PrepSKA Workpackage 6: Deliverable 6.3

A draft options paper on the SKA funding model

This document represents Deliverable 6.3 from PrepSKA workpackage 6. Section 1 presents an initial series of possible funding scenarios for the SKA, based on various implementation options, while Section 2 presents an analysis of so-called 'threshold issues' which are critical to the development of viable funding models. These will be subject to more detailed discussion as WP6 progresses.

Input:
Work Package 6
SPDO Director, Richard Schilizzi

1 Introduction

WP6 have been tasked with devising a number of funding options for the Square Kilometre Array (SKA) project. This task is concerned with modelling the optimal conditions related to the involvement of an international partnership in a global endeavour. In recent months, it has become more apparent that the funding model must also address the period after PrepSKA and before the expected Phase 1 Construction start date in January 2015. In anticipation of more formally agreed positions on how to best deal with the post Preparatory Phase of the project and pre Construction, three strawman models are currently presented addressing the capital expenditure needs of the project. We note that as of April 2010, the project schedule, and the overall conceptual design is evolving, and that construction start in 2016 is emerging as the baseline. For the purposes of this discussion, we have not embedded these revised assumptions on technical scope and project budget envelope in our work. As these revisions crystallise, we will revisit this work and update our own assumptions and interpretation.

Given a range of funding and other constraints that are already known (for example, the likely timing of any involvement by the USA in the project, subject to their strategic processes) it is not expected that all countries should be involved in all aspects of SKA construction. Likewise, discussions so far have concentrated on the current membership of the Agencies SKA Group as the 'core' membership, augmented by some nations that one might reasonably expect to become engaged in due course. Note that this does not include any discussion of expansion of the governmental engagement beyond the current membership. We conclude that any governance and legal framework finally agreed for the SKA should accommodate evolving future partnerships which could potentially contribute to any number of funding needs other than capital construction costs. An approach which does not easily allow an expansion, and perhaps in some circumstances, contraction of the SKA programme membership, is not likely to be optimal.

As such, the number of potential partners considered here in this document number fifteen in total and is based on the inventory of current active and technically-engaged stakeholders in the SKA. These partners are as follows: South Africa, Australia, United Kingdom, The Netherlands, Italy, United States, France, Portugal, Germany, Spain, China, Japan, India, South Korea and Sweden. This is only representative of a possible list of partners based on current involvement albeit participation in R&D or decision boards.

The basic assumptions made about the parameters of the strawman funding models discussed in this document are listed below. Again, we stress that all of these assumptions are based on a snapshot of understanding and that all are under revision at the present time.

- Capital expenditure is considered at a total cost of €1575 million from 2015 to 2021 also called the Construction Phase for Phase 1 and Phase 2.

- Expenditure for the pre-construction phase of the SKA is considered at a total cost of €45 million from 2013 to 2014.

- Figures are based on SPDO estimates of capital expenditure.

Three strawman funding models are presented below.

2 Strawman Funding Models

2.1 Funding Model Strawman 1: Astronet Basic Funding Profile

The original Astronet Infrastructure Roadmap projections for contributions to the construction of the SKA was broadly based on a 1/3 division split among the European bloc, the US and the Rest of the World partners (although note that the profile presented in the Roadmap document is based on earlier assumptions on the project timeline which has evolved since that time). It also assumes that Europe would fund some 60% of the Phase 1 costs, with the majority of the remainder of the required costs being met by the Rest-of-World grouping. Assuming an equal division split within regional blocs, possible yearly-need contributions, based on the project's assumptions on the funding requirement to deliver the project, for potential partners in the SKA are estimated to be as shown in the table below:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
European										
Partner 1	1.22	3.61	11.42	10.24	15.21	17.87	18.98	18.12	11.79	**108.45**
Partner 2	1.22	3.61	11.42	10.24	15.21	17.87	18.98	18.12	11.79	**108.45**
Partner 3	1.22	3.61	11.42	10.24	15.21	17.87	18.98	18.12	11.79	**108.45**
Partner 4	1.22	3.61	11.42	10.24	15.21	17.87	18.98	18.12	11.79	**108.45**
Partner 5	1.22	3.61	11.42	10.24	15.21	17.87	18.98	18.12	11.79	**108.45**
	6	**18**	**57**	**51**	**76**	**89**	**95**	**91**	**59**	**542**
US										
Partner 6	4	4	4	4	97	114	121	116	75	**538**
Rest-of-World										
Partner 7	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 8	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 9	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 10	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 11	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 12	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 13	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 14	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
Partner 15	0.38	1.14	3.59	3.22	9.58	11.26	11.96	11.42	7.43	**60**
	3	**10**	**32**	**29**	**86**	**101**	**108**	**103**	**67**	**540**
Totals	**13**	**32**	**93**	**83**	**259**	**304**	**324**	**310**	**201**	**1621**

Discussion

Collecting the potential funding profiles equally in this way preserves the current overall structure created by the SKA Collaboration Agreement. The other assumption made by the ASTRONET panel in their work was that the European nations would meet 60% of the costs of Phase 1, assumed to be 300M€. The US contribution does not start in earnest until Phase 2, although a modest contribution is assumed in the Phase 1 era.

The table above, within each bloc of contributions, assumes an even split of financial input. The advantage of this approach is that is does enable the required funding for the delivery of Phase 1, without a single major contributor dominating in these early stages. In particular, the details of any host contribution would need careful and detailed consideration. For example, might the host provide the infrastructure cost contribution as the majority, if not all, of their core contribution to the project? This potentially offers the advantage of not having an apparently disproportionate contribution being required by the host, and/or 'losing' candidate site. From a governance perspective, one could imagine this overall approach being attractive, in that it could enable an evenly balanced structure of governance, and a relatively straightforward basis for structuring a governing board and associated decision-making and oversight processes.

However, on the downside, the main drawback of this approach is that is does not easily reflect the likely engagement timelines from the information that we currently have at hand. In particular, on the European side, it requires the assumption that several partners can contribute to the construction programme early, which we believe from current information to be unlikely (from WP6 investigation so far, only a small subset of European nations have indicated in principle a likelihood of investment on these scales at the Phase 1 kickoff point). Similarly, there is an assumption that a wider participation than currently the case is in place, and in a position to proceed for the rest-of-world group. For the third 'group', the USA, the other obvious conclusion from this type of analysis is that when they do enter the programme in a significant way, around the start of Phase 2, they are immediately committed to a very significant contribution profile. Whether this is realistic or not is a subject for discussion.

Another area for discussion, are the impact and implications of this kind of model on the way that one thinks about the associated procurement scenarios. What impact would this type of funding profile have on the nature of contributions being made? Would it be conducive to anything other than a cash contribution? Alternatively could one consider integrating the total contribution from a nation over some period and consider contributions of hardware to that value being made over that period. Perhaps this could usefully be made via some kind of formal regional grouping. We note these points, which are probably applicable in several scenarios, as a basis for further discussion.

The potential for considering the positive elements of this kind of model will be explored in more detail based on the meetings during 2010 with agency delegations.

2.2 Funding Model Strawman 2: Flat Funding Equal Share Profile

In this funding profile demonstrating the expected capital expenditure for the SKA, 15 partners are assumed to equally contribute to the Construction Phases of the SKA regardless of the yearly need of the project. The Post PrepSKA and Pre-Construction Phase are considered to be also shared equally amongst the partners (subject to discussion through the post-preparatory phase working group).

Given the total construction cost of the SKA for 2015-2021 to be €1575 M and 2013-2014 costs to be €45 M, and equal share listing for 15 partners in the SKA looks like this:

	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total P1P2	Total
Partner 1	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 2	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 3	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 4	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 5	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 6	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 7	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 8	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 9	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 10	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 11	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 12	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 13	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 14	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Partner 15	1.5	1.5	15	15	15	15	15	15	15	**105**	**108**
Totals	**22.5**	**22.5**	**225**	**225**	**225**	**225**	**225**	**225**	**225**	**1575**	**1620**

The Strawman funding model 2 is simplistic in the approach but is a useful model to get back to the fundamentals for deriving a possible funding model for the SKA. Disregarding the yearly capital expenditure needs of the project, the division of the contributions is holistically approached and provides a sound basis for drawing out 'levels of partnership' in a fair and rational way. These partnership levels allow us to consider how a funding model can be constructed in a way that will be aligned to potential governance structures.

This kind of model allows one to imagine a workable 'unit of investment' in the project. In negotiations on actual contribution, potential funders could then effectively negotiate contributions according to shares of these units. This is in some ways, similar to the approach reached in the ITER project, where the unit of investment (albeit in complex 'value' units to accommodate the hardware contribution-based approach) is essentially elevenths in the construction phase. One could imagine

major partners 'buying' 2 or more partnership positions in the SKA with the expectation of a more significant 'juste retour'.

The model also accommodates smaller partners in the SKA thus making the yearly contribution of €15 million per year possibly more acceptable to some astronomy budgets assuming it is a high priority project. The obvious drawback in this approach is that is does not permit the project to have access to resource in the way that it currently plans. As such, it would be unlikely that the project could be delivered as even currently envisaged without some significant adjustment, or some flexible approach to ensure the ability to spend on a technically-aligned profile. However, this may not be very different from the way that other large projects within major organisations manage their programmes.

2.3 Funding Model Strawman 3: As Needs Funding Equal Share Profile

In this funding profile, which is based on the same broad philosophy as the previous approach, 15 partners are assumed to bear equal contribution for the Construction Phases of the SKA as per the yearly construction need of the project. The post preparatory phase is shared equally amongst the partners but on a yearly as needed basis.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total P1P2	Total
Partner 1	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 2	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 3	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 4	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 5	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 6	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 7	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 8	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 9	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 10	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 11	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 12	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 13	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 14	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
Partner 15	0.9	2.1	6.2	5.6	17.3	20.3	21.6	20.6	13.4	**105.0**	**108**
	13	**32**	**93**	**84**	**259**	**305**	**324**	**309**	**201**	**1575**	**1620**

Again, similar to funding strawman model 2, this strawman model is subtly different to the previous model as it is based on the yearly 'as need' spend for capital expenditure as estimated by the SPDO.

It is interesting to see that the variations between strawman models 2 and 3 are minimal - less than €6 million per year, per partner, in the peak construction investment period.

3. Developing a funding model based on a share-based approach

Discussions in various fora have identified the possibility of a 'share-based' approach to the funding and organisational structure of the SKA construction/operation phase as one that might be favourable.

Some assumptions that might be relevant to this approach include:

- We assume that there is no significant discontinuity between Phase 1 and 2; we do not plan a 'phase 1 model' and a separate 'phase 2 model'
- Shares should be based on the total sum for construction (~1500M€) irrespective of timing (ie, no differentiation between phases). We note that separate approach to account for the operational phase could be developed, or this could be subsumed in some way with the construction activity.
- For the moment, we ignore the detailed implications of the pre-construction period – we assume that the shape of the partnership might extrapolate from that phase, but our starting point is the completion of an agreement to start construction of Phase 1
- We note that the overall schedule is under revision at present. We still assume Phase 1 will start in 2015 – an assumption that has implications for the possible makeup of the funding consortium. Specifically, on this schedule, it seems unlikely that a probable major partner, NSF, will not be significant participants in the initial phase of the project
- We assume that a governance model will allow for a flexible membership over the construction/operation phase
- We follow the assumption (not necessarily fully explored) that the host site would contribute the basic infrastructure for the project deployment. This would form the majority of their contribution
- We note that contributions may be made in a combination of in-kind or cash, depending on negotiations that will be required

<u>What might the partnerships look like in each phase?</u>

In Phase 1, we might envisage a relatively small group of nations who are positioned and motivated to participate in the initial phase of the project. Based on our current information and knowledge, prior to our planned detailed discussions with funders, we suggest the following as the basis for a 'core' global partnership, using the current system of regional blocs:

Europe: UK, The Netherlands, Italy, Germany, Portugal
Rest-of-world: Australia/NZ, South Africa, Canada

Total: 8 countries.

In Phase 2, we would expect a wider consortium. The major perturbation would likely be the introduction of the USA to the funders, and a broader European consortium. More speculatively at

this stage, one might imagine an East Asian involvement from one or more of China, India or South Korea, all of who are engaged in SKA design activities through PrepSKA.

Europe: UK, The Netherlands, Italy, Germany (more significantly?), Portugal, France, (possibly Spain, Sweden)
North America: USA
Rest-of-world: Australia/NZ, South Africa, Canada, (quite possibly China, India, South Korea), (speculatively, Russia)

For the purposes of this discussion, we use ten 'likely' contributors, plus two possible 'new' contributors, not currently as engaged in the agency level discussions.

Total: 12 countries

What might the share arrangement be?

Approach 1: Based on a 1500M€ total cost, we could assume a baseline unit of 1% = 15M€, irrespective of the phase of the project. Detailed discussions on 'membership' of a consortium could be based on this level. At this relatively small base cost, there might be several advantages:

- Relative simplicity in calculating overall shares and associated costs
- Over the course of the total construction period, with a 'minimum contribution' of 15M€, an ability to retain low, and possibly very low level 'watching brief' interest, alongside much larger partners

Practically, one might imagine the discussions on the developing a funding partnership being based around countries 'buying' shares in the project, in integer units of 15M€. The main disadvantage of this approach is in Phase 1 however, where this integer level might be considered too large (given the overall required spend in these early years – and that this may be incompatible with the possible makeup of the funding consortium in this phase). In both Phase 1 and 2, there might also be a difficulty in managing to secure the required profile of contributions to deliver the project (what one might term the 'achievability test').

Approach 2: To overcome the difficulties discussed above, one could alternatively imagine having two share calculations, still based on integer units of 1%, but split between the two phases.

For example, this could be:

- Phase 1 – 1% of 300M€ = 3M€
- Phase 2 – 1% of 1200M€ = 12M€

This might have the advantage of enabling that 'watching brief' interest in Phase 1, but without destabilising the possibly modest contribution profile in that period. It might allow a similar effect in Phase 2, and allow greater flexibility for funders to hold a modest initial contribution, but one that might increase should strategic conditions allow.

What would contributors expect in return for investment?

In considering a funding model based on this type of logic, and projecting ahead to the nature of negotiations that would be required, some thought on the definitions related to different levels of contribution is required.

We have considered how a funder would view 'benefits' from their investment in SKA. In this, we ignore any wider, 'philanthropic' aims, in favour of the type of discussion likely to feature in any national funding decision process. These are likely to be focused on the benefits to the funding country only and seek maximum domestic return, in whatever form.

There are several categories of benefit that one might consider - each with their own associated questions that require discussion.

Science return

SKA is being built to deliver transformational science in a variety of areas of astronomy. Traditionally, radio astronomy facilities have operate on an 'open skies' approach, whereby users may be granted time, irrespective of their contribution to the construction of the facility. This model has worked well to date, and allows an informal global access to facilities for users from communities. This is however rarely the model used in other areas of astronomy, where to a greater or lesser degree, the level of access is defined by the contribution made to the project. In many ways, access to telescope time is the most obvious way to 'reward' contributors, but would represent a major cultural shift in approach. In addition, funders would need, in their cases, to address the question of access in making their cases. It could be imagined that for some, combined with other potential benefits (see below) this may be a major factor. Conversely, given that the majority of global powers in astronomy are engaged in the SKA, We note that a detailed discussion of this issues is now urgently needed. We suggest that it should be facilitated through ASG (where through WP6 discussions, we will start to identify potential national positions on this issue) and the SSEC (who will need to make judgements on the operational model and how it impacts on the options for time allocation).

Factors that might be important in this question are:

- Desire or requirement to see guaranteed telescope time in return for investment
- Nature of operation: Will SKA be a large survey instrument? How much opportunity for astronomers to bid for small amounts of time for individual projects?
- A collective view between the communities and funder of whether the 'open-skies' policy will be the approach for SKA

Industrial or contractual return

In our 'Threshold Issues' paper, we have introduced some of the issues related to industrial return. This could be in terms of guaranteed contracts to domestic industry in the construction/operational phase, or in terms of providing contributions at a valued level as hardware contributions rather than as cash. We note again that selection of an appropriate model for SKA will depend on discussions of risk appetite for funders, alongside any domestic agendas that may drive local investment cases. We believe that alongside the PrepSKA studies of procurement and governance, we will need to accommodate various scenarios in our funding model options. However, for the purposes of this discussion on how one might apportion impact from the level of contribution, and 'share ownership', we can note the following:

- There may need to be a proportional approach that links contribution to some type of industrial or contractual return
- Discussions on this will be closely aligned to 'industrial capability' studies being undertaken in WP5 and through the SPDO
- Care will be needed in aligning the design timeline with discussions on strategy in this area

All of this will need an early discussion and assessment of procurement policy at Agency level

Regional activities, data centres etc.
The question of how to arrange activities beyond the direct construction and operation work at the site is largely undefined at present. Various models are openly discussed, but most suggest a core headquarters at or near the site, where the construction and ultimately operation will be overseen. Beyond that however, there seems to be broad scope for regional centres of activity in various locations. What these might comprise, and their relationship to the site-located HQ is unclear. However, arguably, these could form part of the agreed investment return that will both determine the level of contribution, and be a result of those contributions.

Managerial or staffing influence in project
One approach that has been employed in other projects, at least at the highest managerial level is an equitable sharing of national staffing. To date there are precedents where the unsuccessful candidate in a selection process (for example, the site decision in ITER) has been rewarded instead with senior management positions. In principle this could be extended to a more general situation where staff recruitment is broadly aligned with contributions. However, this could be extremely difficult to implement practically, not least in that many support or infrastructure-type posts are likely to be filled locally at the site. The scope for a targeted recruitment approach may be limited, although it could feature as a parameter in any negotiations.

'Board-level' influence
We note that there may be opportunities for constructing a governance structure that empowers funders with oversight power in some way proportional to contribution. This type of approach can be considered alongside the WP4-driven discussion of governance models.

At this stage, subject to detailed discussions with funders, it is difficult to see how these questions would manifest themselves in later negotiations. We hope that some initial concept of showstopper positions on these areas (and others) will emerge from the WP5-funder discussions in May/June 2010.

Part II: Threshold Issues in the Development of a Funding Model for the SKA

Table of Contents

1. Objective

The SKA is a unique and exciting project with diverse funders from different countries and regions. Work Package 6 is a support activity in the Preparatory Phase of the SKA that is tasked with identifying funding options for the development of the SKA. The specific objectives are as follows:

- To investigate all aspects of the financial model required to ensure the construction, operation and, ultimately, the decommissioning of the SKA.
- To determine and inform all partners of the timescales and constraints governing possible national funding opportunities for the construction and operation of the SKA.
- To investigate the possibility of obtaining a loan from the European Investment Bank (EIB) and other similar national and/or regional bodies to provide a smooth funding profile for the construction phase of the project.
- To understand the implications of such a loan on the long-term operational funding of the SKA.

This document discusses the threshold issues surrounding the development of any funding model for the SKA by setting out the unknowns, knowns and questions as they currently exist in our exploration of the optimal funding options for partners in the SKA.

2. Overview

Previous iterations of draft funding models are available on the PrepSKA wiki pages: http://webmail.jb.man.ac.uk/PrepSKAwiki. In the course of exploring a number of funding options focused on the construction and operation of the SKA, it has become apparent that the diverse and international nature of the project creates many threshold issues related to funding which must be addressed. These issues impact on both the planning of the overall project, and the decision making of potential funders.

Since the development of the Astronet Roadmap, which made some basic assumptions on the possible funding requirement and timeline for the SKA, work within the project has provided a much clearer current estimate of the expenditure requirements for the construction and operation of the project. This has been elaborated in several outputs from the SKA Project Development Office (SPDO) in the recent past. In this work, we use these assumptions on expenditure as the basis for the 'funding need'. In order to realise the SKA, this 'funding need' must be mapped against the contribution profiles from potential participants in the SKA. Grouping potential contributors into

regional blocs has been a useful tool in establishing potential scenarios and ascertaining how the modelling of the relevant threshold issues should be managed.

The pre-construction period 2013-2014/15 requires ~€57M to cover the detailed design and final prototyping activities of the SKA in preparation for the start of Phase 1 construction in 2015/16. This estimate includes the salaries of approximately 50 engineers & scientists and 35 administrative staff in the probable central SKA Project Office, the costs of prototypes, recruitment costs and office accommodation (still to be finalised). More detailed discussion of this specific aspect is underway in a dedicated Agencies SKA Group (ASG) working group.

In modelling any viable funding option for the construction and development of the SKA, a number of threshold issues related to funding require further understanding as WP6 progresses. These threshold issues are discussed in the following section.

3. Threshold Issues

In determining a funding model which can successfully form the basis for the necessary negotiations that must take place throughout the evolution of the project, threshold issues concerning the credibility and completeness of any model that is created for the SKA must be considered. These issues represent the unknowns in the current funding model which must be understood in preparation for the final options paper on funding. Several threshold issues have been identified and are discussed in this section:

1. Nature of Contributions: In-kind and/or Cash
2. Juste Retour
3. Precursors
4. Operations and Staff Costs
5. Financial Planning

3.1 Nature of Contributions

A key issue is the nature of a participant's contributions to the construction phases of the project - cash and/or deliverable and/or other non-cash contributions (e.g. services). The preferred approach by representatives of the Agencies SKA Group (ASG) to the nature of their potential contributions has not yet been established. This will be explored by WP6 in detailed interviews with the various funding bodies, the policy work packages and with the ASG. It is expected to conclude by June 2010. It is expected that the suitability of the various types of contribution will be determined by the needs and development of the entire SKA programme as well as by the formal position of partners in the funding process.

A fully cash-based, open procurement based on WTO (World Trade Organisation) guidelines is, in principle, the simplest way to proceed (and could yield a cheaper project overall in driving the cost of major procurement items down). Provided there has been adequate prototyping and design activity leading to a detailed 'procurement-ready' design, and that potential industry is appropriately primed, arguably, the overall project risk may be relatively low using this approach.

In contrast, a deliverable based system of procurement (where funders divide the provision of major project deliverables between the contributors) is more complicated. Although it passes (financial) risk on to the providers of the hardware, the level of risk to the project is likely to be comparatively

higher. In particular, evidence from other projects indicates that there is additional complexity, for example, in systems engineering such as in bringing the various elements together, schedule risk resulting from subsystem delivery problems, or potential difficulties such as ensuring that systems being built in parallel meet the required specification. This could ultimately increase overall cost of the project.

Any credible funding model is likely to be a combination of cash and other contributions. For the purposes of this discussion, we restrict consideration to a Euro value which includes both cash and in-kind contributions. However, we do not at this stage provide any detailed comment on the respective advantages or disadvantages of either approach. The implications for any proposal on a funding model for the SKA must take into consideration:

1. The agencies' position on commitment to the project
2. The convergence of the outputs of the work packages in the Preparatory Phase
3. Rigorous risk management
4. The chosen procurement model

One specific area which falls in this general category, but is also discussed further below, is the nature of the contribution to be made by the host country of the facility. One concept that has been discussed widely, but again, not subject to rigorous discussion, is that the host country's main contribution will be via the delivery of the basic project infrastructure. The question of the 'reasonableness' of this assumption set within the overall project funding model, remains to be discussed.

Within this work, we identify several issues that need further discussion in the context of our planning and on which comment is invited from the Core Group:

1. To what degree should we best 'collectivise' countries within a regional bloc? For example, do we make an assumption that there may be a group of European countries organised around a regional organisation?
2. How do the procurement model options impact on the cash/deliverable/no-cash contribution discussions?
3. How does the procurement model impact the project cost and requirements? Anything other than open competition is likely to be more expensive, but note that in a deliverable-based procurement, the costs of the deliverable are absorbed by the contributing country whatever they are, and the project is "charged" only the agreed value of the deliverable. From the project point of view, it is essential to avoid selection of non-optimal suppliers via a juste retour policy. It should also be noted that multiple procurement lines may be needed for some sub-systems (like dishes) because the cost of the sub-system is so large.
4. Should access to the telescope be related in some way to the level of the contribution? Do we retain the "open skies" policy? This is a major question, and one probably requiring substantial discussion as a stand alone topic.

We will work with WP5 colleagues in integrating our studies of funding with possible procurement models, building a flexibility to accommodate non-cash contributions. It may be that two classes of models are required; one based on cash contributions and the other non-cash.

In addition to the hardware contributions discussed above, this might also, in the operational phase, include the provision of regional centres (providing observational, science or data-processing support for example) and other national activities that would be contributions to the overall operation of the facility. In addition, either in situ or within a funding country, staff will be needed to support

technical or other activities. It is not expected that all countries would be involved in all aspects of SKA construction.

These questions need resolution in order to produce a credible funding model for the next stage of development.

3.2 Juste Retour

Some indication of the funding agencies' position on participation in the SKA was made apparent in the policy survey conducted over a year ago. From the responses received, there is a clear expectation that the scenario which improves the case for investment in the SKA from respective governments would be the economic return resultant from juste retour. Juste retour illustrate models where funders provide resource to an organisation or specific infrastructure project, and receive proportional return or benefit from the project. This is usually in the form of industrial return or contracts awarded to the contributor country.

In many instances, identifying a direct wider impact from investment will form a key element in the investment proposals and decisions on funding for each potential contributor to the SKA. Put another way, the return on investment to the respective economies of partner countries from the industry resulting from the SKA is a major motivator for commitment.

Given the probable (although at present, untested) desire of funders to seek direct re-engagement with domestic industry as part of their contribution to the project, establishing an agreed strategy for these elements as part of the development of funding model options is likely to be critical. As noted above, experience in other projects suggests that in major international projects, there are potentially several pitfalls in permitting national or regional hardware contributions to a single infrastructure. The tactical choice in this aspect must be made in the face of a detailed risk assessment of the impacts on the schedule and cost, however attractive it may prove to the funding bodies.

Activities in SPDO and WP5 are expected to map particular areas of expertise and industrial capability in potential contributor institutes and countries onto the project requirements in the procurement phase. This is expected to lead to a streamlined process supporting discussions and agreements on deliverables or juste retour procurement for individual institutes/countries.

The Astronet based strawman funding model does not address juste retour issues but WP6 acknowledges the potential implications for partner commitment to funding. In the final analysis, any case for juste retour could mean multiple procurement lines and greater cost to the project and so the decisions made must be judged against the final total cost of the SKA with the goal of not compromising the feasibility of the project.

3.3 Precursors

Neither the ASG nor the SSEC have reached any conclusion on the treatment of the current investments in relevant SKA technologies in the candidate sites developments. As noted above, there is an informal understanding within the project that the primary contribution from the host site will be the provision of the project infrastructure (roads, buildings, fibre, power, etc.) building on that constructed as part of the precursor telescopes on the site.

There are two areas of uncertainty at present on this. The first is that evaluation is needed to determine how much can be directly used for the SKA, and what the value of that contribution to SKA construction is. SSEC discussions on this did not reach a detailed conclusion and the procedure for doing this from here and by whom is yet to be determined. Indeed, it may yet be concluded by the SSEC and ASG that this is not a critical determinant factor in the forward planning, but that discussion is required.

The second area, looking forward, but building on the precursor activities and evolving in-situ activities, is to understand the detailed infrastructure cost requirements for Phase 1 based on the project specification as it develops. This process is starting now, but will evolve as the system design reaches an appropriate level of maturity.

3.4 Operations and Staff Costs

One of the objectives of the SPDO WP2 is to present a detailed cost breakdown of the estimated expenditure for Phase 1 and 2 of the SKA. The strawman funding model is based on the current iteration released from SPDO and therefore is subject to any changes produced until either work packages come to an end. SPDO currently produces a capital and operations costs breakdown for Phase 1 and 2 of the SKA. A detailed breakdown of operations costs including staff is also speculative at these early stages. There are several factors in understanding operating costs, and consequentially, two broad stages in understanding the implication for determining the funding options. Both are reliant on understanding the likely operating model for the facility. In the first stage, currently being adopted by WP6, relatively crude estimates of operating cost are factored in to WP6 modelling. These largely result from the work done in preparation for the US Decadal Survey process, but are broadly based on generic assumptions on the level of staffing to be employed in an SKA science operations site and how the telescope might operate in practise. Particular uncertainty surrounds the potential utility costs in operation, and the impact of varied types of operation (e.g. the site-specific effects and also how one would organise headquarters and regional activities in support of the project.

In the second stage, the work of the SSEC Operations Working Group and others begins to reach a consensus on the operating model. WP6 will begin to accommodate that evolving information in its work. Reducing the error in the cost estimates is an ongoing process in WP2 and a more credible funding model will result as the project progresses and the system and detailed designs are better understood.

3.5 Financial Planning

The multi-national participation in this global project adds a certain level of complexity in establishing the financial arrangements behind a funding model for the SKA. A myriad of variables including the final governance of the project have the potential to impact on the choice of one funding model over another. In establishing contribution options for funding the construction and operation of the SKA, we must acknowledge the links between the governance and procurement work packages. Any proposed funding option must ultimately account for the contracts that are expected to be sought from industry as dictated by the organisation of the project and the need for acceptable juste retour balanced against the scientific priority of the project and its costs.

In this planning, it is clear that several areas of terminology must be carefully defined. Establishing these definitions not only allows WP6 to clearly plan its models, but can help to advise the SPDO on an agreed approach to project financial planning. Indeed, it is to be noted that each potential funder has its own approach on how projects are planned. Within each country's funding process, there are likely to be differing requirements on the level of detail and certainty of financial planning in the involvement of a major infrastructure project such as the SKA. These areas include but are not limited to:

- Inflation (where a decision on whether and how to include an annual inflation correction within the project cost)
- Management of exchange rate variations
- Net present value modelling
- Establishment of a baseline unit of currency (or an agreed unit value for hardware contributions)
- An agreed treatment of contingency
- Depreciation

The effects of inflation, currency fluctuations, exchange rate risk and real dollar figures are obvious variables that WP6 expects to inform its deliverable. To support this work, WP6 plan to commission a small consultancy project to better understand the financial detail and risks associated with devising adequate funding options for the SKA. This is expected to take place in the following months. Ultimately, the funding options developed for the SKA should result from a thorough exploration of the variables identified here.

4 Conclusions

The threshold issues presented in this document must be considered in the final presentation of suitable funding options for the SKA. WP6 invite discussion on the contents of this document and request guidance and comment on the issues identified.