procedures.....	3
4. Commentary on Individual Items.....	4
4.1 ELT R & D	4
4.2 SKA R & D	5
4.3 KMOS	6
4.4 ALMA Data-Centre	6
4.5 Dark Energy Survey (DES).....	7
4.6 ING	7
4.7 Liverpool Telescope	8
4.8 Gemini.....	10
4.9 UKIRT	11
4.10 JCMT/SCUBA-2.....	12
4.11 e-Merlin/JIVE	13
5. Broader Issues	14
5.1 The UK's International Standing in the Context of Large Telescopes.....	14
5.2 Overlap with other panels	15
6. Recommendations	15
6.1 Recommendation 1: ELT R & D	16
6.2 Recommendation 2: SKA R&D	16
6.3 Recommendation 3: KMOS	16
6.4 Recommendation 4: ALMA UK Data Centre	17
6.5 Recommendation 5: Dark Energy Survey (DES)	17
6.6 Recommendation 6: Isaac Newton Group (ING) La Palma	17
6.7 Recommendation 7: Liverpool Telescope (LT)	17
6.8 Recommendation 8: Gemini	18
6.9 Recommendation 9: UKIRT	18
6.10 Recommendation 10: JCMT/SCUBA-2.....	18
6.11 Recommendation 11: e-Merlin/JIVE	18
7. Consequences	19
APPENDIX 1	20
Committee Membership	20
Conflicts of Interest.....	20
APPENDIX 2	20
Panel's Terms of Reference	20
APPENDIX 3	21
List of items under consideration	21
APPENDIX 4	21
GB Panel's Priority Order of its items	21

1. Executive Summary

This report is a commentary on the PPAN prioritisation of ground-based astronomy projects, which reflects both community inputs and the views of panel members. Our Terms of Reference required us not to repeat the prioritisation *ab initio*, and to maintain the financial envelope imposed by PPAN. However, because so many of our major items were placed by the programmatic review into the assumed unfunded band 4, this zero sum exercise was not possible. We do however recommend that some re-phasing of the R & D programmes should be seriously considered, as a means to provide some scope for continuing the activities placed in band 4 after the PR. The panel considered all the community inputs, as well as those submitted by the projects themselves, and attempted to balance long-term strategic aims against more immediate issues of scientific quality. Our conclusions and recommendations differ significantly from those of PPAN, as detailed below, and so cannot be taken as an endorsement of the PR outcome. In particular, our view is that PPAN placed undue weight on potentially exciting future facilities, at the expense of those that are currently producing world-class science, or are expected to do so in the near future. We were fortunate to be able to assemble a panel with expertise that covered the full range of facilities and projects in our area, and our recommendations are endorsed unanimously by the full panel.

We have tried in our assessments to take account of the needs of the community for certain kinds of scientific capability, which means that individual facilities cannot be seen in isolation and decisions about the future of ground-based facilities must be taken in a coherent way. In particular, many of the facilities we considered have international partners, or are seeking to acquire them. This introduces additional uncertainty, both in terms of the future cost to the STFC of these facilities, and in the amount of time available to the UK community. It is critical that every effort be made by STFC to mesh the phasing in of international partners so that these external contributions have the maximum effectiveness on our programme.

Finally, our panel has contributed as far as it was able to the process of consultation, review and recommendation, over the approximately 7 weeks we had available. We believe that our recommendations are sound. However, we do not feel that this limited exercise can be a sufficient basis on which to make irreversible decisions on whether to fund or close down a facility. Should the latter be essential this would require additional in-depth consultations including further consideration of expert advice on how such a process should be implemented.

2. Background: Assumptions and Constraints

To quote from the STFC's document outlining the consultation exercise of which this panel's report is a part "It is important to emphasize that PPAN and PALS did not identify any poor quality projects in their rankings." The four categories used by PPAN are; high, medium-high, medium-lower, and low. To avoid the perogative perception that the lowest category is poor science and for convenience of reference, in this report we will refer to them as bands 1 through 4 (with 1=high). Based on information from STFC, it is assumed that all those items currently in band 4 will have STFC financial support removed during the period 2008-11.

The panels were instructed to assume that no new money will be forthcoming over this period, and that therefore any re-prioritisation must be assumed to be a zero-sum exercise. If a panel wished to recommend that an item within its remit be moved up from band 4 into a higher (funded) band, then a corresponding saving would need to be found from within items in those higher bands. Clearly such tensioning is problematic if applied exclusively to one panel. This is particularly so in our case, where many of the more expensive facilities are currently placed in band 4. The financial situation of our panel's items is starkly summarized in Appendix 3. Note: there are on-going revisions to these figures based on assumptions of partners and other factors, but for uniformity we show the figures provided at the start of our review. However, in terms of what is actually possible to achieve across the programme, in the cases which have revised significantly lower budgets this must be a crucial element for consideration.

It is not straightforward for our panel to offer a zero-sum solution, since (excluding band 1), we have two R & D projects currently before PPRP, one instrument project (KMOS) almost complete, and a survey project (DES) with the majority of the money already spent. So the only effective “flexibility” involves the relatively inexpensive Liverpool Telescope (LT), the ALMA data-centre to which we shall return later, and the ING. We note that their combined total cost within the three year period is £5.6M whereas the “revised” reduced costs for our unfunded band 4 projects (assuming that the recommended savings by PPAN can be implemented) are; for UKIRT (£4.98M), e-Merlin (£8.05M) and Gemini (£10.5M). From this simple analysis it is clear that in the case of our panel there is little scope for tensioning within the items we are considering.

The other constraint placed on the panels by STFC is that items within band 1 cannot be recommended for reduced funding. However, there may be scope for justifiable reductions in funding for some items in band 2, and the panel recommends this option be examined seriously by the PPRP for the R & D projects discussed later. For the other items in bands 2 and 3, a detailed review would need to be undertaken. In appendix 3 we provide a list of our panel's revised rankings, the implementation of which will require additional resources.

3. Inputs and Procedures

An important part of the panel's task was to consolidate and consider all of the inputs received during the consultation period. There were 268 individual responses related to the ground-based area, and the panel read all of them. They varied greatly, ranging from rather terse expressions of disagreement with the ranking of a specific item, up to a detailed critique of the PR process and justifications for the importance of a specific facility. There were few targeted inputs on the R & D items (ELT and SKA) or for the instrument build of KMOS. This was also true for the ALMA regional data centre and the Dark Energy Survey. In particular, the funding figures for the two R & D projects are fundamentally different in nature from the costs supplied to the panel for the other items: the former are simply aspirations of those associated with these projects, which are currently being considered by the PPRP. The vast majority of community inputs focused strongly on the telescope facilities; ING, UKIRT, JCMT, Liverpool Telescope and e-Merlin. Predictably, the majority of inputs on the telescopes and on e-Merlin were aimed at those placed in the lowest category following the Programmatic Review. After the consultation period deadline had

passed, an on-line web survey was set-up on behalf of the community (Nial Tanvir, Leicester) and the panel also noted the results from this survey.

The process by which the panel's comments and recommendations were developed involved a telecon, and two full day face-to-face meetings of the panel, as well as many e-mail exchanges. In preparation for our meetings we constructed our own proforma, and completed them for each item. This included a SWOT type analysis (Strengths, Weaknesses, Opportunities and Threats), as well as consideration of broader issues, and an attempt to understand why each item was given its ranking position in the PR by PPAN. We did not seek to exactly mimic the metrics used by PPAN, although we did consider the same broad areas as those listed in the "News from Science Board, January 2008." Finally, based on all inputs and our deliberations we propose our own ranking in each case and give our reasons.

Below we list the individual items under consideration and provide a commentary on each. This contains a brief summary of the community's submissions. We also comment on the documents provided, and give our view on merits or otherwise of each item.

4. Commentary on Individual Items

In the sections below we describe what the panel deemed to be some of the more important issues to consider when determining the relative priority of each item.

In order to facilitate the discussion we have ordered the items into topics e.g. R & D, and instrument build, a data-centre, and a specific survey project. This is followed (not in priority order) by the telescopes/observatories: ING, LT, Gemini, UKIRT, JCMT and the radio interferometer e-Merlin.

Note: the condensed summary of the panel's views on all these items can be found together in the recommendations section 6.

4.1 ELT R & D

There is no specific reference to ELT R & D in the community responses, although there is reference to using some of our present facilities e.g. the WHT+laser guide stars, as test beds for the E-ELT. The ELT R & D is a continuation of previous activity e.g. the ATC led FP6 instrumentation design studies. The STFC invested £3.2M in these studies and targeted some specific technology developments. The strategic aim is to place the UK in a strong position to be P.I. and/or co-P.I. on future ELT instruments. It is essential that such a UK national programme for ELT R & D be aligned with ESO's activities, and more generally global activities. For example ESO E-ELT recently approved a 3 year development phase funded at 57.2M euro, and which will culminate in 2011. It is very clear that there are major opportunities for knowledge exchange with UK industry, which may include the award of contracts, and some such links are already established.

The proposed future activity is currently before the PPRP who will have much more detailed information on what the proposed funds are to be spent on, and will have the opportunity to fully explore the consequences of any reduction in the level of funding requested, and any possible re-phasing. Noting the very considerable jump in funding in years 2 and 3, the panel felt it was important for the PPRP to ascertain whether the proposed spend profile is appropriate, or whether a re-phasing would be possible. Given the current extreme lack of flexibility in the astronomy programme in years 2 and 3, even a 1 year delay in the proposed almost £2M upturn in funding of

the ELT R & D would provide headroom. This could offer the opportunity to build back into the programme some facilities currently in band 4 (assuming such a raising of priority is justified). Therefore the panel urges a careful examination by the PPRP of options for some re-phasing of this programme. In order to signal this, it recommends moving this item from band 2 into band 3, without in any way implying a reduction in priority for the UK's involvement in the ELT preparations in general.

4.2 SKA R & D

There were no community inputs specific to SKA R & D, but a number did refer to SKA in the context of support for e-Merlin and ALMA, and it was also discussed in a document on the strategic development of radio astronomy.

There are some generic programmatic similarities between this activity and the ELT R & D, in that both activities are currently being considered by the PPRP. The other similarity with ELT R & D is the significant step up in requested funding in years 2 and 3. This requires the PPRP to fully understand issues such as the eventual timing of the facility and its pathfinders. It is generally accepted that the ultimate SKA facility(s) will be constructed some years after the ELT.

The panel did its best to understand the interplay of the various SKA related activities in a global context. However, in some respects the situation regarding the roadmap to the SKA is more complex than that to the ELT.

Our summary is as follows. The UK aspires to eventual leadership in some major part(s) of the SKA, and is playing a central role in SKADS, the European SKA design study, which will evolve into PrepSKA (with funding from an FP grant starting in April 2008: the lead in this activity is the STFC, which raises an interesting issue concerning their conflict of interest). The UK is trying to bring all SKA related global organisations together. For example, the UK will host the international SKA Development Office (SPDO). Meanwhile, MeerKAT, the South African so-called “few percent SKA” and Australia's ASKAP, could use outcomes from SKADS (note, these facilities will outperform the VLA, and are in the southern hemisphere). In Europe the well advanced Dutch-led LOFAR project is the most important pathfinder for the SKA. A consortium of UK universities is involved in LOFAR and is now seeking funding from STFC. Their request is currently being considered by the PPRP, at the same time as this item – SKA R & D. Clearly the potential synergies between them must be considered by the PPRP.

During the course of our review the panel received a document entitled “Pathway to the SKA: a UK Strategy” prepared by P. Diamond. This listed a large number of technical developments that have derived from radio astronomy, although many of these were not foreseen originally. A long list of predicted potential benefits from SKA developments is also provided. The strong outreach element derived from UK radio astronomy is mentioned as well, although the planned pathfinder SKA facility based in the UK (via LOFAR) is unlikely to attain the iconic status of the Lovell telescope!

The panel noted that the UK was already well positioned in a number of SKA related programmes and pathfinders mentioned above, and we do not want to risk losing this advantage. That said, the panel hoped that the PPRP will succeed in bringing a greater coherence to all these activities. As for the SKA R & D programme, given the current extreme lack of flexibility in the overall astronomy programme in years 2 and 3, even a 1 year delay of the significant upturn in proposed funding would provide headroom for build back into the programme of some facilities currently in band 4

(assuming such a raising of priority is justified). Therefore the panel urges a careful examination of options for some re-phasing of this R & D programme. In order to signal this it recommends moving this item from band 2 into band 3, without in any way implying a reduction in priority for the UK's involvement in the SKA preparations in general.

4.3 KMOS

There were few respondents who commented specifically on KMOS. Some mentioned a concern about the relative timing of KMOS on the VLT (routine use 2011) and Flamingos-2 on Gemini South due in 2009, which might result in some of the science being done first using Flamingos-2. Although these instruments do not have the same specifications, since KMOS has 24 deployable integral field units whilst Flamingos-2 has multiple slits designed for use with AO, still there is considerable overlap of science areas between the two.

The panel considered that KMOS represented a very good deal in terms of guaranteed time i.e. 125 nights due to the UK instrument consortium. Furthermore UK astronomers will gain early access to KMOS through the commissioning and science verification observations. The other important consideration, and the reason that our panel did not discuss this item in as much depth as most of the others, is that most of the money for the construction has now been spent, with only about £1.3M (out of £6.0M) still to come. Based on the information provided, the panel felt that KMOS was appropriately placed in band 1, and should certainly be funded to completion.

4.4 ALMA Data-Centre

There was a mixed community response on this item. Some of the responses were against supporting ALMA RC on the grounds that such centres had not been demonstrably successful in the past, and that users would prefer to contact the main hub, e.g. "I would question the need for the ALMA Regional Centre. ALMA itself is obviously a high priority, but I have never been impressed with these support groups that have been set-up." Also, since ESO is the coordinating European body for ALMA, it is not clear why they did not undertake to provide user support, just as they do for the VLT. There were several supportive inputs, e.g. "We are concerned that if ARC is not funded (a modest commitment in comparison with our investment in ALMA via the ESO subscription), UK researchers will be less competitive in exploiting this revolutionary facility." Whilst fully considering all these community responses, the panel felt that the number of inputs was not sufficient to conclude that there was a broad community consensus on this item.

The panel noted that the PPRP report supported 70% of the requested funding, at a single centre, with a review after two years. Obviously the PPRP was concerned about the need for a "critical mass" of expertise, a worry also shared by this panel, who did not think that a distributed centre was a good model for user support. The panel recognised that ALMA is one of the UK's cornerstone future projects, and it is probable that a UK centre would enhance the UK's exploitation. However, there is a significant risk that many UK users may choose to by-pass it and seek assistance from other specialist centres. In this regard the panel is lacking specific information on exactly what level of support will be provided across Europe and the USA. It would be necessary to have this information in order to make a final decision on funding. With this caveat in mind the panel considered that in the current climate of

extreme pressure across the whole programme, the ALMA data-centre should be considered as a lower priority than its current position i.e. moved to band 4. Finally, it was difficult to judge the level of Knowledge Exchange or Outreach, although for the latter it is very likely there would be some components.

4.5 Dark Energy Survey (DES)

DES is a photometric survey of 5000 sq. deg. in multiple filter bands (griz), to be carried out on the 4m Blanco Telescope at CTIO. It will use a combination of weak lensing, photo-z's, supernovae and clusters to constrain Dark Energy out to $z \sim 1$. The design is now complete and construction of the camera has begun, with commissioning expected to begin in 2010. The survey proper is expected to take place over 5 years starting in 2011, based on our latest information. The project appears to be on track for US funding. It passed a major DOE milestone (CD2) early in 2008 and is now included in the Presidential FY2009 budget. There seems no reason to question US funding at this stage. The UK contribution is mostly approved, with a significant fraction of the hardware completed or components ordered. The remaining spend in years 2 and 3 is about £650K, and we assume that the exploitation of the results will be funded from grants.

There were rather few specific community inputs about this item, although it was mentioned in the context of other projects in ~ 50 responses. Of the specific inputs, one from the P.I. noted the favorable review of the project in the US by DOE, which apparently will release matching funds to the STFC commitment. Another response from a group closely involved in the DES survey, pointed out that substantial university funds had been invested in this project.

The panel considered the review paper by Trotta (summary of Dark Energy projects, May 2007) in which DES was listed along with a number of other projects aimed at constraining Dark Energy, but which made no attempt to prioritise between them. There is some overlap in scientific aims between the DES project and Pan-STARRS, although the later project currently has only very modest STFC investment contained within elements of rolling grants of the three UK universities currently members of the Pan-STARRS consortium.

Overall the panel felt that DES was probably correctly placed in terms of band 2, but that it should lie towards the lower end when compared with other facilities in our panel's list also in this band.

4.6 ING

There were about 45 community responses specific to the ING, all of which focused on the WHT. The WHT is seen by the community as playing a key follow-up role in many projects and space missions over at least the next 5-8 years, and for surveys such as UKIDSS and future ones planned for JCMT/SCUBA-2, and e-Merlin. It is also seen as a useful test bed for nurturing instrument groups, offering them the opportunity for mounting specialist instruments.

Some extracted comments are, "There is a wealth of follow-up work of survey work in a great many areas that the ING delivers; it is inconceivable to lose this capability."

"The observatory continues to be in high demand from the UK community with over-subscription factors of 3-4, and continues to deliver exciting and world-class observations. Importantly, as part of its forward planning, it is about to offer three new instruments that will play a major role in answering the big questions at the heart

of the STFCs scientific aspirations, and hence is deserving of a higher priority than currently given in the programmatic review.”

“The UK needs to maintain access to and influence upon good flexible telescopes in each size class in the northern hemisphere, as well as the south. This is a basic infrastructural need for a nation aiming to be first-rank in world astronomy either on the ground or in space. A ranking based on science done and likely to be done would surely place the ING ahead of the Liverpool Telescope.”

“I would like to specifically mention the ING, and the WHT in particular as a shining example of a cost-effective and productive facility. Not only is the science output per pound spent remarkable, it also provides the UK with a facility for testing instrumentation. For this, a medium-aperture telescope is needed such as the WHT. The observatory must be commended for its efforts to operate (successfully) within a very tight and over the years shrinking budget. It has found new avenues to secure funding (HARPS/Kepler) and I am confident a cost-effective route can be found to exploit this facility and maintain crucial access to a medium-aperture northern 'work-horse' telescope.”

The panel echoed many of those sentiments expressed by the community. It also noted that the WHT was considered as the *raison d'être* of the ING, although several inputs also mentioned the usefulness of the 2.5m INT. The ING has achieved a very good publication rate (>150 ING papers per annum); on this metric the WHT does better than any comparable telescope. The WHT has produced many high impact papers in recent years, several of which were based on results obtained by using private instruments. There is also a high over subscription factor of 2.0-3.5 in recent semesters. The 45-50 independent programmes per year involve participation of 155 PhD students over the last 3 years. It is also extremely cost effective, with the cost to the UK of access to the ING planned to decrease by nearly a factor of 3 between 2008/9 and 2009/10, due to a streamlined operations system and the sale of WHT time to the US based HARPS-N planet-finding spectrograph consortium (but with a consequent decrease in the UK fraction of time to from 50% to 35%).

Currently the WHT provides a test bed for AO developments. Paid for mostly by the Netherlands, the UK does not contribute directly to the cost of this programme, except via some observatory manpower. Nevertheless it has strong synergy with parts of the ELT R & D programme.

Given its strategic importance for the UK community, its flexibility and its continuing high productivity and impact, it seemed clear to the panel that the ING has been ranked too low in the PPAN priority list. Its capabilities, instrument suite and flexibility of use are not replicated by any of the current ESO telescopes. Following the HARPS-N deal, the ING will be extremely cost effective compared with any similar observatory. The panel recommends that the ranking be raised from band 3 up to band 2.

4.7 Liverpool Telescope

Unusually within this consultation exercise a significant number (>20) expressed surprise that the LT had in their opinion received too high a ranking in the PR compared with other northern facilities (ING, UKIRT, Gemini-N). There are two aspects to this negative perception of the LT's relatively high ranking by PPAN:

- Concerns about the quality of the data and modest productivity of the facility. However it is still a relatively new facility, which saw first light at the end of

2004 (albeit after considerable delay). It is also a complex facility in terms of its robotic operation. Many of the projects that it is supporting involve long-term monitoring; the LT's performance has improved markedly over the last year following the commissioning of an autoguider. The pressure factor is quite low at present (<2), but should improve when the FRODOSPEC fibre-fed spectrograph is commissioned later in 2008. This oversubscription factor should be monitored, because the relatively low current demand from the PATT community would be a serious concern should it continue into the future.

- Concerns about the fact that the LT is limited to rather short observations, it has a relatively small aperture, and serves quite a small community – consequently it is seen by some as a niche instrument.

Although the LT is very useful for fast follow-up of transients and for monitoring programmes, some other facilities can offer something similar e.g. the ING is currently building ACAM, an optical imager for the WHT with low resolution spectroscopic option. This will have 4X the field of view and 4X the sensitivity of the LT, and will be available at very short notice for observations of transients.

For the LT, based on the proforma supplied by the project the panel noted the following aspects. The STFC funding (~£0.4M pa) for the LT buys 40% of its observing time. Using information from the LT web site, to date it has produced a total of 30 refereed papers since 2004. The breakdown is as follows: 2005 (1), 2006(10), 2007(12), 2008(7 so far). This is somewhat below what one might expect for a front line facility (half the publication rate of Gemini for a similar stage). However, many of the projects undertaken by the LT are genuinely long-term. But on the other hand the use of the LT for target-of-opportunity projects many involving rapid publication, should offset the long term nature of many of the projects it undertakes in terms of its productivity. The LT has supported a total of 108 programmes over the last three years, involving the participation of 23 PhD students.

The LT has a close synergy with a number of other projects. It is particularly important for the follow-up of transient objects detected using other ground and space-based facilities e.g. GRBs, SNe, microlensing, and exoplanet follow-up. Looking ahead there will be exploitation of the unique spectroscopic capability (FRODOSpec) and new instruments such as RISE and SupIRCam. Aside from the public outreach/knowledge exchange aspect, PPAN's high ranking seems to reflect the relatively high proportion of Science/Nature papers produced by the facility, but often the LT data is one element of the data-set in these papers. In terms of overall productivity the panel felt that the output from other STFC facilities with lower PR ranking such as the ING, were significantly greater.

Overall, the panel recognised the strengths of the LT especially in terms of its knowledge exchange (as the first fully functioning medium aperture robotic telescope) and also in terms of its outreach activities, for example the UK National Schools Observatory (NSO) project, with 9000 observing requests from schools at the time of the community input deadline, having been processed since 2004. However, when the panel looked at it the context of the other facilities we are considering, we found that we could not agree with the PPAN ranking. The panel was in agreement with the vast majority of the community input, that the LT was too highly rated in the PR, and recommends that it be classified as band 3.

4.8 Gemini

In contrast to the veritable flood of community inputs received regarding for example, UKIRT and e-Merlin, there were relatively very few received regarding Gemini, which is currently placed in the lowest band 4. There were approximately a dozen responses, most of which addressed several other ground-based telescopes as well. This is probably due to the fact that many feel the debate over Gemini had already taken place over the preceding months. Some of the main themes extracted from the community's inputs are listed below.

- Gemini offers unique northern hemisphere access for UK to an 8m class telescope. A number of responses point out that the arrangement between GTC-ESO would result in at best a few nights of access for UK astronomers over a limited period, and hence in no sense would this be a realistic substitute for retained access to Gemini North.
- That STFC senior management badly mishandled the original Gemini recommendation, with key people not involved in the process, the predictable leak of information and then their subsequent statements. This unfortunate sequence of events could have been avoided if senior UK astronomers knowledgeable about the Gemini project and its international partnership, had been involved.
- Gemini offers not only access to state of the art instruments, but also to Subaru via international exchanges and ambitious projects such as WFMOS

We now turn to the STFC's written commentary on Gemini, which appears at the end of the prioritisation list. Their statement is "The UK remains a partner in Gemini until at least 2012, but the intention is to sell 50% of our time on the two telescopes from 2009. Options remain to contribute to the Aspen instrumentation programme. There is a need for a full strategic review of future provision for ground-based astronomy beyond 2012, balancing the access to ESO (which in the future will include GTC in the northern hemisphere), Gemini, Subaru, JCMT and other ground-based astronomy facilities within the context of a capped overall budget."

In terms of other factors that the panel discussed, there are both factual (over-subscription rates) and more anecdotal items, such as the general success of Gemini projects and performance of its instruments, plus management issues. The panel preferred not to delve too deeply into the latter, but the aforementioned STFC review should clearly do so in a structured way and make some direct comparison between performance indicators of Gemini and the VLTs. In favour of the UK keeping access to Gemini North it is important to point out that with *just* 23% of Gemini North observing time plus 35% (reduced from 50%) of the 4.2m WHT, neither telescope alone can provide adequate optical/IR access to the northern skies.

The final point is that by remaining in the Gemini consortium the UK will be in a position to build one of the next generation instruments e.g. WFMOS or PRVS, which is key to the Aspen programme. If the UK was to win a central role in the WFMOS project, it would build on our heritage of being at the forefront of wide-field spectroscopic surveys. The UK's past contributions in this area of astronomy are one of the reasons that we regularly come at or near the top of international tables using metrics of scientific impact e.g. citations overall and specific top cited papers.

The panel is in agreement that time should be sold, preferably on Gemini South but with an eye to the new instruments coming on line on Gemini South (possibly with unique capabilities compared with those on the VLT). Also, the UK should participate in a carefully targeted way (considering the VLT future instrument suite) to the Aspen

instrument programme. The panel recognised that, in common with ING, Gemini serves a very broad science base, including the follow-up of objects discovered by ground and space-based surveys. The panel also considered Gemini in the context of other 8m facilities e.g. the VLT and recognises there are perceived and actual problems with Gemini, for example the high cost of operations, relatively low scientific impact, and some management issues. As the Gemini project currently stands the panel recommends that the ranking be raised from band 4, to the top of band 3.

However, the panel understands that the concerns mentioned above are also fully recognised by our other Gemini partners (particularly the USA and Canada). If with coordinated effort these problems can be rectified, then in such a situation the panel would be willing to move Gemini North to band 2 given its great strategic value in the northern hemisphere and the importance of continued interactions with Subaru.

As with other items, the panel's recommendations are based on our scientific assessment. However, since Gemini is our most expensive item we should note the following factual information. Since Gemini was placed in band 4 by PPAN, and even assuming a funding reduction to around half in years 2 and 3, if 50% of our time can be sold, this still comes to £7M over the three years. So, as stated earlier in this report (see section on Background) within the items in our list, moving Gemini from “unfunded” to “funded” cannot be a zero-sum process without bouncing practically all other items into band 4. Therefore a broader review across the programme will be needed. Finally, as has been well publicised, to withdraw from the project immediately will very likely cost more than the option of staying within the consortium until a full review of the future of our ground-based facilities has been carried out, as mentioned in the STFC's consultation paper.

4.9 UKIRT

PPAN placed UKIRT in band 4, and the community responses to this were high in numbers and robust in tone. Some selected quotes from these are given below. Clearly the vast majority of these inputs were prompted by what was universally perceived by the sub-set of the community that responded, to be the surprisingly low ranking of UKIRT in the PR. A general theme from the responses was that UKIRT was delivering excellent science and was seen as being at the peak of its productivity. Some members of the community commented on the excellent science being carried out using cassegrain instruments, and were against moving to a 100% survey mode. Whilst many others emphasised the importance of completing the UKIDSS. Some specific quotes are:

“It is essential to continue UKIDSS as it is delivering right now!”

“UKIRT remains the near-IR telescope of choice for a number of science areas.”

“I believe that UKIRT is one of the great current successes of UK astronomy and it is important that the full UKIDSS program be completed.”

“The UKIDSS survey is the current jewel in the crown of UK astronomy.”

“It is proposed to immediately shutdown facilities in the prime of life, e.g. UKIRT, with higher priority given to a number of projects having much lower scientific impact.”

Note that each quote above is taken from an independent community submission.

The STFC/PPAN commentary on UKIRT was stark in the extreme – although subsequently somewhat modified regarding the date proposed to move towards

100% survey mode, from almost immediately to the end of this year. However, the STFC statement that “efforts are in hand to find international partners, and should these efforts fail, immediate closure would have to be seriously considered.” remains on the PPA’s agenda. Also, although PPA recognised that the UKIDSS survey was still only partially complete, it felt that the overlap with the VISTA survey meant that its priority was lowered. In addition it felt that the science done with other instruments on UKIRT could be covered using other telescopes.

The panel noted the following points taken from the information provided by the project. UKIRT supports around 270 UK astronomers per year, either as PI/Co-I or archive users. The oversubscription is 2.5 in recent semesters, leading to 60 papers per year. Joint operation costs for both the highly rated JCMT and UKIRT allow for a very economical package, and consequently a cost effective operation for each facility.

The panel felt that the low ranking of UKIRT within the PR was a result of a tendency by PPA to emphasise new over the existing facilities. Of course there is a need for eventually sunsetting of some facilities in order to sunrise others, but this must be based on sound assessments of productivity and impact of the mature telescopes. WFCAM is currently undertaking world-leading surveys e.g. UKIDSS. The delivery of the UKIDSS survey in terms of the UK’s commitment when joining ESO, is due in 2012. There is no serious competition for UKIRT/WFCAM (since WIRCAM on the CFHT has less grasp) in the northern hemisphere, where many of the future surveys will be performed e.g. Pan-STARRS and Sloan-3, until if and when ESA’s space mission DUNE (now merged with a spectroscopic mission, and together called EUCLID), is finally selected for launch in 2018. The issue of competition from VISTA is not compelling since the latter is not yet ready to commence its survey, whereas UKIDSS is well on the way to completion and complementary optical survey data can be easily obtained.

Based on the scientific value of the UKIDSS survey to UK astronomers, and our commitment to ESO, plus the above mentioned operational efficiency and cost effectiveness, the panel strongly recommends that UKIRT should continue, together with a partner, for the very least up until the completion of UKIDSS at which time a full scientific assessment of plans the future use of UKIRT can be made. Furthermore, it is obvious that to have any chance of attracting a partner, a few years of future operation would need to be guaranteed. The panel agrees with the unanimous view expressed in the community responses, that UKIRT is too low in the PPA PR rankings, and so recommends that it be placed in band 2.

4.10 JCMT/SCUBA-2

There were relatively few (~6) community inputs, presumably a consequence of its high ranking in the review, and there were no negative comments. Many of the inputs referred to the need to ensure that appropriate means should be available to follow-up on SCUBA-2 surveys, and other observations. The panel questions if there is any point in giving certain facilities high priority (e.g. SCUBA-2, SWIFT) if the facilities required for essential spectroscopic and imaging follow-up e.g. ING, Gemini, e-Merlin etc., are given such a low priority that it leads to them being cut. See also this report’s Broader Issues section 5. In addition several community responses noted that the cost of operating the JCMT would rise if UKIRT was closed.

The panel noted that the success and impact of the JCMT is inextricably linked to that of its main new instrument SCUBA-2, due for full scientific operation early in

2009. The SCUBA-2 legacy programmes will take up 55% of the UK/Ca/NL time. Although there will also be the HARP-B instrument, the future of the JCMT will be tied to that of SCUBA-2. A review in 2-3 years time should examine this aspect. The clear opportunity is for the UK to gain or strengthen leadership in key areas such as obscured galaxies at high redshift, star formation in general, debris discs and solar system formation. The panel noted the impressive metrics for the JCMT listed in the project's submission to PPAN. A significant concern of the panel, which is shared by many in the community, is the fundamental importance of a vigorous follow-up programme using complementary facilities, in view of the relatively poor spatial resolution of SCUBA-2, and the need for optical, near-infrared and radio data.

The panel endorsed the high ranking of JCMT/SCUBA-2 in band 1 of the PR.

4.11 e-Merlin/JIVE

There were a very large number of community responses (~ 110) concerning e-Merlin. These ranged from letters of support at high level i.e. Directors of ASTRON, NRAO and INAF, as well as very many from young astronomers and even members of the public. Points frequently stressed included;

- the loss of e-Merlin would be a total waste of previous large investment, whereas the science potential is high, e.g. the 2005 review stated that “e-Merlin would be world-leading for at least another decade.”
- e-Merlin is a unique training facility for young astronomers, being the only one in the UK, and many PDRA's mentioned that radio astronomy is an important part of their multi-wavelength requirements
- that the e-Merlin up-grade is a huge leap (like upgrading a 4m optical telescope to a 20m), and it fills an important range of baseline parameter space needed for image fidelity
- e-Merlin has a very high profile across Europe, and many European astronomers (as well as UK ones) would lose capability e.g. JIVE/EVN, and the UK's high reputation in this area would be seriously damaged.
- there would be synergy with the SKA science, and the current skill base in radio astronomy would be retained and the potential SKA community encouraged and expanded by its involvement using e-Merlin.

In addition the panel considered other issues such as the threat to e-Merlin from the e-VLA. This could come on line within 1-2 years of e-Merlin, and have better sensitivity, but could never match e-Merlin's spatial resolution. Merlin's past publication rate is medium, but with the large increase in capability of e-Merlin it is poised to grow considerably. The growth of the user base has already started, and with 32 e-Merlin legacy proposals currently planned, it should increase by an order of magnitude. One problem faced in judging the potential science impact of e-Merlin is the breadth of the areas it will cover ranging from astrobiological molecules to cosmology. It is difficult to predict which subject areas are likely to provide the highest science return, but with a factor of 30 increase in sensitivity of e-Merlin wrt Merlin, it is guaranteed to lead to major discoveries. Therefore the panel agreed that e-Merlin offered dramatic potential to both traditional UK radio astronomy users and importantly to a broader community. Even accounting for the competition (e.g. e-VLA) e-Merlin could be a world-leading facility well into the next decade. The proposed legacy programs demonstrate the great breadth of science which will be opened up by this new facility.

As a result of the considerations above the panel recommends raising the ranking of e-Merlin from band 4 into band 2. This recommendation was based on our scientific assessment. We were naturally also aware of the financial implications if this is implemented, and in this regard we noted the following statement in the STFC's document describing the process of the PR. "The cost of construction of e-Merlin is being borne by NWDA. STFC plans to discuss the situation with NWDA and the University of Manchester, mindful of the potential strategic link with the SKA." The panel welcomed such an initiative but was concerned at the major unknown of whether a significant cost reduction to the STFC could in fact be achieved.

Finally, the panel was alarmed that one of the assumptions in the planning for a reduced budget is a total withdrawal from JIVE in years 2 and 3, saving approx. £170K per year. This would remove the UK's involvement in the European VLBI network, of which UK astronomers have had a significant fractional use. Other consequences would be our exclusion from EC funded projects like EXPRéSS (real time correlation via the internet) together with various other sources of funding in FP7.

5. Broader Issues

Our panel has not attempted to summarise all the external evidence supporting the excellence of the UK's astronomy programme, but we refer to the conclusions of the recent report by the international panel commissioned by PPARC, EPSRC, the IoP and the RAS in 2006. This highlights our high standing in the international scene, and by implication the dangers we now face in the current situation.

5.1 The UK's International Standing in the Context of Large Telescopes

A big question to address is does the UK have access to an appropriate suite of such facilities? In numerous places in this report it is stated, based on the community's inputs and in the panel's opinion, that ground-based telescopes are essential for follow-up of surveys and space missions, as well as doing key science in their own right. Critics often claim that astronomers have never given up access to a ground-based large telescope. However the facts show otherwise. As one of the correspondents in this consultation states, "In 1990 the UK had access to the equivalent of two out of the fifteen 4m-class telescopes then operating (the largest apertures at the time) i.e. that was ~13% of the global 4m telescopes comprising 85% of UKIRT, 60% of the WHT and 50% of the AAT." There are now thirteen 8m class primary mirrors. With ESO and full membership of Gemini the UK has access to an equivalent of 1.2 times an 8m telescope, or 9% of the global 8m telescopes. Assuming a 50% reduction in our Gemini access if we can sell the time, this becomes ~7.5%, or roughly half what we had in 1990 in terms of the world's then largest telescopes. Furthermore, in the near future the plan is for our access to UKIRT to reduce to ~40% if we can find a partner, plus 35% of the WHT (following the HARP deal with the US), and officially 0% of the AAT. Meanwhile Spain and South Africa have their own 10m telescopes, and Germany and Italy are part of the 8m LBT project. Using such basic metrics the UK is slipping down the international league of large telescope users.

5.2 Overlap with other panels

In addition to the panel's allocated facilities there some areas where it felt it was essential to have a view. In particular in areas that overlap with interests of the panels, especially those dealing with Computation and Theory, Space Science and Exploration, and to some extent Astro-particle Physics.

Theory underpins all efforts towards interpretation of data, and so a healthy theory base is essential. As with observing facilities this requires renewal and enhancement of computer hardware, and support of the operational costs. This must form a key part of what is often referred to as a “balanced programme.”

Turning to astronomy from space, all past experience points to the fact that all such missions need access to multi-wavelength ground-based telescopes in order for their results to be fully exploited. Just two examples are the UK's high standing in the fields of X-ray surveys, and infrared and sub-millimeter surveys. Indeed, the UK's initial inability to build on our premier position in radio astronomy in the 1960's can be attributed to our then lack of access to large optical telescopes. We should learn the lessons of the past, and seek to optimize our impact in the future.

On the issue of large survey data-bases and wide field astronomy units, the panel saw the relevance of these related to large scale imaging and spectroscopic surveys. However it felt that in many, if not all, cases the specific survey projects concerned should bring forward their own plan for data processing and archiving. Finally, ASTROGRID – the panel noted that a large amount of time, money and effort had gone into this project, and that now it was just about ready for serious community use. Whilst it was difficult to imagine how this project could be set at a high priority, in the current climate, nevertheless it seemed reasonable to devote just sufficient resources to enable it to be tested for a trial period in the field by astronomers, and then to decide what its longer term future should be.

Finally, the panel's remit did not cover the issue of community support via standard and rolling grants, yet without these the value of access to facilities is minimal. The balance between grant funding and facilities is another example of the necessity of tensioning across the whole programme to arrive at a coherent result.

6. Recommendations

In formulating our recommendations the panel first had to agree on some overarching issues, which would have a significant influence on the result. The panel is fully cognizant of the need to invest in new facilities, and the necessary phasing out of some existing ones. However, having reviewed all the material in depth we believe that the ranking outcome of the PR has got this balance wrong. The proposed closing down of world-class highly productive facilities on a very rapid timescale, in addition to the loss of science to the UK community, would seriously damage the UK's high-standing in international astronomy. In terms of metrics such as publications and citations this would jeopardise our hard won position as second only to the USA in general (and ahead in some areas), and number one in Europe.

The panel realises that funding constraints are obviously a critical issue in implementing any scenario that requires additional resources. One can identify two ends of a spectrum in formulating a coherent approach. Either we can assume that we are currently in an anomalously dire situation regarding funding, and that things will eventually improve, albeit at best after the three funding years under consideration. In that event this becomes a damage limitation exercise in which we try to sustain as much of the programme as possible, retaining our core activity with

a strategy to recover in the future. At the other end of the spectrum the assumption is that things will not improve significantly over a period of at least 5 years. In this scenario we would have to face the prospect of a significant reduction in capacity to deliver all the things listed, at least those within this panel's remit. This second scenario, although quite possible, cannot be known for some time, and hence without being excessively exuberant the panel's opinion was that it was justified to assume some modest improvement in the situation in the future, and that is the basis of its recommendations.

Finally, if it transpires that a major long term reduction in the UK's astronomy base is unavoidable, with all the negative consequences that this implies i.e. one cannot easily resurrect a community built around a subject area once it has been dispersed, then the panel strongly believes it is essential this is managed as part of an open and fully considered process. Our panel's efforts in just over 7 weeks may contribute to this process, but it cannot be considered as entirely adequate in determining the fate of whole areas of astronomy.

Below we extract the main points from the preceding sections, and present them in the form of a set of recommendations. For comparison our panel's rankings are compared with those of PPRP/PPAN in Appendix 3

6.1 Recommendation 1: ELT R & D

The ELT R & D programme is central to ensuring the future of the UK's premier position in ground-based astronomy. The key issue is targeting investment, including UK industry and also phasing our activities. A detailed programme for this is being considered by the PPRP. The panel felt that careful alignment with ESO's recent initiatives and future EU programmes was essential, particularly regarding the timescales of our investments. For this reason the panel recommends that ELT R & D should be moved into funded band 3 (near to the top). This is not because of any reduction in priority of the UK's key roles in the ELT, but simply because the panel felt that elements within the programme during the assumed steep ramp-up of funding should be carefully considered for re-phasing.

6.2 Recommendation 2: SKA R&D

The panel noted that the UK was well positioned in a number of the SKA related programmes and "pathfinders" mentioned above, and we do not want to risk losing this advantage. That said, uncertainties in the overall SKA schedule and tensioning with other UK radio facilities, result in our recommended lowering of the ranking into band 3. The situation here is rather different from that of the ELT R & D project above, in that the SKA R & D includes numerous "pathfinders" that will all produce science in their own right. The panel encouraged PPRP/PPAN to attempt to bring a greater coherence to UK radio and SKA activities, and to carefully examine how the projected increase in funds over the next three years could be rephased. It is important to emphasize that the panel does not imply any reduction in the high level of importance to the UK of our involvement in the SKA, simply the fact that currently many important issues and timescales remain to be resolved.

6.3 Recommendation 3: KMOS

This instrument is the UK's flagship involvement in our first round of building VLT instruments. The consortium observing time accrued as a result (125 nights) is a

major resource when compared with the UK's current return of VLT time. Most of the hardware money has now be spent. The panel agreed that KMOS was appropriate to be included in the top band 1.

6.4 Recommendation 4: ALMA UK Data Centre

The panel noted the pros and cons, based on the past experience, of setting up a regional data centre for major international facilities. This came down to the need for critical mass of expertise and ease of access for our community. On balance the panel felt that the desired outcome might be achieved by other means, such as arrangements with other UK centres having specialist technical and scientific experience in this area. With this in mind the panel recommends lowering the ranking into band 4.

6.5 Recommendation 5: Dark Energy Survey (DES)

The panel noted that this project is now relatively far advanced, and money has been invested in the UK in hardware. Although there has been some schedule slippage, its full approval on the US side is now imminent (we are informed). There are several other projects, some with UK involvement, that will address the problem of Dark Energy. Given that this is one of our highest priority topics, and taking account of the uncertainties it would be prudent to pursue more than one avenue, including the DES. The panel felt that DES was probably correctly placed in band 2, but that it should lie towards the lower end when compared with the other facilities within our remit also in this band.

6.6 Recommendation 6: Isaac Newton Group (ING) La Palma

The panel considered in broad terms the ING's strategic importance to the UK community. This was based on its current capabilities, instrument suite and flexibility of use, and the importance of having access to ground-based northern hemisphere optical/IR follow-up for on-going and planned surveys and space missions. These qualities are not fully replicated by any of the current ESO telescopes. Following the HARPS-N observing time access deal, the ING will be extremely cost effective when compared with any similar observatory. The panel therefore recommends that ING (primarily the WHT) be raised from band 3 (assumed funded) to band 2. Its role beyond 2010/11 should be assessed as part of the general review of ground-based facilities already mentioned in STFC planning documents.

6.7 Recommendation 7: Liverpool Telescope (LT)

The LT clearly has well defined elements of Knowledge Exchange and Public Outreach to its activities, although perhaps the former has now largely fulfilled its role. It has a well established place in the follow-up of fast transient and in monitoring programmes, along with several other (robotic and otherwise) mid-small aperture telescopes. But it does not have a clear strategic importance to a large fraction of UK astronomers. The panel felt that this did not add up to a justification for such a high ranking in the PPAN review, and recommends a ranking in band 3 as more appropriate. The panel noted that this was also consistent with the great majority of community inputs received on the subject.

6.8 Recommendation 8: Gemini

The panel supports the sale of up to half the UK share, noting the need to maintain northern access and participation in unique instruments coming on line on Gemini South. The panel also considers that the UK should participate in a targeted way in the Aspen instrument programme. Based on the detailed arguments set out in section 4.7, the panel recommends moving Gemini from band 4 to the top of band 3.

The panel also considered Gemini in the context of other 8m facilities e.g. the VLT and recognises there are perceived and actual problems with Gemini, for example the high cost of operations, relatively low scientific impact, and some management issues. However, the panel understands that these matters are fully recognised by our other Gemini partners (particularly the USA and Canada). If with coordinated effort these problems can be rectified, then in such a situation the panel would be willing to move Gemini North to band 2 given its great strategic value in the northern hemisphere and the importance of continued interactions with Subaru. In this context defining the role that the UK should play in reviewing the future operational model of Gemini is clearly very important for the forthcoming STFC review.

6.9 Recommendation 9: UKIRT

The panel agreed that the primary role for UKIRT in the future is to complete the UKIDSS survey. Although finding a partner in order to reduce operation costs is important, this should not be allowed to delay the completion of UKIDSS, which is also a component of our agreement on accession to ESO. The panel recommends that UKIRT operations should continue at the very least up until the completion of UKIDSS, after which a full review should be undertaken. Given the high priority of UKIDSS, recognized by both the panel and strongly emphasized by the community inputs, the panel recommends raising the priority of UKIRT from band 4 up to band 2.

6.10 Recommendation 10: JCMT/SCUBA-2

The panel recognised the crucial link between the success of the JCMT as a facility over the next few years, and its new instrument SCUBA-2. One concern is that in order for the UK to fully capitalise on the great science potential of SCUBA-2, we must have access to appropriate follow-up facilities, both in multi-wavelength terms and in spatial resolution in the sub-mm and radio. The panel recommends that JCMT/SCUBA-2, stays in the highest ranking band 1.

6.11 Recommendation 11: e-Merlin/JIVE

The panel agreed that e-Merlin offered dramatic potential to both traditional UK radio astronomy users and importantly to our broader community. Even accounting for the competition (e.g. e-VLA) e-Merlin could be a world-leading facility well into the next decade. The proposed legacy programmes demonstrate the great breadth of science which will be opened up by this new facility. As a result of this we recommend raising the ranking of this facility from band 4 into band 2, realising of course that this implies either a tensioning elsewhere in the programme (since within our panel's allocated items moving it from unfunded to funded would require a decimation of the currently funded items) or a drastically reduced operations contribution from the STFC.

Whichever option is explored, the panel was alarmed by suggestions of the possible UK's withdrawal from JIVE/EVN activities. We have benefited greatly from this international collaboration and withdrawal would seriously damage the UK's international standing in radio astronomy.

7. Consequences

It is obvious from the panel's recommendations that we are unable to achieve the STFC's brief of a zero-sum exercise. However, this task was impossible from the outset, since Gemini was already placed in band 4 (unfunded) with a best case scenario in which we sell half the time, corresponding to a three year spend of £7M. It is by now well known that if we withdraw immediately from the consortium then it will cost the same as staying in as a partner until 2011. So moving Gemini into the funded band, would require most of the items originally in bands 3 and 2 to move into band 4 to compensate. This is not a solution that the panel is willing to propose.

We do identify some potential savings in years 2 and 3, by strongly recommending rephasing of elements of the R&D programmes. It is inevitable that our items will eventually have to be tensioned against other elements in the programme. We cannot, and were not asked to do this. As an indication of our panel's overall ranking we list all our items in priority order in Appendix 4, but we caution that some rankings are dependent on outcomes we do not yet know (e.g. Gemini: improvement in some key aspects, ELT and SKA R & D programme phasing: the level of pan-European support to be provided for ALMA users).

APPENDIX 1

Committee Membership

Professor Martin Ward, Chairperson (Durham University)
Professor James Hough (University of Hertfordshire)
Professor Mike Barlow (University College London)
Dr Jane Greaves (St. Andrews University)
Professor John Peacock (University of Edinburgh)
Professor Clive Tadhunter (University of Sheffield)
Professor Robert Fender (University of Southampton)
Professor Robert Kennicutt (University of Cambridge)
Professor Richard Ellis (Caltech, and Oxford University)

Conflicts of Interest

Ward: institutional conflict with KMOS and ELT R &D

Hough: Chair on the ING Board

Barlow: Co-I in the Dark Energy Survey (DES) team. Chair of the KMOS oversight committee.

Greaves: member of Scuba-2 GT team, survey manager for a Scuba-2 legacy project, former staff member of the ATC. Prospective e-Merlin Legacy project leader, and member of e-Merlin TAC. Member of UK ALMA advisory board

Peacock: Associated institutional conflict with ATC projects. Co-I in the Dark Energy Survey (DES) team

Tadhunter: e-Merlin legacy Oversight Committee, Liverpool Telescope Oversight Committee

Fender: UK LOFAR consortium P.I. Member of e-Merlin legacy programme.

Kennicutt: No direct conflicts of interest

Ellis: No direct conflicts of interest

APPENDIX 2

Panel's Terms of Reference

Extracts from a document on the STFC webpage titled, "Update on the Consultation Process " by John Womersley:

The panels have been asked to reread and distill the community input and summarise the points being made, and add their own commentary about the prioritisation and what they think STFC should do. They are not asked to re-do the programmatic review, but to comment on the outcome, and to suggest how to implement it within a financial envelope – for example, they could make suggestions about the need to maintain a viable programme in particular areas of this committee's programme through limiting or sharing costs or - if it is critical enough - by reducing support for other projects in your area. This advice would come to PPAN and PALS (and to the Executive).

The panels will have the input to the programmatic review (all the documents that PPAN and PALS had) to inform their discussions, plus the financial numbers for each project that PPAN and PALS used. They will have the feedback to PI's and the

proposed action from PPAN/PALS on each project. They will need to understand the level of savings that needs to be achieved and they can explore different models of squeezing the programme. They can't just expect to move projects up in priority but can explain what could be done with a small increase in each area (this will help us tension between areas).

APPENDIX 3

List of items under consideration	Current PPAN band	Panel's revised band	Cost(£M)		
			Y1	Y2	Y3
ALMA Regional Centre	3	4	0.21	0.28	0.33
Dark Energy Survey (DES)	2	2	0.52	0.48	0.17
ELT R & D	2	3	0.38	2.25	2.25
Gemini	4	3	3.5	3.50	3.50
ING	3	2	2.10	0.75	0.77
JCMT/SCUBA-2	1	1	1.41	1.43	1.86
KMOS	1	1	1.59	1.07	0.24
Liverpool/Tel.	2	3	0.36	0.37	0.38
e-Merlin/JIVE	4	2	2.62	2.68	2.75
SKA R & D	2	3	0.10	1.25	2.54
UKIRT	4	2	2.02	2.14	0.82

NB: items listed in alphabetical order. In the context of the programmatic review, those items in band 4 are currently assumed to be subject to withdrawal of financial support.

APPENDIX 4

GB Panel's Priority Order of its items

JCMT/SCUBA-2
 KMOS
 ING and UKIRT (equal)
 e-MERLIN/JIVE
 DES
 Gemini (dependent on outcomes, see recommendations)
 ELT R & D
 SKA R & D
 Liverpool Tel.
 ALMA Data Centre