STATEMENT OF WORK FOR THE STUDY, PROTOTYPING AND PRELIMINARY DESIGN OF AN SKA ADVANCED INSTRUMENTATION PROGRAMME TECHNOLOGY

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A	2013-02-14	-	First draft release for internal review
B	2013-02-26	-	• Introduction of target TRL • Correction for AIP technology not at Element level
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Block diagrams			
Other			

ORGANISATION DETAILS

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LIST OF ABBREVIATIONS AND ACRONYMS

AIV.....Assembly, Integration & Verification

PA/QA.....Product Assurance, Quality Assurance

TRL.....Technology Readiness Level

SEMP .....System engineering management plan

SKA .....Square Kilometre Array

1 Scope

The study, prototyping and design of an SKA AIP technology shall include the research and development necessary to further the design and prototyping of the AIP technology and all subsystems to the level of a preliminary design.

The work is being described on the basis that the activity associated with study, prototyping and design covers all instances and if necessary, variants, of the AIP technology required to complete the SKA telescopes on both sites.

The work includes but is not limited to the following tasks

1. The generation of the functional and performance requirements for the AIP technology.
2. The design and analysis of the AIP technology, with a view not only of meeting the required performance and schedule constraints, but also of taking advantage of the most economic and efficient industrial methodologies and thereby ensuring competitive costs.
3. The calculation of the costs of the AIP technology, including margins, from construction to operation.

2 Related Documents

2.1 Applicable Documents

[AD1] SKA PA and Safety plan SKA-OFF.MGT.QA-SKO-QP-001
[AD2] SKA Documents requirement descriptions (DRD) SKA-TEL.SE-SKO-DRD-001
[AD3] SKA Change Control Procedure SKA-OFF.SE.CDM-SKO-PR-001
[AD4] SKA IP Policy

2.2 Reference Documents

[RD1] SKA SEMP
[RD2] SKA baseline reference design.

3 Requirements

3.1 Project definition

The SKA Observatory is described in the preliminary design document [RD2]. The Elements have been allocated preliminary functionality and performance requirements. The derivation of Element and technology functional and performance requirements is based on the SKA community experience with radio telescopes and guided by the decisions of the SKA Board. Non-functional requirements are yet to be derived, and it is part of the work to derive and analyse them in order that they might drive the design in a timely manner.

The work described in this statement of work is to be undertaken by consortia of research organisations and industrial entities.

The Functional Requirements are subject to change. A Consortium shall make provision for such change and do so with no additional cost for those of a reasonable magnitude and date of

occurrence. Such changes will be analysed for impact together with Consortia, and if authorised for implementation will be done so by the SKA Board.

It is part of the work to establish realistic interfaces and to provide designs and prototypes.

3.1.1 Deliverable Item definition

The items covered in this statement of work are

1. The design of the AIP technology, up to the point where detailed design of said AIP technology can be readily undertaken.
2. All necessary development, design and analysis documentation

Technical concepts have been developed by the SKA community and are provided by SKA to the Consortium. These concepts have been developed in the framework of conceptual design development, analysis and evaluation, leading to a logical architecture definition reflected in the breakdown of the system in the technical specification.

The baseline reference design [RD2] provides the consortium with a starting point for the work.

The consortium shall undertake the research and development activities associated with the AIP technology and is free to redefine the definition of the AIP technology in consultation with the SKA Office who will in turn consult with the affected interfacing Elements. ***The information of the baseline reference design is provided as information to aid the derivation of functional and performance requirements and does not represent a preferred technical solution for the SKA.***

3.1.2 Project stages Definition

3.1.2.1 Stage 1 (Research & Development at conceptual level)

The main objective of stage 1 is to place on a firm basis the requirements for the AIP technology and to perform necessary prototyping that will verify basic assumptions on the feasibility of the concept. The output of stage 1 is a conceptual design for the AIP technology such that the design can progress to stage 2.

3.1.2.2 Stage 2 (Requirements generation & Preliminary Design)

The main objectives of stage 2 are to produce a consolidated design, to demonstrate its compliance with the applicable specifications, provide a cost and schedule estimate and document the supporting analysis and plans, provide a risk estimate and produce draft specifications and statements of work for the eventual construction.

Stage 2 contains

- **Critical analysis of the baseline design and exploration of alternatives**
- **Generation of functional and performance specifications for the AIP technology.**
- **Generation of interfaces with other Elements of the SKA.**
- Refining the AIP technology concept by the consortium and validating it through thorough study and analysis. This includes hardware development, test and evaluation where already necessary to ascertain compliance with the applicable requirements. Design and analysis shall cover as a minimum:

  - All identified subsystems of the AIP technology
  - All control systems necessary for the operation of the AIP technology
  - All power and infrastructural requirements for the AIP technology.
  - Analysis shall include finite element modelling (for example in relation to the environmental specifications for the site), computational fluid dynamics, control analysis, RFI/EMC analysis, RAMS analysis and safety analysis
- Risk assessment, cost estimation and schedule for construction and retirement of such risks and estimates in parallel with the process of design and analysis

During stage 2 of the study, the technical solution shall be addressed to such a level of detail that:

a) Technical specifications, development and verification plans are available for all items to be developed within the study (at least two levels below Element level)
b) Fulfilment of all applicable requirements is demonstrated
c) All critical areas, in terms of performing this study, are identified and solutions presented.
d) Within the framework of this study, the development risks (on technical, cost and schedule basis) are evaluated with a high degree of confidence.
e) All critical areas, in terms of performance, end-to-end cost and schedule of the eventual procurement, integration, verification and operation of the AIP technology are identified and presented.
f) End-to-end technical, financial and schedule risks associated with the eventual procurement, transport, integration and operation of the AIP technology are evaluated within high degree of confidence. Risk mitigation measures are identified and a draft risk register established.
g) Production, transport, integration and verification plans are established, down to the lowest level of the product tree the contractor has established.
h) End-to-end costs associated with the eventual procurement, transport, integration and operation of the AIP technology and the containing Element are clearly identified and quantified in a draft cost estimate.

Following the commencement of stage 1 there will be a formal confirmation of the critical requirements placed on the AIP technology, where outstanding specifications are placed, and existing ones are confirmed. Throughout stage 1, SKA will provide updates to environmental specifications and other applicable requirements, regulations and standards within the scope of this work, subject to Change Control [AD2].

Stage 1 starts at T0 with the kick-off meeting for this study and ends with the successful completion of the review of the conceptual design and prototype reports. Stage 2 follows and ends with the stage 2 review (PDR – Preliminary Design Review), acceptance by SKA of the associated documentation and closure of associated actions.

3.1.3 Project Schedule and Key Milestones

The total time span for the design shall not exceed 3 calendar years from the start of the study (kick-off meeting) to the completion of the last milestone.

Milestone number	Short description	Latest date	Location	Comment
1	Kick-off meeting	T0	Consortium premises	
	Progress meetings	T0+4 weeks	Telecon or Consortium premises	
2	Requirements Review - Finalisation of the R&D concepts	T0+12 weeks	Office of the SKA	
3	Submission of stage 1 (review) data package	T0+90 weeks	N/A	
4	stage 1 review meeting (SRR & PDR)	T0+94 weeks	Office of the SKA	
6	Closure of stage 1 (Attainment of TRL 5)[1]	T0+98 weeks	N/A	Start of stage 2
7	Submission of stage 2 (PDR) data package	T0+140 weeks	N/A	
8	Review of stage 2 data package (PDR)	T0+148 weeks	SKA offices	
9	Closure of stage 2	T0+154 weeks	N/A	

3.1.3.1 Kick-off meeting

The main objective of the kick-off meeting is to confirm the mutual understanding of the scope of work specified herein, including the applicable specifications.

In particular the consortium shall

- Present the project plan, schedule and work breakdown structure
- Introduce the key resources and team members

[1] Technology Readiness Level 5 – 'Component and/or breadboard validation in relevant environment' - The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.

- Make a technical presentation of the proposed solution.

The consortium shall take the minutes of the meeting and record the action items.

3.1.3.2 Progress meetings

A progress meeting shall be held every 4 weeks during the whole duration of the project. Progress meetings may be held at the consortium premises or over the telephone/video conferencing facilities available.

The consortium shall provide a written progress report at least three working days in advance of the meeting.

The consortium shall take the minutes of the meeting and record the action items.

3.1.3.3 Stage 1 and Stage 2 reviews.

The review procedure shall be as follows. The contents of the review data package shall be established as a minimum eight weeks before the review. As a minimum it shall contain design reports and analysis reports for all subsystems of the AIP technology and all deliverables as specified herein.

The review shall be organized by SKA and will involve members of the SKA project office as well as external consultants as members of the review board. The chair is appointed by SKA. The membership of the board is communicated to the consortium at the earliest possible time.

The review board shall review the documentation provided and submit written comments to the consortium no less than 3 working weeks before the review meeting. The consortium shall provide written answers to the board no less than 1 working week before the review meeting.

The agenda of the review meeting shall be agreed upon between the consortium and the review chair no less than 1 week before the review meeting. The review meeting may include in depth presentations by the consortium of the work undertaken. No detailed schedule of a review meeting is specified but for planning purposes it can be expected that a review may last 4 working days.

3.1.4 Deliverables

Without exception, but within the provisions of the SKA IP Policy all design information arising from the study will become property of the SKA. Without exception all hardware or prototypes developed as part of the study will remain property of the consortium. The consortium will undertake to keep such prototypes in safe storage for a period not less than 3 calendar years after the completion of the study.

All deliverable documents shall be provided in electronic and paper format to the SKA project office.

3.1.4.1 Progress reports

In addition to the compliance with the applicable Document requirements description, the progress report shall address

- Any assumptions used in the design that are not part of the technical specification
- Advances made in the design of the AIP technology and its subsystems
- Problems found and corrective actions
- Non-conformities identified and possible remedies
- The project planning and updates on progress

Progress reports shall include a draft agenda for the meeting and the action items being tracked.

Progress reports shall include clear indications (e.g. red flag reports) of problems that may jeopardise the study or the eventual procurement of the AIP technology.

The consortium is required at the earliest possible moment to alert SKA in case of problems that may cause the AIP technology to fail to meet its specification. This shall be done, wherever possible, in advance of the submission of any Non Compliance Report.

3.1.4.2 Stage 1 data package

The Stage 1 data package shall cover all activities conducted during the R&D phase. The nature of R&D dictates that a definitive list of deliverable documents cannot be drawn up. Nevertheless, as the endpoint of Stage 1 is intended to be a demonstration of the attainment of Technology Readiness Level 5 (TBC), the following evidence will be required.

- A clear description of the technology, including the design of prototypes and demonstrations performed and explanations of how the testing environment is relevant to the expected SKA Phase 2 environment. Clear references to SKA Phase 2 requirements, as they exist, are necessary.
- Identification and detailed descriptions of any or all demonstrations and/or analytical studies that have been performed, upon which the feasibility of the technology depends. Any and all reference documentation of the results of analysis and modelling, performed demonstrations, as well as any experimentation or demonstrations performed by others, that establish the technical and/or economic feasibility of the technology shall be provided.
- Compelling arguments that indicate likely connections between the component and/or breadboard demonstrations performed in a relevant environment and yet-to-be-performed demonstrations at higher levels of integration (e.g., systems-level), in relevant and operational SKA Phase 2 environments shall be provided.
- An evaluation of the technical risk (Low, Medium, High), and required effort (Low, Medium, High) to advance to preliminary design is required.

3.1.4.3 Stage 2 data package

The stage 2 data package shall cover all activities undertaken during stage 2. The data package shall document the baseline design and the trade offs that lead to this definition. The data package shall demonstrate compliance with the applicable requirements and establish verification plans. The data package shall provide a robust cost and schedule estimate for construction, assess and document

risks, establish the statement of work for construction and provide a sound basis for detailed design for SKA Phase 2.

The data package shall include but not be limited to:

1. The AIP technology overall design report providing the critical characteristics that provide the required functionality and performance.
2. Specific design reports for all second tier subsystems (the AIP technology being the first tier). The design reports shall include the manufacturing/procurement approach, transport, installation and verification, support equipment for operations.
3. Finite element models where relied upon to demonstrate compliance
4. Software architecture models and use cases
5. Parametric models used for the optimization of the design.
6. Analysis reports: Finite element modelling (including all mechanical and thermal load cases), thermal analysis, fluid dynamics, RFI/EMC analysis, safety analysis, hazard analysis. In cases where specific construction or assembly equipment is required. The analysis shall cover these and their operation.
7. Cost analysis for development, construction, verification, commissioning and steady state operations
8. Preliminary construction plans
9. Configuration items list
10. Compliance matrix
11. Preliminary maintenance plan
12. Preliminary verification plan
13. Schedule estimate for construction
14. High level risk register
15. Draft Statement of work for the construction of the AIP technology
16. Draft technical specifications for the construction of the AIP technology.

4 Tasks applicable to all project stages

4.1 Project management and control

1. The consortium shall implement a centralized project management system
2. The consortium project manager shall be the principal point of contact and have full authority to deal with all matters arising during the study, including but not limited to technical matters.
3. The consortium shall implement a work breakdown structure that reflects the subsystem architecture and is based on the final system product tree. Work package managers shall be identified and changes to the assignments shall be communicated to SKA no later than the earliest progress meeting.
4. The consortium shall implement a project plan and schedule following the work breakdown structure.
5. The consortium shall communicate to SKA any deviations from the project plan.
6. The project plan shall be updated according to the work done as a minimum at each progress report.

4.2 Configuration management

The consortium shall follow the principles of configuration management as laid down in the SKA SEMP [RD1], or equivalent best practices. In particular,

1. The consortium shall identify each document, drawing, subsystem or part, establishing the item configuration and relation to the hardware and software at any time in the study
2. The consortium shall establish a configuration control process, in agreement with best practices.
3. The consortium shall ensure that all personnel that use or generate information can easily access and have appropriate training in the tools implemented to ensure configuration control.
4. The consortium shall provide a central repository for all information and that this repository is properly backed up.
5. The configuration item data list shall, as a minimum, list all documents that define or describe the AIP technology. The configuration item data list shall be updated with each progress report.

4.3 Change requests and waivers

Change management is described in 5. Once a baseline has been established and investment in further development of the baseline is planned, configuration management shall be employed. Changes are inevitable and shall be actively managed.

Proposed changes are of two broad classes based upon their impact on the system as a whole. If a proposed change affects the SKA budget or overall schedule, or affects more than one Element, or changes external interfaces, it is classed as Major or System level. All other change proposals are classed as Minor. This Statement of Work is concerned solely with Major or System level change requests.

Change requests are here defined as formal requests for a change to the requirements of the study or the terms of the study (e.g. dates etc). A change request is formally issued by the consortium or SKA and requires agreement of the other party to take effect.

A change request shall be addressed within one calendar month of receipt. Absence of response shall be assumed to be a rejection of the change request. A change request shall, as a minimum, include a rationale, technical feasibility of proposed changes, backed by analysis, and a list of the affected subsystems, including performance impacts. Schedule and cost impacts must be addressed.

A waiver is defined as permission, granted by the SKA Office to the consortium to deviate from the specification or a particular clause in the statement of work. It does not imply a change to the specification nor to the statement of work.

Waivers shall be addressed within one calendar month of receipt by the SKA Office. The absence of a response shall be assumed to be a rejection of the waiver request. A waiver request shall, as a minimum, include a rationale, the technical feasibility of proposed changes backed by analysis, and a list of the affected subsystems, including performance impacts. Schedule and cost impacts must be addressed.

4.4 Red flag reports

A red flag report shall be issued by the consortium within 24 hours of the occurrence of a major problem jeopardising the timely delivery, achievement of the supply milestones, or the achievement of the technical performance and requiring the immediate attention of SKA. This reporting shall apply at all project levels.

4.5 Quality assurance and safety

The consortium shall implement and maintain throughout the study a quality assurance and safety approach that covers all aspects of ISO9001 and all specified reliability, quality assurance and safety requirements.

All national safety laws and legislation applicable to the design, development, manufacturing, installation and operation of the supply shall be followed and fulfilled.

5 Documentation

All documentation and correspondence shall be in English.

All deliverable documentation shall follow the SKA numbering system.

All original documentation shall be delivered in PDF format and MS-WORD. All secondary (e.g. scanned) documentation shall be delivered in PDF format.

Electronic drawings, finite element models or other modelling shall be delivered in widely acceptable portable data formats as well as their original. The use of ANSYS for FEM, SolidWorks for CAD, MATLAB/SYSML for control modelling and UML for computer modelling is encouraged.

6 Delivery

All deliverables shall be sent to the SKA project office.