



Business Plan for the SKA Organisation

EXECUTIVE SUMMARY

This Business Plan describes the work to be undertaken in the pre-construction era of the SKA project in order to achieve construction readiness. It describes the operation of a new, stronger SKA Project Office, the governance of that Office within a wider technical project, and the relationship of that Office with global efforts towards a common aim. Resulting from detailed discussions with potential Members of the proposed SKA Organisation, the Plan presents an investment plan, based on a conservative baseline position, and the broader likelihood of a growing partnership in the future. In both scenarios, potential staffing structures are presented and linked to the requirements of the project described in the Project Execution Plan. Taken together with the blueprint document of the tasks required to deliver the pre-construction phase of the SKA project, the Project Execution Plan, the Business Plan is intended to be a living document, and one that may be amended and updated as required to meet the demands of the project.

1. Introduction

1.1 The Square Kilometre Array is a multi-purpose radio telescope covering the frequency range from 70 MHz to >25 GHz that will transform mankind's view of the Universe and play a major role in answering key questions in modern astrophysics and cosmology. For the past 3 years, the global radio astronomy community has been engaged in the development of the system design for the SKA as a major part of the Preparatory Phase of the project. With the end of the Preparatory Phase now approaching, the international SKA project has agreed that the next step for progress is the establishment of an SKA Organisation as a legal entity, through the incorporation of a UK company limited by guarantee to oversee the delivery of the 'pre-construction phase' of the project and with the overall aim of delivering the activities described in this Business Plan.

2. Purpose and Scope of the Plan

2.1 With the overall aim of preparing the SKA project for eventual construction, the Business Plan for the Organisation has been based on the description of tasks and schedule developed in the Project Execution Plan (PEP), a document which presents the detailed programme of work for the pre-construction phase to be undertaken.

2.2 The SKA Organisation will have the overall aim of implementing the pre-construction phase of the SKA Facility. Specifically, the goals of the SKA Organisation in the pre-construction phase will be to:

- Progress the SKA design and prototyping through the pre-construction phase to the point that production readiness reviews have been successfully completed and related data packs prepared;
- Establish industry participation strategies, procurement processes, and the protocols governing the selection of work package consortia, ready for use in accordance with the PEP timeline;
- Work towards identifying funding commitments for SKA Phase 1 (SKA1) construction and operations on a timescale commensurate with the planned start of construction;
- Prepare the long term SKA organisational structure and arrangements for the construction, verification and operation of the SKA;
- Build relationships with relevant national and international astronomy organisations to leverage skills and ensure SKA 1 science and opportunities are fully integrated into a global astronomy perspective.

2.3 Taken together, these goals amount to moving the SKA project to a position where, should the parallel efforts to identify construction and operation funding be successful, construction of SKA 1 can begin as soon as practicable. Depending on the eventual level of resourcing available to the Organisation, this might be expected in early 2016.

3. Organisation Structure

3.1 In order to achieve the goals by 2016, from 1st January 2012, the Organisation will operate with an overall structure as shown in Figure 1. A Director-General reporting to the Board of Directors leads the SKA Project Office (SPO) and exercises management and system design authority for the whole project, as granted by the Board. In addition to this centrally coordinated SPO, the Company, through its Board of Directors representing the Members, will oversee the work of technical activities being undertaken globally

via Work Package Consortia (WPCs) operating to deliver the technical requirements of the SKA. WPCs are likely to be self-organised consortia of Participating Organisations (POs) and Industry required to deliver the critical sub-system work packages. They will be funded directly from (multiple) national sources but will report to the SPO. The broad structural relationships are shown in Figure 1 below.

3.2 The baseline plan for the SKA pre-construction phase, from which the activities and financial projections in this Business Plan are determined, is contained in the SKA Project Execution Plan (PEP, Revision K, 17 January 2011, http://www.skatelescope.org/uploaded/38221_SKA_Project_Execution_Plan.pdf). As a living and evolving document, the PEP will be periodically revised to remain an appropriate framework in which the DG, leading the SPO will exercise authority over the project. Amendments to the PEP, and any material changes to the Business Plan or wider scope of the SKA Project will follow the processes described in the Articles of Association for the Organisation. The basis for the PEP and Business Plan will be regularly evaluated by the Board.

3.3 Funding for the WPC activities will be provided at a national level, either through government grants or contributions from public and private partners. The planning in the PEP allows for an extended period over which such funding can be secured. It is not necessary to have all funding in place before the Organisation can be established, provided there is prospect of a sufficient level of commitment in place (see Sections 6 and 7) to allow the initiation of activities.

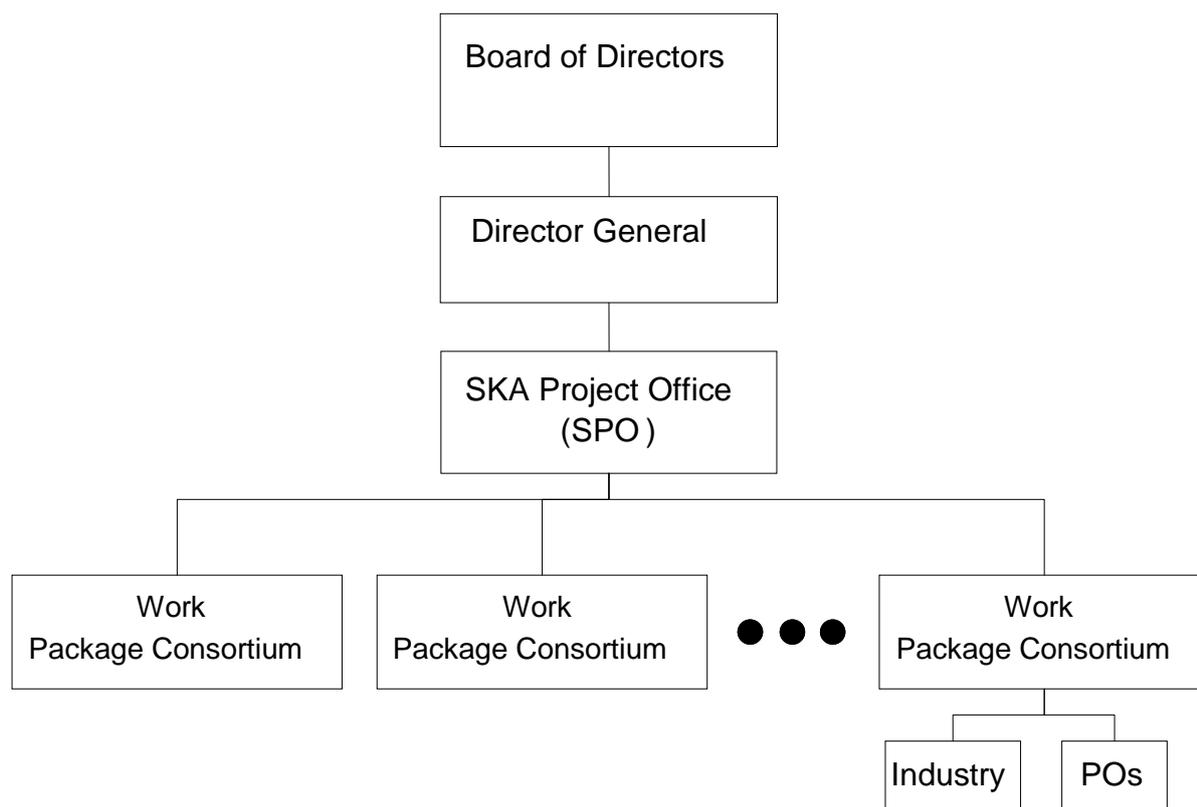


Figure 1. The top-level organisation chart for the SKA Project.

4. Governance

4.1 Governance over the Project and the activities of the Organisation will be through the Board of Directors, with various areas of responsibility delegated to the Director General. There will be several key elements and actors in ensuring good governance of the project:

- **SKA Board of Directors:** This is the Board representing the Members which will have oversight of the overall strategic direction, governance and progress of the project. Specifically, the Board of Directors will direct the activities of the Company and ensure delivery of the aims of the Project Execution Plan during the pre-construction phase. The Board will be advised on financial procurement and associated administrative matters by a standing Finance Committee, and on the specific issue of the site selection, will be supported by the SKA Siting Group (SSG) as defined in the Members Agreement and Articles of Association. The Board will appoint and manage the performance of the Director General;
- **Director General:** The Director General reports to the Board and has responsibility to provide overall leadership of the SKA project and its progress through the pre-construction phase, with the end goal of realising construction readiness by 2016 and preparing the construction phase to follow. He/she will exercise the overall project, operational and financial authority granted by the Board of Directors, including internal management of the SPO, and develop and maintain the required strategic relationships necessary to deliver the SPO and distributed programme effectively. Several advisory committees will support the Director General, as discussed below.
- **SPO:** The SPO will be appropriately staffed in order to execute those work packages within the Pre-construction Execution Plan (PEP) for which it is directly responsible, define and manage all interactions with WPCs, receive and integrate work done by WPCs and other sub-contractors, and coordinate the wider SKA project.
- **Work Package Consortia:** The workpackage consortia have the responsibility to deliver production-ready subsystems (design and analysis documents, verified prototypes, etc) according to requirements defined by the SPO. Consortia may be single organisations (either an industrial or participating organisation) or a multi-partner, multi-national consortium. To reduce managerial overhead within the SPO, such consortia must be organised so that the work package will be delivered via a Bilateral or Multi-Lateral Agreement (MLA) between the SKA organisation and the consortium. Typically this will require the consortium members to organise themselves via a consortium agreement. Each consortium, acting as a WPC, will then be operated under the Bilateral or Multi-Lateral Agreement with the SKA Organisation for their deliverables.

4.2 Figure 1 above shows the broad overall structure of the SPO relative to the external WPCs. As described above, it is intended that the key elements of the SKA Organisation will be supported by an external advisory structure. The elements of the structure fall into categories of those advising or supporting the Board itself (such as the Finance Committee) and those advising the Director General (such as the Science, Engineering and Industry Advisory Committees). The detailed terms of reference for all these bodies will be determined in the Byelaws, but it is assumed that these groups will comprise suitably qualified members and will meet on a regular basis.

4.3 Figure 2 below shows an organogram demonstrating the broad relationships between the Board, Director General, and the expected starting advisory structure. In this diagram, the SKA Site Selection Advisory Committee (SSAC) is shown. SSAC will operate as an independent expert committee tasked with providing a motivated recommendation on the SKA site to the Board. They in turn will transmit the report and recommendation to the Full Members who will make the ultimate decision on the site. Oversight of the site selection process to arrive at a motivated recommendation by the SSAC, and support for the Board in this task is provided by the SKA Siting Group (SSG). Both SSAC and SSG (formally a working group within

the Organisation) will disband following the site selection. The outline appointment and reporting links of the various committees are indicated in the diagram.

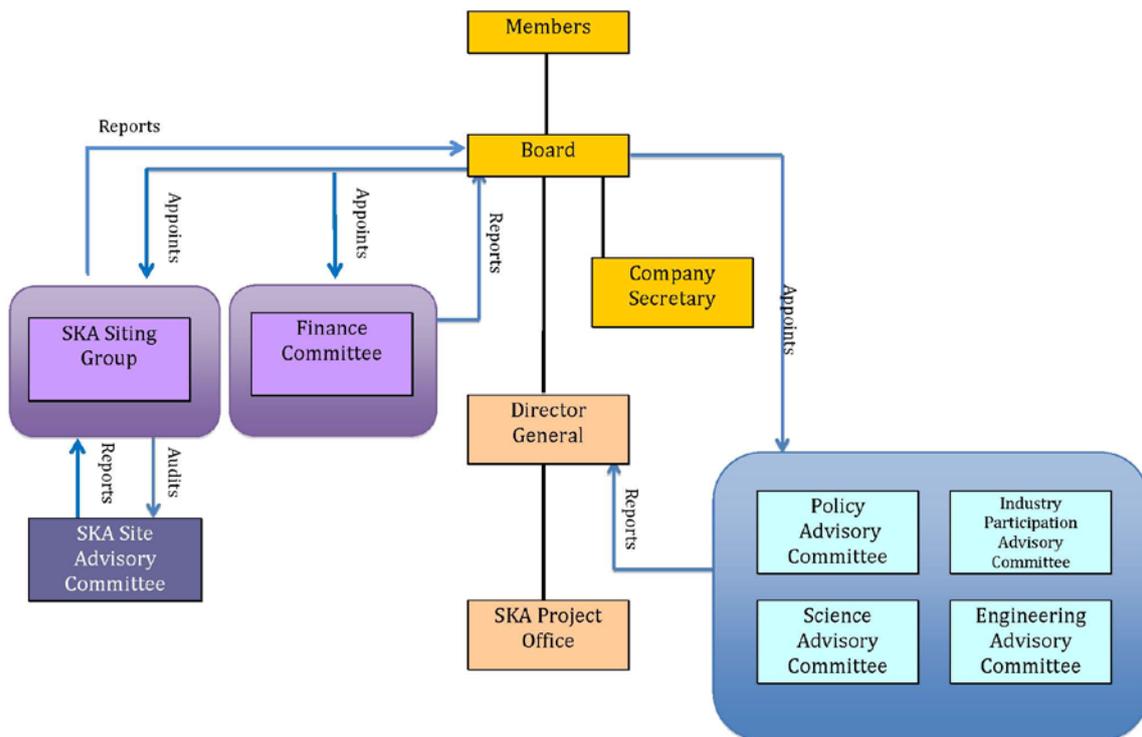


Figure 2: Diagram illustrating the initial SKA Organisation Advisory structure

5. Execution of the work program

5.1 Defining the detailed work programme

5.1.1 The PEP provides a top-level Description of Work and a Work Breakdown Structure for the Work Package areas needed to deliver the aims of the pre-construction phase, namely achieving construction readiness. It includes lists of milestones and deliverables, and the project structure, dependencies, and schedule including the planned formal reviews. The Risk Strategy and Risk Management principles are also outlined.

5.1.2 Following the review of the PEP in 2011, and endorsement of approach by the SKA Founding Board, this Business Plan presents a two stage process that is designed to progress activities in a flexible manner that can accommodate the potential income streams, and available resources over the planned Organisation lifetime. These are:

- Stage 1: 'Completing the Preparatory Phase'
- Stage 2: 'Delivering Construction Readiness'

5.1.3 Based on the preliminary top level WBS developed in PrepSKA and used in the PEP, at least eleven work packages will be executed in the pre-construction phase, five of these will be executed by the SPO and six by Work Package Consortia (WPCs as described in Figure 1) in the contributing countries under

Bilateral or Multi-Lateral Agreements to the Organisation. The work to be delivered in the pre-construction phase by the SPO covers the following five areas:

- *Management*
Manage the successful design and development of SKA technology, initiate procurement for SKA1 construction, and provide the foundations for later phases of construction, verification and operation.
- *Science*
Review, refine and monitor science drivers and science breadth; carry out science simulations; support science and engineering tradeoffs for SKA1 and SKA2; develop and refine the SKA science operations plan.
- *System design, and system engineering*
Complete the preliminary and detailed design of SKA1, the early definition and preliminary design of SKA2; and control and manage the system engineering effort at all levels and across levels.
- *Maintenance & Support and Operations*
Complete the preliminary design of the SKA1 maintenance and support system.
- *Site Engineering*
Finalise the design of the configuration; carry out the design of SKA1 infrastructure; initiate procurement of SKA1 infrastructure (sub)systems; roll out and test infrastructure on core and remote sites.

5.1.4 The six sub-system work packages to be delivered by WPCs in the pre-construction phase will cover the following areas:

- *Dish Array*
Carry out the dish development and testing program; design and develop the phased array feeds (PAF) and wide-band single pixel feed design and development as part of the Advanced Instrumentation Program; prepare data-packs for SKA1 dish array procurement.
- *Aperture Arrays*
Generate the subsystem designs for the AA-low array for SKA1 and the AA-mid array for SKA2; carry out environmental tests; prepare for manufacture; and construct and verify AA-low and AA-mid models, the latter as part of the Advanced Instrumentation Program; prepare data-packs for SKA1 AA-low procurement
- *Signal Transport & Networks*
Generate the sub-system designs; develop the network infrastructure including a central facilities fibre network cabling and routing plan; construct prototype systems; prepare procurement data-packs.
- *Central Signal Processing*
Carry out the electronic design and implementation; carry out the signal processing software design and implementation; prepare for signal processing integration and verification; carry out the mechanical design and environmental testing; prepare procurement data-packs.
- *Software & Computing*
Generate the overall software architecture, interfaces and the configuration control within which the other work packages will operate; carry out the detailed design for the central processing of

SKA data; develop science data access software; develop sky simulations and data reduction algorithms and software to support the key science projects; develop the system software

- *Power*
Generate a complete, costed power solution for SKA1, and a detailed plan for the extension of the solution to SKA2; generate an intra-system power; develop and carry out a power systems operations plan; carry out an assessment of the applicability of emerging power solutions to the SKA.

5.2 Delivering the Plan

5.2.1 The remainder of the Business Plan focuses on two areas. The first is demonstrating viability of an overall programme leading to delivery of the pre-construction objectives (both SPO and WPC work packages). This means both an assessment of cash resources to deliver operational support of the SPO, and the availability of ‘local contributions’ to deliver the WPC work packages. With this, the Plan also proposes an approach to assigning work package responsibilities. The second area is the more detailed resourcing and structure of the SPO.

5.2.2 The project is adopting a strict system engineering approach which must be informed by the likely funding availability. The Director General and Board will review progress towards this aim regularly at Board meetings.

- *Pre-construction phase Stage 1: January 2012 – March 2013*

In the first stage (essentially completing the final steps of the preparatory phase programme, see Figure 3), the SPO will sign agreements by mid-2012 to complete or undertake specific work required to bring each sub-system through to (sub)systems requirements reviews (SRRs), and to provide the necessary input for the SPO to develop detailed work breakdown structures (WBSs) for the pre-construction phase. The detailed programme elements and resource requirements in the SPO to undertake these tasks are discussed in Section 7.

- *Pre-construction phase Stage 2: March 2013 – December 2015*

In the second stage, following the SRRs and accounting for the outcome of the Stage 1 assessment, work packages will be defined through to the beginning of telescope construction based on detailed Work Breakdown Structures (WBSs) developed in Stage 1. The project will conduct Preliminary Design Reviews (PDR, planned for Q4 2013), Critical Design Reviews (CDR, planned for Q4 2014) in preparation for Production Readiness Reviews in Q1 2016. These dates refer to the reviews at system level, which will be followed by the sub-system reviews. The final deliverables of the work packages during the pre-construction phase will be a series of “data packs”, which are self-contained document sets containing sufficient detail to let construction contracts.



Figure 3: Top-level SKA Schedule

5.3 SPO Operation

5.3.1 Under the Director General's leadership, the SPO will be responsible for the overall management and engineering of the project, in order to steer the pre-construction phase and to address all science and engineering challenges efficiently. The SPO will be responsible for the overall SKA project management and system design. The staffing requirements of the SPO are determined by the need to properly execute the five SPO work packages which are central to the design of the SKA.

5.3.2 As indicated in the PEP, the engineering strategy and philosophy within the project will be based on internationally accepted system engineering principles, standards and practices. A dedicated SKA Systems Engineering Management Plan, to be utilised and rolled out throughout the project, will be developed by SPO and form part of the processes, procedures and policies to be adopted within the SPO and the WPCs.

5.3.3 The SPO will also be the integrating body for both the managerial and engineering aspects of the project. To achieve this, the SPO will be resourced with managers, engineers and support personnel at both system and subsystem level. The SPO will be responsible for the system-level engineering. It will also ensure that the work performed by the WPCs results in coherent and integratable subsystems. To this extent SPO staff will form the glue between the different parts of the system and work closely with the WPCs.

5.3.4 The system level system engineering team will be led by a Chief System Engineer, and comprises three system engineers, a power engineer, a monitor & control Engineer, an EMC/RFI Engineer, a logistics engineer, a maintenance and support engineer, and a procurement engineer. This team will work closely with the Project Engineer and the Deputy Project Engineer, Science staff, and subsystem system engineers and will be responsible for the execution of the full spectrum of system engineering activities such as requirements development and analysis, architectural design, tradeoff studies, logistics engineering, etc. During both stages of the pre-construction phase, this team will oversee and manage the engineering effort covering aspects such as change control, technical control boards, implementation and testing of changes, etc.

5.4 Project management

5.4.1 The project management strategy and philosophy will be based on internationally accepted project management standards and practices. To execute the managerial and integrative work the SPO will be staffed with an overall SKA Project Manager, five Technical Project Managers functioning at subsystem level and working closely with WPCs, a project officer, a mission assurance officer, configuration management officers, and industry liaison officers. This management team will be responsible for the establishment and roll out of project management practices and tools across the project. The technical project managers will have the responsibility for the successful development and eventual delivery of all aspects of the subsystems in terms of schedule, cost, quality and performance. They will oversee the execution and management aspects of the work carried out by the WPCs and collect and integrate project management information from the WPCs into the overall project. In this regard they will work very closely with the WPC project manager(s). Regular project reviews at both system and subsystem levels will be performed.

5.4.2 Additional specific responsibilities of the SPO managers will be:

- Integration of risk management;
- Development of the WBS into which WPCs will be able to bid;
- WPCs proposal evaluation and valuation
- To fill gaps that exist or where, in the view of the SPO, promising technologies are not being pursued.

5.4.3 The responsibility for the integrative effort and oversight at the subsystem level will be a task for the WPCs. This will imply that the WPCs are staffed with managers and system engineering teams at subsystem level similar to the SPO.

5.4.4 A transparent model for interaction between SPO and WPCs is proposed that guarantees due diligence and oversight (Figure 4). Consortium members within each WPC will be required to sign an appropriately structured consortium agreement and before work packages can be agreed, consortia will have to demonstrate the availability of local funding and appropriate resources. These elements will be further described in bi-lateral or multi-lateral agreements between the WPC funding bodies and the Organisation. In addition, in both stages of the work there will be optimised control by the SPO over the relevance and performance of the work, and the resulting deliverables. Frequent contact between SPO and the WPCs at management level will take place (e.g. face-to-face meetings and weekly telecons) in addition to more formal monthly written reports.

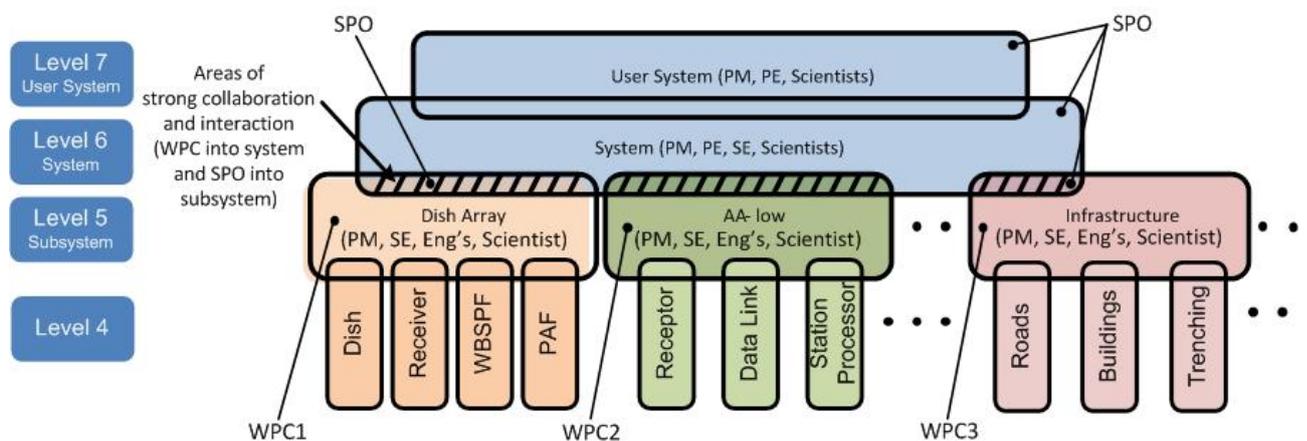


Figure 4: The relationships and interactions between system level activities carried out at SPO and the subsystem activities agreed with the Work Package Consortia.

5.4.5 The SKA Organisation will arrange the process for assigning responsibility for the delivery of the six sub-system workpackages listed in paragraph 5.1.4 by issuing a call for proposals based on an appropriately detailed work breakdown structure determined by the SPO. The process by which the WPCs are selected follows below.

5.4.6 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 as described in the PEP (Section 2.2.3.2). 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. Several implementation options or solutions may be included within each Work Package.

5.4.7 Initial informal expressions of interest by some Participating Organisations in particular areas of work based on the preliminary top level WBS, as contained in the PEP, have shown that the formation of consortia is already underway and that resources are being marshalled in most of the areas covered in the PEP. These developments often build on existing relationships and have led to the establishment of national academic-industrial links.

5.5 Work Package Assignment

5.5.1 As a basic principle, a 'bottom-up process' for workpackage assignment is planned. 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 Board will call for proposals in response to a statement of work from organisations, industry or consortia to undertake work packages. Consortia would propose on the basis that the necessary resources come from e.g. national grant programs, industry in-kind contributions and local organisational resources. In some specific cases of direct contracts to industry from the SPO, funds would come from the SPO operational budget. The entire process will be managed by the SPO which will ensure that potential Work Package Consortia have the capability, funding and adequate plans to carry out the work.

5.5.2 The assignment process is based on self organisation of WPCs, where parties (potentially from several countries) with particular expertise will negotiate amongst themselves to generate an optimum approach meeting the needs of the project as set out in the Statements of Work for the workpackages developed by the SPO. In some PEP workpackage areas, this may yield a single respondent, but in others, and where there are multiple parties interested in a particular workpackage area, a 'competitive' process between proposing consortia will be needed. The SPO will evaluate the proposals in terms of the planned approach and the availability of the appropriate expertise and capabilities in order to deliver the required workpackages. In certain areas, the capability being offered may not be sufficient to carry out all activities identified in the Statements of Work, resulting in gaps in PEP workpackage coverage. This may mean that mechanisms are needed to ensure that all the activities in the PEP phase can be delivered using the available resources. Such optimisations are initially expected to be conducted by the SPO led by the Director General, however, the Board of Directors have the formal responsibility of approving the assignment of workpackages to the WPCs and adjudicating on options. Separately, there could be a requirement from Members that WPC activities are linked to local contribution level. If required, policies on these issues will need to be detailed at Board level at the appropriate time. The Director-General would be responsible for making recommendations on the earned value of each Work Package to the Board of Directors for approval. Criteria for the earned value analysis will be agreed with the Board.

5.5.3 The assignment process for the work packages is the same for both Stage 1 and Stage 2 and will be as shown below in Figure 5.

5.5.4 Once established, the SPO will work to develop a detailed process for the proposal and technical evaluation process (the main stages of this are discussed in section 7 below). The Board will also, on formation, need to develop its own guidelines and working procedures for the overall evaluation and oversight procedures. The Board should also develop policy on what the earned value will be used for (e.g. guaranteed observing time) as this will be an important incentive for consortia to deliver to schedule.

5.5.5 Rather than a 'contract' with strict legal conditions, it is proposed that the provision of activity by a WPC controlled by a Bilateral or Multi-Lateral Agreement (MLA) between the body or bodies funding that WPC activity, and the SKA Organisation. Such an agreement would specify, among other items:

- The parties responsible for resourcing the activity (assumed to be at the funding body level);
- A statement that resources from all contributing parties are available;
- The nature of the contribution to be made by each party with appropriate detail, if required, on schedule and other matters;
- Consideration of programme management issues and oversight arrangements; and
- Treatment of risk acceptance and matters relating to contingency provision and dispute resolution
- Arrangements for acceptance of the assigned value of work

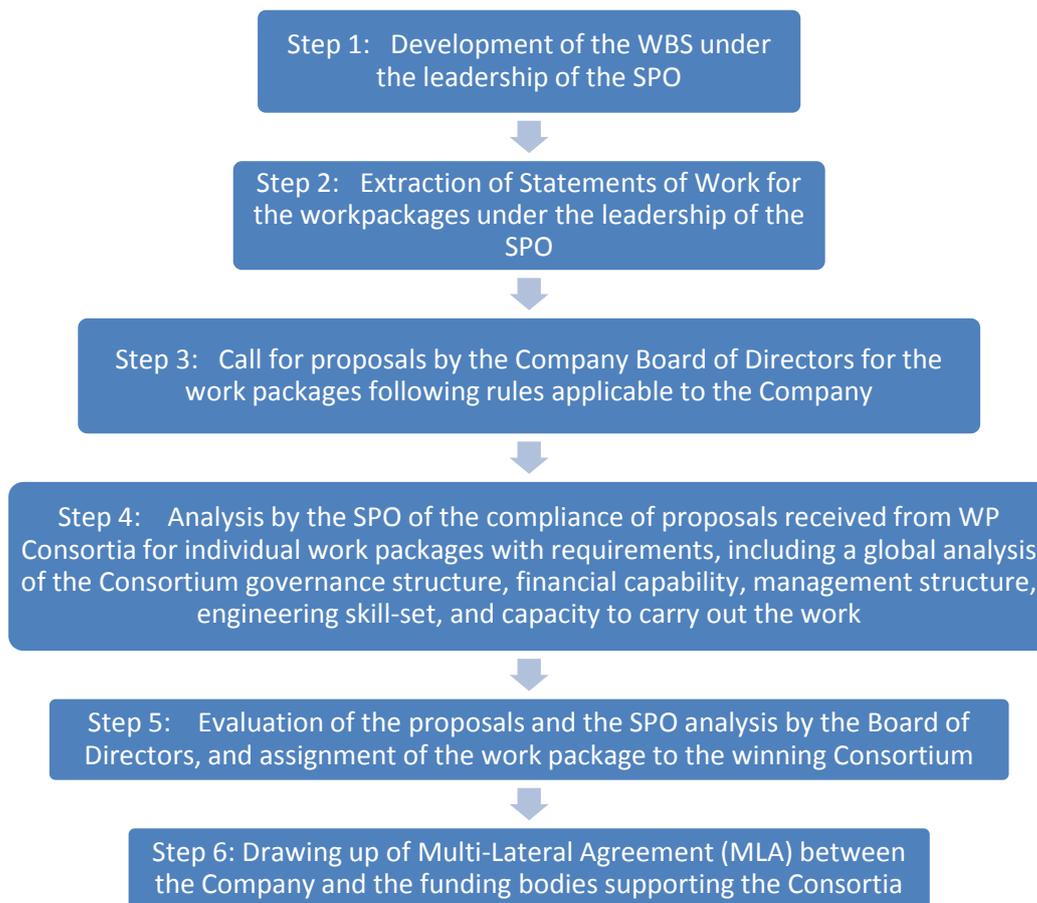


Figure 5: Outline Process for assignment of work packages

5.5.6 If and when difficulties occur, procedures are in place in the MLA, ultimately leading to the point where the funding body answers for their responsibilities to the other MLA signatories on delivery of a contribution. There is therefore a shared understanding of responsibility, as opposed to a strictly legalistic contractual arrangement. It is noted that this has worked well in the case of ESA historically, and offers an attractive and compelling mechanism to suit SKA needs in the coming phase, where there is no exchange of funding between SPO and WPCs (and hence no simple route to a formal contractual relationship). There is some (schedule) risk associated with negotiating such MLAs, but this is unlikely to be different to the demands of contract negotiation in any other model.

6. Resources required

6.1 The activities envisaged to take the SKA programme to construction readiness were identified in the PEP. It describes the work to be undertaken, in terms of the desired technical and organisational approach, but makes no attempt to fold in actual financial capability from funders. The PEP was reviewed by an external Panel chaired by Gary Sanders in early 2011, and several detailed recommendations were made which will be taken into account in the evolving programme of work moving into the pre-

construction phase. The recommendations of the Sanders review have informed the process of developing this Business Plan.

6.2 The complete planned programme as detailed in the PEP, including both SPO (as a ‘cash’ contribution) and distributed activities funded as ‘Local Contributions’ enacted through the WPCs, with their estimated required resources, is shown in Figure 6. 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. The SPO costs include staff costs for project management, system engineering, science support for system engineering, site work, outreach and office administration (19.3 M€), and office infrastructure and operational costs for the SPO (computers, recruitment costs, education and public outreach materials, travel expenses, review panel expenses, other meeting costs, consultancies, software tools, and general expenses, 8.2 M€). 100 k€ has been adopted for the person-year cost for salary and benefits for both WPCs and SPO.

6.3 Building infrastructure for the SPO is being provided by the UK as local hosts. After establishment of the Organisation, and associated planning approval procedures, it is intended that a new, dedicated SPO building will be delivered in late 2012 to replace the current accommodation in the University of Manchester’s Turing Building,. The new building, at Jodrell Bank Observatory, will remain the property of the University of Manchester, but will be leased to the Organisation for the duration of the pre-construction phase. The UK will assume responsibility for any leasing costs that may arise relating to the new building, at the earliest opportunity, the details of the hosting arrangement between the interested UK parties and the Organisation will be presented to and agreed by the Board.

	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 6: Rolled-up resource plan for PEP workpackages

7. Resourcing plan

7.1 Resourcing the overall pre-construction activities

7.1.1 Work through the SKA Founding Board has examined the level of resources potentially available to the SKA Organisation, both in terms of the potential funding for the operation of the SPO, and to the wider technical activities. Fundamental to the Business Plan and the funding modelling, the Members Agreement and Articles of Association for the Organisation describe two Membership states:

- Full Member: Required to pay a minimum Membership Contribution of €1M over the four-year pre-construction period. Permitted to make additional (cash) contributions and as with other areas, open to participate through Local Contributions;

- Associate Member: Can have non-voting representation at meetings and is defined as ‘aspiring to full membership’ – hence required to provide a cash contribution as a Full Member within the pre-construction phase. Able to make a Local Contribution.

7.1.2 According to the Members Agreement, each Full Member will pay a minimum membership contribution of €1M in cash. If a party joins ‘late’ (ie after the initial phase of incorporation) then they must still pay the full sum. There is no financial penalty in the agreements for an Associate Member that does not make the pledged step-up to Full Membership for any reason, but they would be free to upgrade their membership at a month’s notice. In order to proceed with the establishment of the Organisation, a minimum of five Full Members is required.

7.1.3 Given the above definitions, a task in developing a Business Plan has been to examine how many Full Members there might be contributing resources to the Organisation and to map these assumptions, in the first instance, to the requirements foreseen in the PEP. It is worth highlighting again here that the PEP considers two elements:

- ‘Cash’ resources (30% of the total) to run the central SPO in its coordinating role, and to enable execution of SPO Work Packages; and
- ‘Local contributions’ (70% of the total) from funders to their institutes to deliver support for technical activities within distributed Work Package Consortia

7.1.4 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 summary, these are that Members will 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, either in support of the new SPO physical infrastructure, or as additional voluntary contributions to the operation of the Organisation. The option of accelerated payment of membership contributions would help fund the execution of the pre-construction programme (see Section 6.3 below).

7.1.5 In addition, other resources, such as that from the EU FP7 GO-SKA project, will be available to the Organisation in support of its goals. Effort arising from these funding sources will be integrated into the overall Organisation activities.

7.1.6 The Business Plan must also 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 means 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 SPO-specific additional resources. It should be noted that depending on the site selection outcome, the available cash contributions could increase.

7.1.6 In addition to the minimum level of resources to be made available to the Organisation for operation of the SPO, several delegations have indicated conditional or unconditional positions on funding for local technical activities as part of work package consortia. This business plan presents the outcome of early discussions on how the different work packages could be resourced by Members or Associate Members of the Organisation. These latter elements are not formally part of the business case to proceed with establishment of the Company, but form a major element in the assessment of viability of the SKA pre-construction phase project as described in the PEP.

7.1.7 Figure 7 shows the investment plan as determined from planned contributors within the Founding Board divided between contributions to the Company for operational funding of the SPO, and an initial estimate of possible contributions to the distributed WPCs which the SPO will direct but are resourced locally by contributing bodies (see further discussion under Figure 7).

Country	Pledged SPO resources	WPCs	Total
Australia	1	3.5	4.5
Canada	1	8	9
China	1	3.5	4.5
France	Tbd	2	2
Germany	Tbd	Tbd	
India	Tbd	Tbd	
Italy	1	10	11
Japan	Tbd	Tbd	
Korea	Tbd	Tbd	
Netherlands	1.6*	15	16.6
New Zealand	1	Tbd	
South Africa	4	Tbd	4
Spain	Tbd	Tbd	
Sweden	Tbd	Tbd	
UK	6	10.5	16.5
TOTAL	16.6	52.5	69.1

*: Note that €0.6M is proposed as in-kind effort at the SPO

Figure 7: Minimum level of resources proposed so far by the individual countries

7.1.8 The column labelled ‘SPO resources’ represents the current understanding of available resources to the Organisation (either through cash or as dedicated staffing resources) to support operation of the SPO, based on statements made by the international delegations at recent Agency-level meetings. As such, in the context of this Business Plan, it represents the proposed (minimum) resources available for operational activities **independent of the site selection process**. Note that several of the signatories to the Letter of Intent for the Founding Board, for example France and Germany, remain in discussion internally on their potential contributions and accession. In addition, there is some inherent uncertainty arising from the telescope site selection process. Depending on the outcome, additional contributions to the SPO operation may be available for deployment.

7.1.9 The total funds available to the SPO so far for the SPO-led WPs (1-4 and 11) and the SPO management costs associated with the sub-system WPs 5-10 (see Figure 4) is 16.6M€.

7.1.10 The column marked ‘WPCs’ represents the outcome of initial discussions on potentially available local resourcing to the technical work package consortium activities around the world. Further discussions with some, **but not all**, interested parties have taken place to:

- Understand where areas of potential interest lie in the various PEP work areas;
- Understand where any potential gaps in interest or coverage lie in the work packages;
- Determine, along with an understanding of uncertainties and issues, potential overall resourcing level by country and WP area; and
- Understand current informal discussions on developing WPCs and where potential leadership might lie.

7.1.11 The results of these further discussions are shown in Figure 8 below as a top-level non-country-specific summary of a potential mapping of the technical activities defined in the PEP (column title ‘PEP’) to

potentially available local resourcing (column title 'Potential WPC funding') for the non-SPO work packages. It does not include expressions of interest from countries that did not take part in the further discussions mentioned in the previous paragraph, and it does not attempt at this stage to manage known uncertainties such as the outcome of the site selection process. As a consequence, the column displaying potential WPC funding in Figure 8 is not consistent with the summary table in Figure 7.

		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 8: Analysis of potential WPC interests from a range of potential SKA Organisation members

7.1.12 The initial analysis 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.

7.2 Resourcing the SPO

7.2.1 Based on discussions and emerging statements of commitment, this Business Plan assumes that an initial Organisation membership of eight partners would emerge. With such a group, the baseline income for the SPO could be delivered on the following profile:

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
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 9: Resourcing assumptions for an initial SKA Organisation Membership of eight countries

7.2.2 Such an income base would allow a credible start to the pre-construction phase programme for the SPO, and enable systems level work to be carried out on schedule until the end of the Systems Requirements Reviews in mid-2013 (see section 7). Thereafter, it would not be possible to maintain the volume and rate of work foreseen for the SPO in the PEP due to under-resourcing. On this scenario, it is unlikely that the required overall systems level activity and central coordination work by the SPO can be

carried out on the baseline PEP schedule, so this will very likely slow down the evolving programme (both at SPO and the Work Package Consortia) after mid-2013 and prevent completion of the pre-construction phase by the end of 2015.

7.2.3 The expected total staff numbers and expenditure profile for a flat funding rate of 4.15 M€ per year are shown in Figure 10.

	2012	2013	2014	2015
Staff numbers	30	30	30	30
Staff costs (salaries and benefits, no inflation)	3.0 M€	3.0 M€	3.0 M€	3.0 M€
Office costs (material)	0.3 M€	0.03 M€	0.03 M€	0.03 M€
Office costs (operations)	0.85 M€	1.12 M€	1.12 M€	1.12 M€
Total	4.15 M€	4.15 M€	4.15 M€	4.15 M€

Figure 10: Total staff numbers and expenditure profile for a flat funding rate of 4.15 M€ per year

7.2.4 The staff numbers by category are shown in Figure 11 (PEP numbers in brackets).

	SPO Staff numbers	U Man SPDO staff transferring to SPO
Management	5 (4)	1
Engineering	14 (9)	5
Science Support	2 (2)	0
Site Development	2 (2)	0
Outreach	1 (1)	0
Administration Staff	6 (7)	2
TOTAL	30 (25)	8

Figure 11: The staff numbers by category for a flat funding rate of 4.15 M€ per year

7.2.5 The number of staff proposed in 2012 has been increased compared to the PEP primarily to ensure that the first major review in the next cycle of the system engineering process, the top level system requirements review, can be carried out as fast as possible since this review has to precede similar reviews at sub-system or element level.

7.2.6 The inevitable delays in recruiting new SPO staff in the start-up phase in 2012 will result in less expenditure on staff costs in 2012. Assuming recruitment starts on 1 January 2012 and a delay before new staff assume their posts, about 800 k€ will be carried over into the subsequent year. The implication is that the pre-construction phase work will be completed by the end of the first quarter of 2016 utilising these available resources.

7.2.7 It is clear from Figure 9 that from 2013 onwards, additional cash resources will be required by the Company beyond that which is currently projected, in order to achieve ongoing solvency and allow the SPO to carry out its central role in the project as set out in the PEP. The disparity may, for example, be mitigated by:

- Additional resources being introduced from ‘Associate Members’ (or other, potential newcomers to the project) joining the Organisation;
- Additional Full Member cash contributions above those required by the Members Agreement being offered by Member signatories, or formally requested by the Board of Directors;
- SPO-specific contributions of staff effort in addition to cash contributions from Members being made;
- Some degree of re-profiling of activities and effort requirement by the SPO, likely at the expense of delays in achieving construction readiness by the end of 2015;

- Once in operation, the possibility of the Organisation seeking a bank loan to assist with cash flow; or
- More speculatively, support from non governmental bodies such as the European Union.

7.3 Additional Full Members joining the Company

7.3.1 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 12:

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

7.3.2 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 8, 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 is displayed in Figure 13 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 13: Profiled contributions including additional Full Members joining in the pre-construction phase

7.4 Proposed expenditure and funding flow with new members joining

7.4.1 The total staff numbers and expenditure profile that can be achieved with the projected funding profile shown above in Figure 12 (India and Korea joining in 2013, Sweden in 2014 and Japan in 2015) are shown in Figure 14.

	2012	2013	2014	2015
Staff numbers SPO	30	40	43	47
Staff costs (salaries & benefits, no inflation)	3.0 M€	4.0 M€	4.3 M€	4.7 M€
Office costs (material)	0.30	0.18	0.04	0.09
Office costs (operations)	0.85	0.97	1.06	1.11
Total expenditures	4.15 M€	5.15 M€	5.4 M€	5.9 M€

Figure 14: staff numbers and expenditure profile for the funding profile shown in Figure 12.

7.4.2 The impact of the above spending profile on SPO staff numbers by category are shown in Figure 15 (PEP numbers are shown in brackets).

Staff numbers SPO	2012	2013	2014	2015
Management	5 (4)	8 (7)	8 (9)	9 (9)
Engineering	14 (9)	17 (16)	20 (20)	20 (20)
Science Support	2 (2)	2 (2)	2 (4)	3 (5)
Site Development	2 (2)	2 (6)	2 (8)	2 (9)
Outreach	1 (1)	1 (2)	2 (2)	2 (2)
Administration Staff	6 (7)	10 (14)	10 (16)	11 (17)
TOTAL	30 (25)	40 (47)	43 (59)	47 (62)

Figure 15: Staff numbers by category for the funding profile shown in Figure 12

7.4.3 As noted earlier under Figure 11, the SPO engineering staff in 2012 has been increased compared to the PEP in order to boost the system engineering team working on the system requirements prior to the system requirements review. This analysis must precede similar requirements analysis at element (sub-system) level which will be carried by WPCs. In subsequent years, the choice has been made to keep the engineering staff at the PEP level and decrease SPO staff in other categories. The shortfall in staff numbers for site development and science support compared with the PEP will impact the volume and rate of work done by the SPO in these areas, while the shortfall of administrative staff will inevitably mean that substantial inefficiencies will occur, resulting in delays in completing tasks. Consideration will have to be given to reducing the shortfalls in staff for site development by secondments from the host country to the SPO. Similarly, consideration will need to be given to reducing the shortfalls in project scientist and commissioning scientist staff by secondments to the SPO from the participating organisations.

7.4.4 Figures 16 and 17 show illustrative SPO organisation charts for 2012 and 2015 on the basis of the growing staff profiling required to deliver the PEP as described in Figure 15. The illustrative breakdown of posts proposes the inclusion of a Deputy Director General position (dotted lines). The eventual detailed structure, including decisions on this and other posts, will be finalised by the Interim Director and Director General as the pre-construction phase evolves.

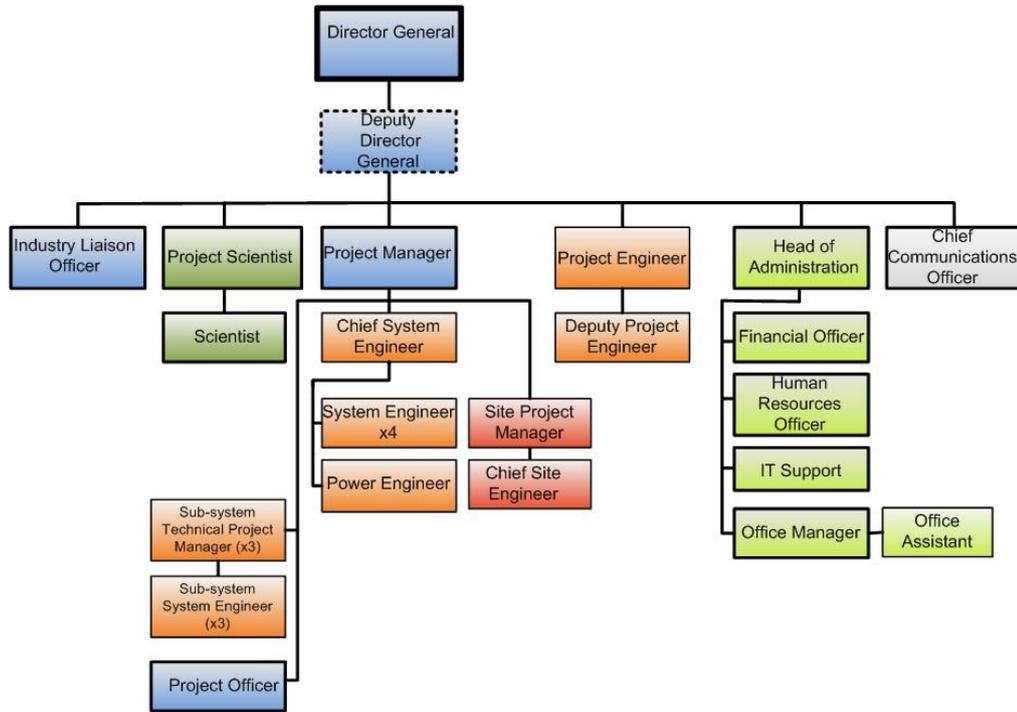


Figure 16. Illustrative SPO organisation chart for 2012: Colour coding: blue – management, orange – engineering, dark green – science support, red – site development, grey – outreach, light green – administration staff, dotted lines indicate potential Deputy Director General post for discussion.

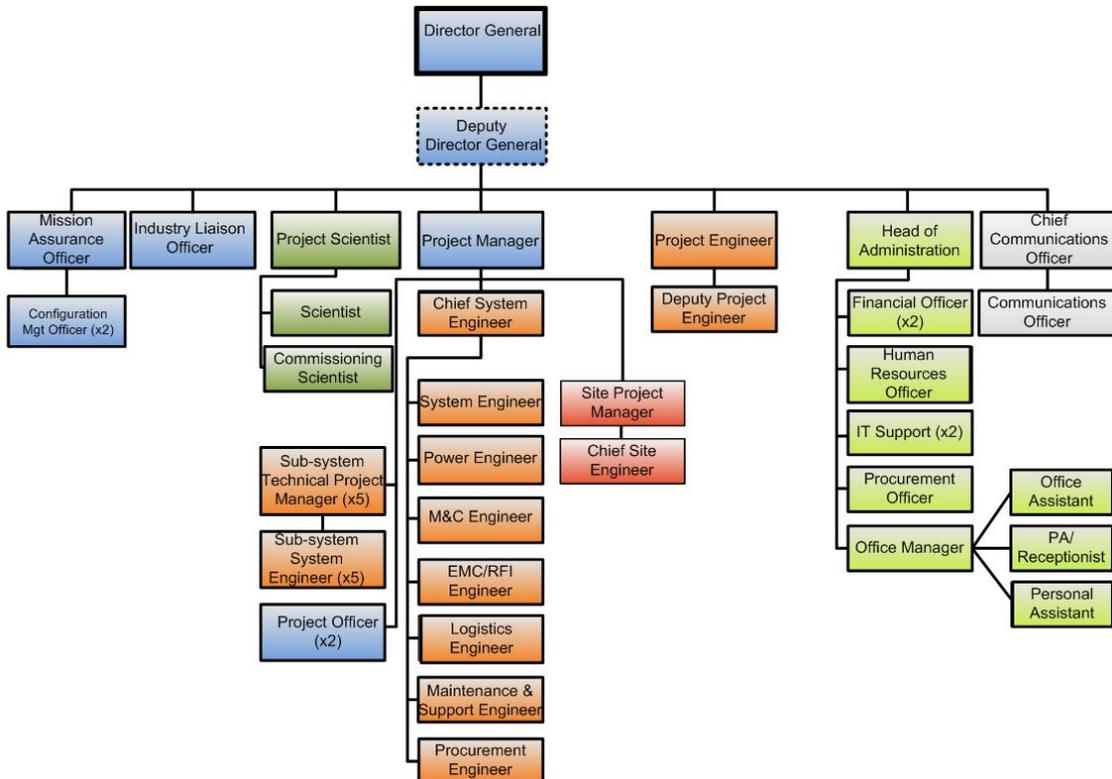


Figure 17. Illustrative SPO organisation chart for 2015: Colour coding: blue – management, orange – engineering, dark green – science support, red – site development, grey – outreach, light green – administration staff, dotted lines indicated potential Deputy Director General post for discussion.

8. Schedule

8.2 Stage 1 Work Package Consortia Agreements

8.2.1 In order to allow Stage 1 agreements to be signed as soon as possible after 1 January 2012, preparations for drawing up agreements with the Work Package Consortia will utilise the services of the SPDO initially, since the SPO will not come into existence until 1 January 2012. A provisional sequence of activities, deliverables, and estimated resources required for Stage 1 is shown in Figure 18.

Period	Activity	Deliverable	SPO resources required	WPC resources required
Nov 2011 – Mar 2012	Pre-Stage 1 Planning	Development of Statements of Work for sub-system work packages	5 SPDO/SPO staff at 30% (8 person months)	3 people per sub-system (75-120 person months)
Nov 2011 – Mar 2012	Assemble Work Package Consortia	Consortium Agreements	TBD	TBD
Nov 2011 – Mar 2012	Develop Terms and Conditions for SPO MLAs and commercial contracts	Terms and Conditions for SPO MLAs and commercial contracts	TBD + legal consultancy	0
Nov 2011 – Oct 2012	System Requirements Development	Documentation for Systems Requirements Review, system level WBS	System Engineers (56 person months)	TBD assistance
Mar 2012	Prepare Request for Proposals for Work Packages	RfP issued by Board of Directors	TBD	0
Apr 2012	WPC Consortia prepare responses to RfP	Responses delivered to Board of Directors	0	TBD
May 2012	SPO to evaluate responses	Report to Board of Directors	TBD	0
June 2012	Board of Directors to assign Work Packages and sign MLAs (and commercial contracts if required)	Multi-Lateral Agreements (and commercial contracts)	TBD	TBD
Jul 2012 – Jun 2013	Technical requirements development for each element of the system	Documentation for Systems Requirements Reviews for each element: detailed WBS for each element	6 person years (PEP estimate)	91 person years (PEP estimate)

Figure 18: Stage 1 Work Package activity, deliverables and resources

8.2 Stage 2 Work Package Consortia Agreements

8.2.1 Stage 2 Work Package activity has been defined in outline in the PEP, but is less well defined at this point in time than stage 1 Work Packages. The detailed Work Breakdown Structures for Stage 2 will be developed as deliverables in Stage 1 Work Packages. A very provisional sequence of activities, deliverables and estimated resources required is shown in Figure 19. Note that the completion dates of the element-level System Requirements reviews are planned to take place over a six month period from January to June 2013. This will result in a staggered set of RfPs and subsequent steps for Stage 2 agreements.

Period	Activity	Deliverable	SPO resources required	WPC resources required
Jan 2013 – Jul 2013	Prepare Requests for Proposals for Stage 2 Work Packages	RfPs issued by Board of Directors	TBD	0
Feb 2013 – Aug 2013	WPC Consortia prepare responses to RfP	Responses delivered to Board of Directors	0	TBD
Mar 2013 – Sept 2013	SPO to evaluate responses	Report to Board of Directors	TBD	0
Apr 2013 – Oct 2013	Board of Directors to assign Work Packages and sign MLAs and commercial contracts	Multi-Lateral Agreements and commercial contracts	TBD	TBD
Nov 2012 – Dec 2015	SPO to prepare for system level PDR, CDR, PRR	Documentation for Preliminary Design Review, Critical Design Review, Production Readiness Review	149 person years (PEP estimate)	TBD
Jan 2013 – Dec 2015	WPC:other Stage 2 Work Packages, TBD	Defined in the PEP, but subject to revision as part of Stage 1 WBS development	38 person years (PEP estimate)	353 person years (PEP estimate)

Figure 19: Stage 2 Work Package activity, deliverables and resources

9. IPR in the company operation

The treatment of Intellectual Property Rights in the Company is laid out in the Members Agreement and the Articles which specifies the development of IP policy by the Board.

10. Risks

10.1 A complete risk register will be maintained by the project and reviewed on a regular basis by the Board. The risk register will be used as a tool to monitor the progress of the project at all levels including both project-level risk assessment and technical risk assessment. A core aim of the project will be to retire risk as the project progresses. The main project risks to be considered at the start of operation of the company are:

1. Overall financial viability during the pre-construction phase. The total funds currently identified for the pre-construction phase (Section 6) are less than the total estimated funds required during preconstruction (Section 5). At this stage of the project the identified funds for SPO operations and Work Package Agreements are within 25% of those required and this risk is judged to be moderate. A related risk is that the funds identified in good faith to support the WPC work prove not to be available for the work that is needed. This risk may be mitigated in various ways:
 - a. Additional members joining the organization – significant numbers of potential members have been identified;
 - b. Identifying additional sources of funding of WPC activities outside the current boundaries (e.g. through strategic partnerships outside the current membership of the SKA Organisation);
 - c. Re-scoping the work or schedule to be undertaken within preconstruction.

2. The funds available to the SPO are insufficient and/or the profiling of availability does not match the required spend profile. Two scenarios are discussed in this Business Plan, based on alternative minimal and potential growth-based income profiles. The currently identified funds (Section 6) are 60% of the required funding over the programme period. The risk is that the SPO cannot be staffed at the required level. There are sufficient funds for year 1 but thereafter the reduced level of funding will impact the SPO's ability to manage the entire engineering project and carry out its specific Work Packages on the required timescales. This in turn will impact the ability of the Work Package Consortia to deliver on schedule. This risk is judged as modest, but at a level that the project can precede in good faith, albeit without the planned significant expansion of staffing. Significant numbers of potential new members are identified and the funds which would be secured by them joining the project would ensure the operation of the SPO closer to the required level. The risk can be mitigated by:
 - a. Additional members joining the organization – significant numbers of potential members have been identified (and their impact on potential resourcing is shown in Figure 8)
 - b. Re-scoping the work or schedule to be undertaken within preconstruction by the SPO.

A further financial risk concerns the possibility of late Membership Contributions, and its impact on the operational solvency of the Organisation. This can be mitigated by appropriate construction of Byelaws and close oversight by the Board.

3. Recruitment of the Director General on an appropriate timescale. The formation of the Company coincides with the retirement of the current SKA Director and the need to recruit a Director General. Delays in recruitment could impact the project schedule.

4. The WPCs are not formed in time or there is no appropriate WPC formed to undertake the work required. In order to deliver the work outlined in the Business plan and detailed in the PEP, WPC will need to involve organisations and industry with a range of skills and knowledge. Forming consortia will take time both to find appropriate partners as well as reaching agreement on the required management structures and MLA for the consortium. These risks can be mitigated by:
 - a. The adoption of a multi-stage approach to the assignment of work. This is already being followed and could be extended to allow consortia to form or modify between stages

 - b. Modifications to the work breakdown structure to partition the required work to enable consortia to take on a subset of the required work, with the rest of the work becoming a new work package which would in time be assigned to a different WPC.

 - c. The SKA organisation acting proactively to identify partners to WPC where gaps have been identified by the SPO.

5. A delay in the site decision which will prolong the uncertainty in the level of contributions to the pre-construction phase (both cash and in-kind), delay the appointment of the SKA Director General and impact the engineering timeline.
6. Staffing the SPO does not proceed at the required rate. There are two aspects of this risk (i) the retention of existing key staff and (ii) the recruitment of staff to the new positions on an aggressive timescale so that the SPO can execute its responsibilities within the project. The risk can be mitigated by:
 - a. Having sufficient funds in place at the right time to attract staff
 - b. Use of secondment of key staff from members of the Company.