

Seventh Framework Programme: Research Infrastructures

Contract No. 212243

Preparatory Phase for the Square Kilometre Array

PrepSKA Workpackage 6:

**Developing a funding model for the SKA:
Funding Model Options for Interested SKA
Funding Agencies**

Deliverable 6.4

1 Introduction

The PrepSKA project was created to examine the critical technical and policy issues associated with the Square Kilometre Array (SKA). In the policy area, three parallel tracks of work were established, examining governance (Workpackage 4), procurement (Workpackage 5) and funding (Workpackage 6). The project commenced in 2008, at a time where there was an optimism that the project would move seamlessly from the preparatory phase into a construction phase. The various workpackages (WPs), particularly in the policy area, were planned with this starting assumption, although as the work has developed, the step change in progress experienced by the whole project has impacted on the PrepSKA, and the direction of workpackages such as WP6.

The reality of the project has been the realisation that the both the technical and policy aspects of the project would not have progressed to the point where it could move into a construction phase. On the technical side, it was recognised that a further period of detailed design would be required (a 'pre-construction phase') while on the policy side, an interim phase, with an interim governance and funding structure would be needed.

The Agencies involved in the project, initially organised as an informal group, quickly took the decision to move to a new, more formal structure with a view to developing the frameworks needed for this proposed interim 'pre-construction' phase. The focus of PrepSKA, and in particular WP4 and WP6, shifted substantially towards developing a potential model for this pre-construction phase, with potential extensibility to the construction phase.

Deliverable 6.3 examines the modelling undertaken looking ahead to the full construction phase of the project and the alternative approaches that might be applied. For this deliverable, 6.4, the focus has shifted to the pre-construction phase; however, it should be noted that many of the same principles may apply and extrapolate from the pre-construction phase.

2 Setting the Scene

PrepSKA WP6 began in mid-2008. At that time, governance of the SKA project was achieved through a combination of an informal agency-level working group, providing high-level oversight of the overall programme and a separate science-engineering advisory committee providing steering of the technical scope of the project. Resourcing for the project was restricted to a combination of a EC funding through the Preparatory Phase study, national funding for technical activities, and contributions, through a

central Common Fund, to fund operation of the SKA Programme Development Office (SPDO). The project schedule at that stage (Figure 1) envisaged completion of SKA Phase 1 around 2016, based on completion of PrepSKA developing through a production readiness phase into a phased construction.

SKA timeline

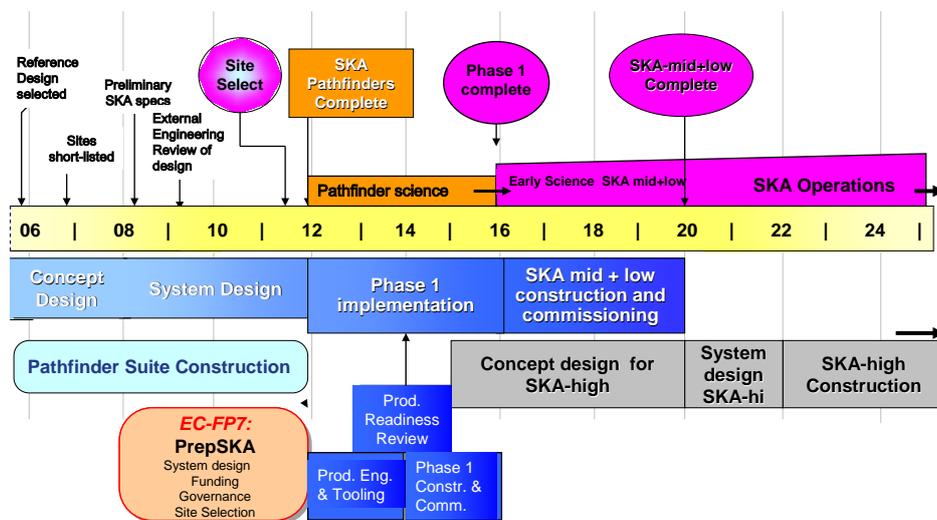


Figure 1: SKA Project Timeline, November 2008

An early question for WP6 was to consider what was meant by the development of ‘a funding model’. Examination of the question identified the definition as *“A coordinated, coherent and equitable plan for the allocation and optimisation of funds to construction, operation and ultimately decommissioning of the SKA”*.

In very basic terms therefore, the aim of WP6 would be to:

- 1 – Identify the financial requirements of the SKA project, following an assessment of what the project would aim to deliver and on what schedule
- 2 – Consider potential partnerships (either individually or regionally) that could make up the group of funders of the SKA project in the construction and operation phases and
- 3 – Identify potential mechanisms for that potential group of funders resourcing the requirements of the project.

The ultimate aim of these steps would be to present how the various shares of resource needed to realise the SKA could be formulated. In addition to potential sums, the nature of those contributions and the implications of various scenarios were important to understand. To what degree would a cash-based project be achievable? How important to potential funders would the ability to contribute in kind be? What are the links between a funding model and governance and procurement factors that would need to be borne in mind by potential funders? What are the associated issues (for example, the operational model or the approach to access) that would play a role in determining the funding model?

In order to enable any potential modelling of funding scenarios, a clear definition of schedule and scoping assumptions was necessary. In the early stages of PrepSKA WP6, the main reference point was SKA Project Memo 100 – Preliminary Specifications for the Square Kilometre Array (available at http://www.skatelescope.org/uploaded/5110_100_Memo_Schilizzi.pdf). Memo 100 presented a costed approach leading to a broad description of SKA as follows:

- SKA Phase 1 – Cost €300M, comprising €200M for components, €100M for infrastructure
- SKA Phase 2 – Cost €1200M, comprising €800M for components, €400M for infrastructure
- SKA Phase 3 – relating to high frequency capability, is not discussed.

These, or variants on these values, form the basis of the financial modelling that was at the core of the WP6 work. One element that permeated much of the work was the question of ‘building to cost’ or ‘building to a science case’. After consideration of the issues and discussion within the core group, the agreed approach within WP6 was to assume development to a target cost. More recently this theme was further addressed at the science level within the wider SKA project in SKA Memo 125 (Garrett et al., 2010, available at http://www.skatelescope.org/uploaded/62422_125_Memo_Garrett.pdf) which, driven by a desire to develop a more focused, science driven case, defined SKA Phase 1 (hereafter SKA1) at a fixed construction cost of €350M. This work also presented a revised schedule for SKA1:

2010-12	Telescope system design, prototyping and costing
2013-15	Detailed engineering design & pre-construction phase
2016-19	Construction, commissioning & early science observations
2016	Advanced Instrumentation Programme decision (instrumentation options relevant to SKA2)
2020	Full SKA1 science operations begin

The schedule for SKA2 and assumptions for its scope and costing remained more open-ended at this stage, although a programme of de-risking technical development was established, with decision points on technical readiness.

One immediate difference is the importance, highlighted by WP6 in 2009, of the period following the Preparatory Phase, but prior to the start of construction, to the funding and governance of the project. This so-called 'Pre-construction phase' can be termed SKA Phase 0, and has its own distinct identify within the project.

The period from mid-2010 into 2011 was a watershed in the development of the SKA project. In addition to the focusing of the project science case for Phase 1 discussed above, it marked the point of implementing a stronger, albeit still only semi-formally constituted agency-oversight group. This group, together with the SSEC, commissioned several critical areas of work.

Firstly, recognising the need to establish a detailed work programme, technical and organisational objectives and a resourcing plan for the pre-construction phase, a working group comprising members of the SSEC and the SPDO was commissioned to produce the pre-construction phase 'Project Execution Plan' (PEP). PrepSKA WP6 leader Berry was also a member of the authorship team. The PEP defined the technical activity requirements for the period following the conclusion of PrepSKA, and laid out the basis for a new organisational structure for the project.

The PEP is available at: [www.skatelescope.org/.../38221 SKA Project Execution Plan.pdf](http://www.skatelescope.org/.../38221_SKA_Project_Execution_Plan.pdf)

The PEP describes a model featuring a central SKA Project Office (SPO) with overall responsibility for central design activities, system engineering and project management, to be funded through direct contributions from members of the SKA Organisation. Then separate from this central structure, technical activities organised around a defined workpackage description would be locally-funded in laboratories, institutes and industry around the world. Overseen by an appointed Board or Council representing the funding partners, the SPO would be given the authority to centrally control the project, able to manage the progress of the technical activities being undertaking as part of a single, globally agreed plan of action leading to construction readiness of the SKA.

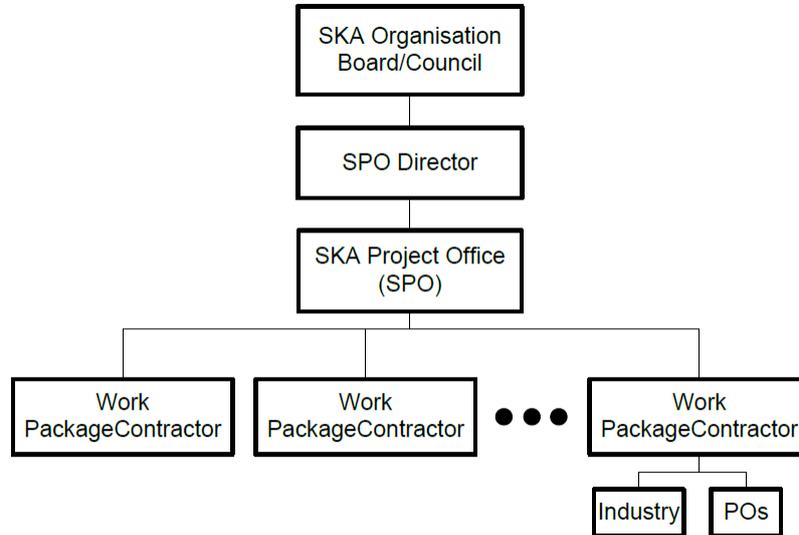


Figure 2: The structural relationship of a governing Board/Council, a central SKA Project Office (SPO) and distributed technical activities, as foreseen in the Project Execution Plan

3 Focussing on the pre-construction phase Funding Model as a template for the SKA Funding Model

During 2011, after the signing of an agreement establishing a more formal SKA Founding Board of funding bodies and governments, workstreams were established to move towards implementation of a new SKA Organisation, with a first governance and funding model. PrepSKA WP4 leader Vogel assumed responsibility for the development of a legal model able to deliver the required aims and structure defined by the PEP. WP6 leader Berry assumed responsibility for definition of a pre-construction phase funding/contribution model. These parallel streams of work developed through 2011, leading to the successful establishment of the SKA Organisation as a legal entity under UK law in late 2011. Behind the formal legal structure was an agreed ‘Business Plan’ resulting from financial modelling of potential contributions to the pre-construction phase by prospective partners in the new Organisation.

In the remainder of the deliverable report, we will show the evolution of thought from a highly abstract initial set of assumptions and funding concepts, to the realisation of a first phase of the project. In order to deliver this, a process was undertaken to establish and negotiate a funding model through the auspices of PrepSKA WP6, ultimately through a legally-constituted group of Organisation members providing agreed contributions to the project. Thanks to the remarkable progress achieved in 2011, it is therefore possible to use the current situation as a testbed for ideas about the future. In addition, it is possible to reflect on the issues that have arisen in the development of the pre-construction (SKA0)

Organisation and extrapolate them to the future, and SKA1 and SKA2, and again, test how they may impact on the project.

The SKA Pre-Construction Phase: A case study in developing a working funding model for the SKA

Through support from the PrepSKA project, workstreams were established by the ‘SKA Founding Board’ to progress the project to an implementable pre-construction phase. In the funding/financial model area, led by WP6, work was undertaken through a series of workshops with the project and potential stakeholders.

At an early stage, in parallel with the development of a pre-construction governance model, led through members of the PrepSKA WP4 team, it was agreed that a ‘Business Plan’ was required to describe the operational and financial function of the project and the proposed SKA Organisation. In developing the Business Plan, several basic principles, generically important to the development of a funding model, were identified and part of the discussions:

- The need to establish a clear understanding of the cost and scope of the planned programme in whatever period phase is being considered;
- An understanding of any constraints there may be on the project through the nature of contributions (for example the division between cash and in-kind contributions);
- The relationship with the chosen governance and procurement/work assignment arrangements, and the impact that these will have on the overall structure of the project; and
- An understanding of national positions and requirements from funders – the potential value of their contributions and what they expect to receive in return for their investment.

The table below summarises the way that source information was gathered in order to develop an overall understanding of basic principles behind a funding model for the pre-construction phase of SKA.

Parameter	Source information/basis for agreement
Cost and scope of planned programme	Detailed in SKA Project Execution Plan and in associated discussions, identifying a fixed cost for SKA-1.
Nature of contributions	Discussions around PEP and requirements of project determined starting point for requirements; Contributing countries have views and potential constraints on the nature of the contributions they may make.

<p>Relationship with other policy issues</p>	<p>Discussion within PrepSKA and in implementation working groups – external advice on potential legal structures leading to a recommended structure.</p>
<p>Funding positions from potential Organisation members</p>	<p>Establishment of basic principles on return-on-investment based on collective Agency discussion. Individual negotiation with potential funders on potential contribution level.</p>

As part of PrepSKA WP4, discussion and external advice, alongside the selection of Jodrell Bank Observatory as the location for the SKA Organisation Headquarters, determined that the preferred legal was selected to be a UK Company Limited by Guarantee. Operating rules and the financial framework for contributions from Members would be described in detail in the company Members Agreement and Articles of Association.

Furthermore, discussions among the agencies confirmed the twin approach to funding and resourcing activities proposed in the PEP. The funding structure of the project has evolved to one with a combination of centrally-directed ‘cash’ contributions, and locally-directed non-cash contributions which would, in the pre-construction phase at least, arrive in the form of delivered contributions to the project. Discussions amongst the Agencies indicated a stance where a combination of contribution types was required.

Now and in the future, it seems likely that an ongoing cash contribution to maintain a viable central organisation structure (essentially, providing for a central project administration and project management/control) will be required. However, outside that, there are a range of models that have been and continue to be successfully used in major RI projects. These range from mainly cash/subscription-based organisations such as the European Space Agency and European Southern Observatory (notably, both International Organisations) to models where substantially larger contributions are made via in-kind mechanisms. Such choices may have a large impact on the eventual governance model, but also relate intimately to the Return on Investment requirements of contributors, and how they are delivered. As a policy statement in this period, the conclusion must be that a minimum level of cash contribution is required in order to maintain the functionality of the construction/operation phase SKA Organisation. What minimum level is will be subject to discussion within each project and detailed evaluation driven by the project’s requirements. For example there may be elements which can only sensibly be provided by a centrally-procured action for reasons of risk mitigation. However, this is always set against the demands of the funders and in-kind contributions will likely form an important element of the overall contribution structure, but only if carefully managed. At various times, the additional management risk and cost of a majority in-kind or non-cash contribution to SKA has been noted.

Examining the SPO element first, the resource requirements for the central project office were established in the PEP and refined substantially in the Business Plan.

Q1 Is there a group of contributors positioned to provide support to the project and what are their boundary conditions or assumptions on how those contributions may be delivered?

A1 In this instance, an informal group had already coalesced into the SKA Founding Board, bound more formally by the signing of a Letter of Intent that demonstrated their desire to realise the next phase of the project beyond the Preparatory Phase, and committing resources to aid the delivery of their collective aims. This group came together with several agendas: Some were hosts or potential hosts of elements of the facility (either of the SKA itself, or the physical base of the Organisation) which presents an additional factor to be considered in the appropriateness of a 'host premium' in some form. Others were positioning themselves to deliver resources on the required time. The remainder would be categorised as 'interested' parties, not ready to provide resources yet, but positioning so that they would be able to some time in the future. This group had reached the broad conclusion that a hybrid core-distributed funding model (the SPO centrally-funded, other elements of technical work funded locally as 'in-kind' contributions).

Q2 Is there an understanding of the resource requirements in the phase under discussion?

A2 In this pre-construction period, the requirements and scope had been determined based on the best available assumptions in the Project Execution Plan and incorporating the most recent schedule assumptions. These were broken down into a core element (essentially the creation of a Common Fund) to support the operation of the SPO, and estimated costs of the technical work in several workpackages, to be locally funded.

Q3 What constraints are imposed by the development of the legal model?

A3 Parallel discussions on the structure of the Membership Agreement and Articles of Association, linking the funding and governance model development established several important principles:

- That (for the pre-construction period) the basic principle of decision-making should be to disassociate influence on a Board from the financial contribution; essentially all Members being equal irrespective of their financial or work contribution to the project aims
- That a minimum contribution (€1M) should be provided by prospective Members of the Organisation, although contributions greater than this level would be welcomed – these contributions being provided to operate the SPO
- That a 'register of contributions' would be established to track the total value of commitment being made by Members and that in the future, this could be used when

considering potential returns in some manner to be determined (although this itself may be complex due to local legislative interpretations of taxation and ‘perceived benefit’ to a contributor.

These various points enable the derivation that there is a ‘unit cost’ of Membership of €1M, and that if a Member contributes more, then while good for the Organisation, there is no obvious additional benefit through work or influence. It is instructive to note that the collective will to expedite progress in SKA in the pre-construction phase has resulted in this rather egalitarian view by the contributors, but in the much greater scale of investment for full SKA construction, it seems unlikely (although not impossible) that this would continue. Much more likely is the situation that contributors would seek a more direct return for greater contribution.

The complete planned programme as detailed in the PEP, including both SPO (as a ‘cash’ contribution) and distributed technical activities funded as ‘Local Contributions’ enacted through the WPCs, with their estimated required resources, is shown in Figure 3. The resources required to carry out this work were estimated to be a total of 90.9 M€ over the 4 year period, comprising 63.4 M€ for Work Package consortia and 27.5 M€ for SPO costs. Broadly speaking, this results in a roughly 1/3 – 2/3 split between the ‘cash’ requirement and ‘technical support/in-kind effort’ requirement. In the pre-construction funding model discussion, carrying this split concept through to the potential contributions was discussed at length, but not taken up as a formally agreed proposal for moving forward.

	2012		2013		2014		2015		Total		TOTAL Cost €	
	py	Material €	py	Material €	py	Material €	py	Material €	py	Personnel €		Material €
Rolled up Total	116	5,650,000	156	5,890,000	184	6,310,000	182	9,390,000	637	62,860,000	27,240,000	90,900,000
1 SPO Management, Admin, Outreach and Office Costs	11	2,050,000	22	2,710,000	26	1,770,000	27	1,670,000	86	8,600,000	8,200,000	16,800,000
2 Science	2	-	2	-	4	-	5	-	13	1,300,000	-	1,300,000
3 System	4	-	5	-	7	-	7	-	23	2,300,000	-	2,300,000
4 Maintenance & Support	0	-	1	-	1	-	1	-	3	300,000	-	300,000
5 Dish Array	18.5	2,275,000	22.7	1,475,000	20.7	2,375,000	17.2	1,225,000	79.1	8,010,000	7,350,000	15,260,000
6 Aperture Array	40.25	1,100,000	40.25	155,000	37.5	365,000	37.5	5,535,000	155.5	15,550,000	7,155,000	22,705,000
7 Signal Transport and Networks	6	-	8	-	10	-	10	310,000	34	3,400,000	310,000	3,710,000
8 Central Signal Processing	13	-	27	200,000	37	300,000	35	200,000	112	11,200,000	700,000	11,900,000
9 Software & Computing	16	225,000	18	1,350,000	22	1,500,000	22	450,000	78	7,800,000	3,525,000	11,325,000
10 Power	2	-	4	-	11	-	11	-	28	2,800,000	-	2,800,000
11 Site Engineering and Site Office	2	-	6	-	8	-	9	-	25	2,500,000	-	2,500,000

Figure 3: Rolled up resource requirement plan, taken from the PEP

The resources understood to be available to the Organisation are calculated based on assumptions from the Members Agreement and the pre-construction working group’s discussions on potential funding

contributions from Founding Board signatories. In order to reach this understanding, the working group, through WP6, convened a series of meetings to explore potential funding scenarios from each contributing member to the SKA Organisation, developing negotiated positions on contributions in each case.

As a baseline Members would contribute a minimum of €250k each year of the pre-construction phase as their membership contributions in order to join the Board, but also that some potential contributors have indicated available cash or in-kind resources beyond that minimum. The resulting (ultimately agreed) funding model is shown in Figure 4 below. Note that some statements were made on a conditional basis, for example the position of Australia was linked with the site selection process, and assumed success of their bid to host the project infrastructure.

Country	2012	2013	2014	2015
Australia (site dependent minimum)	0.25	0.25	0.25	0.25
Canada	0.25	0.25	0.25	0.25
China	0.25	0.25	0.25	0.25
Italy	0.25	0.25	0.25	0.25
Netherlands	0.4	0.4	0.4	0.4
New Zealand	0.25	0.25	0.25	0.25
South Africa	1	1	1	1
UK	1.5	1.5	1.5	1.5
TOTAL M€	4.15	4.15	4.15	4.15
Desired spend profile M€ (from PEP)	4.55	7.41	7.67	7.87

Figure 4: Agreed cash contributions to the operation of the SPO in the pre-construction phase

Given the timing of the discussions (and still the case as PrepSKA draws to a close), the funding plan also needed to accommodate the timing and implications of the telescope site selection. Both candidate sites have provided position statements on how they would respond to differing outcomes of the site

selection, but the nature of these meant that the most appropriate way of proceeding is to present a plan based on the minimal projected income situation and using the current statements being made by the respective delegations on availability of cash and other relevant additional resources. It should be noted that depending on the site selection outcome, the available cash contributions could increase.

Figure 4 presents effectively a ‘snapshot’ of the potential membership base at the time of the development of the Organisation. It is, in essence, the first Funding Model for the initial phase of SKA.

In comparison with the SPO requirements, it was recognised that a wider membership would be needed. As with other funding model developments, projections were made to examine how the group could develop further. Such assumptions were needed in the development of the SKA Business Plan, required as a supporting component of the founding documentation for the SKA Organisation.

Several countries, not included in the initial eight described above, are in discussion regarding joining the proposed Members Agreement, and hence offering a minimum contribution of €1M during the pre-construction period, alongside technical contributions. These countries may first be Associate Members stepping up to become Full Members. According to the wording of the proposed agreements, these new Members would be required to provide their minimum contribution of €1M in full. If we assume that such acceding countries would ‘catch up’ with the profile of their contributions upon joining, and then revert to the annual €0.25M payment for the remainder of the period this would bring the available resourcing nearer to the requirements of the PEP, as shown in Figure 5:

	2012	2013	2014	2015
New Members Added		2	1	1
Additional SPO resource from new members (M€)		1	1.25	1.75
TOTAL M€	4.15	5.15	5.40	5.90
Desired spend profile M€ (from PEP)	4.55	7.41	7.67	7.87

Figure 5: Potential overall resourcing to the SPO from additional Full Members of the SKA Organisation

One specific example of this scenario, based on realistic assumptions and expectations for the ability of countries to join the SKA Organisation, follows below. In this projection, there is the core of Full Members shown in Figure 6, but now with two new additional Full Members in 2013 (in this case, based on discussions to date, India and Korea), a further new Full Member in 2014 (Sweden) and a fourth in 2015 (Japan). Based on discussions with Founding Board delegations, the confidence level in the likelihood of funding being realised, as displayed in Figure 6 using a colour coding (green: high

confidence that resources will be realised, red: low confidence, amber: uncertain or moderate level of confidence that resourcing will be achieved).

Country	2012	2013	2014	2015
Australia	0.25	0.25	0.25	0.25
Canada	0.25	0.25	0.25	0.25
China	0.25	0.25	0.25	0.25
France	Tbd	Tbd	Tbd	Tbd
Germany	Tbd	Tbd	Tbd	Tbd
India	Tbd	0.5	0.25	0.25
Italy	0.25	0.25	0.25	0.25
Japan	Tbd	tbd	tbd	1
Korea	Tbd	0.5	0.25	0.25
Netherlands	0.4	0.4	0.4	0.4
New Zealand	0.25	0.25	0.25	0.25
South Africa	1	1	1	1
Spain	Tbd	Tbd	Tbd	Tbd
Sweden	Tbd	Tbd	0.75	0.25
UK	1.5	1.5	1.5	1.5
TOTAL M€	4.15	5.15	5.40	5.90
Desired profile M€ (from PEP)	4.55	7.41	7.67	7.87

Figure 6: Profiled contributions including additional Full Members joining in the pre-construction phase

Then turning to the distributed technical activities, it was necessary to establish a working approach for determining the distribution of technical work being undertaken in the pre-construction phase. The Business Plan assumes that consortia of bodies will be responsible for technical work in the pre-construction phase, stating that “In each stage of the pre-construction phase, Consortia will be assigned the work packages by the SKA Organisation following, where possible, a competitive process”. However, “the specialisation and scope of the work packages, as well as the capacity needed, may mean that only one Consortium can be formed in practice to carry out the work in a specific technical area”. Informal discussions with potential members of the new Organisation established that there was likely to be sufficient interest (and potential resources) to cover the required areas of work.

As a basic principle, and following extensive discussion at Agency level, the Business Plan, generated through WP6, proposed a ‘bottom-up process’ for workpackage assignment. Within this model, the field will be open for any interested party or parties acting as a Consortium to organise themselves in response to work advertised as an opportunity. The Organisation Board would then be responsible for organising the eventual assignment. This type of structure has implications for the development of the funding model, in that it requires a priori assumptions of potential resourcing availability, together with a clear understanding of potential technology interests. However, the open, bottom-up process does not permit implementation of a juste-retour type structure. There are, in principle, and where there may be competition from more than one potential provider of resource through work, no guarantees of that work being assigned to a particular consortium and hence their funding bodies. However, similarly, such a self-organising approach does allow the development of consortia that reflect national desired priorities for activity.

Technical WP in PEP	WP Name	Potential WPC funding	PEP
WP5	Dish Array	7.0	14.6
WP6	Aperture Arrays	23.2	22.0
WP7	Signal Transport & Networks	1.9	3.0
WP8	Central Signal processing	5.1	11.0
WP9	Software and Computing	17.2	10.6
WP10	Power	0.6	2.2
Total		55.0 M€	63.4 M€

Figure 7: Analysis of potential resourcing of PEP WPs based on statements by potential pre-construction phase Organisation members

An initial analysis (Figure 6) shows that there is substantial interest already in the technical work package areas within several of the countries listed in Table 7 although in some areas, additional funds will be required to ensure that all technical areas are appropriately resourced. However, it is to be expected that as additional Members join the Organisation as Full Members, the total volume of available effort will increase further towards the level discussed (and judged to be appropriate in the external review) of the PEP. In addition, it must be recalled that the basic principle of the workpackage assignment process is one based on open competition, with no assumption of nationally-focused efforts in particular workpackages.

As such, the approach presents some profound implications for how countries would operate in defining their own positions. These are along the lines of the previous models, whereby there is a 'standard share' contribution level, here €1M, which results in Membership of the Organisation, and offers as a main benefit access to the decision-making at Board level. Then separately, there is an enhanced level of contribution proposed by some Members. In the case of the UK, this is essentially a 'host premium' associated with the UK's hosting of the pre-construction phase SPO, while both the candidate sites have stated positions on enhanced contributions that are linked in part with the ongoing site selection process.

5 Conclusions

The funding model and principles shown in the sections above present the outputs for discussion and the baseline funding proposals for the Agencies SKA Group in their deliberations on supporting the SKA project through the pre-construction phase.

The arguments and case forms the basis for the final output in which PrepSKA WP6 has played a major role, which is the SKA pre-construction phase Business Plan, for which the financial model presents the basis for creation of the SKA Organisation.

