Periodic WP2 Progress Report 2

WP2 SKA design

Objectives of WP2

WP2 is the main SKA design activity; it will produce a costed top-level design for the SKA and a detailed system design for Phase 1 of the SKA. This work is being undertaken by the SKA Program Development Office based at the University of Manchester, together with the organisations and institutes participating in WP2. WP2 is divided in 7 subtasks and the progress within each of these subtasks during the period 1 October 2009 to 31 March 2011 (T+19 to T+36 months) is presented in this report.

Restructuring of WP2

Shortly after the publication period of the first periodic report, WP2 was restructured to reflect the system engineering approach adopted within the project. This restructuring resulted in a consolidation and reorganisation of the subtasks and the activities within each of them. Milestones and deliverables were also changed to reflect the focus on design reviews to be conducted within each of the subtasks.

This report covers the progress within each of the subtasks of the restructured WP2. The CoDR and SRR dates for each work package are summarised below in Table 7.

Table 7: List of WP CoDRs with expected Review dates

Milestone no.	Deliverable No.	Review name	Original Delivery date	Revised delivery date
WP2.1 SKA System				
MS7		System Concept Design review (CoDR)	T+22	T+22 (Feb 2010)
	D2.1	System CoDR Report	T+23	T+23 (Mar 2010)
MS7		System delta Concept Design review (CoDR)	None	T+34 (Feb 2011) (23 -25 Feb 2011)
	D2.1	System delta CoDR Report	None	T+35 (Mar 2011)
		Monitor and Control CoDR	None	T+43 (Nov 2011)
MS8		System Requirements review (SRR)	T+36	T+46 (Feb 2012)
	D2.2	System SRR Report	T+37	T+47 (Mar 2012)
MS9		System Preliminary Design	T+45	T+57 (Jan 2013)
	D2.3	System Preliminary Design Report	T+45	T+58 (Feb 2013)
WP2.2 Dish Verification Programme				

MS35		Dish and Dish Array CoDR	T+26	T+39 (Jul 2011) **(13-15 July 2011)**
	D2.4	Dish and Dish Array CoDR Report	T+27	T+40 (Aug 2011)
MS36		Dish and Dish Array SRR	T+36	T+59 (Mar 2013)

	D2.5	Dish and Dish Array SRR Report	T+36	T+60 (Apr 2013)
		Final Dish Array PrepSKA Wrap up report	None	T+48 (Apr 2012)
WP2.3 Aperture Array Verification Program				
MS59		Aperture Arrays CoDR	T+30	T+36 (Apr 2011) **(19-20 Apr 2011)**
	D2.6	Aperture Array CoDR Report	T+31	T+37 (May 2011)
MS60		Aperture Array SRR	T+45	T+49 (May 2012)
	D2.7	Aperture Array SRR Report	T+46	T+50 (Jun 2012)
		Final Aperture Array PrepSKA Wrap up report	None	T+48 (Apr 2012)
WP2.4 Signal Transport and Networks				
MS73		Signal Transport & Networks CoDR	T+26	T+39 (Jul 2011) **(28-30 Jun 2011)**
	D2.8	Signal Transport & Networks CoDR Report	T+27	T+40 (Aug 2011)
MS74		Signal Transport & Networks SRR	T+42	T+55 (Nov 2012)
	D2.9	Signal Transport & Networks SRR Report	T+43	T+56 (Dec 2012)
MS75	D2.10	Final STaN PrepSKA wrap up Report	T+48	T+48 (Apr 2012)
WP2.5 Digital Signal Processing				
MS90		Digital Signal Processing CoDR	T+26	T+36 (Apr 2011) **(14-15 Apr 2011)**
	D2.11	Digital Signal Processing CoDR Report	T+27	T+37 (May 2011)
MS91	D2.12	Final Digital Signal Processing PrepSKA Wrap up report	T+48	T+48 (Apr 2012)
WP2.6 Software and Computing				
MS104		Software & Computing CoDR	T+33	T+42 (Oct 2011) **(12-14 Oct 2011)**
	D2.13	Software & Computing CoDR Report	T+34	T+43 (Nov 2011)
MS105	D2.14	Final Software & Computing PrepSKA wrap up report	T+48	T+48 (Apr 2012)
WP2.7 WP2 Design Study Management				
MS128	D2.15	Periodic WP2 progress report 1	T+18	
MS129	D2.16	Periodic WP2 progress report 2	T+36	T+36 (Apr 2011)
MS130	D2.17	Periodic WP2 progress report 3	T+48	T+48 (Apr 2012)
		Annual Project Plans for WP2 tasks	T+21, T+33	T+33 (Jan 2011)

Key

	Milestones and deliverables which have slipped beyond the WP2 PrepSKA timeframe
	Deliverables that have been added to wrap up the domain for WP2

WP2.1 System

Objectives

This subtask represents the engineering work to be done to define and design the SKA as a complete system. System engineering processes and procedures are also being developed as part of this subtask with the aim to roll out and adopt these processes across all level of the project.

Participants

Work package number	WP2.1		**Start date or starting event**			T+0 months	
Work package title	SKA system						
Activity Type	SUPP						
Participant id	4	7	9	10	11	12	13
Person-months per beneficiary	6	(38)	(12)	8 (+24)	(6)	(26)	(12)
Person months delivered							
Participant id	14	15	17	ICRAR	SPDO	18	
Person-months per beneficiary	(12)	(24)	(16)	(24)	**102** (+66)	6	
Person months delivered							

Progress

WP2.1.1 SKA definition and design

The first major deliverable following the restructuring of WP2 was the SKA System Concept Design Review (CoDR). This review was conducted during February 2010 and several documents, developed within this subtask, were presented to an external review panel.

The strategic aim presented during the CoDR was to facilitate narrowing down options and technologies as the project moved forward from a very wide base. However, the CoDR Review Panel observed that this strategy was not well-supported by the budget and the schedule. The two main recommendations of the panel were that (1) the science goals needed to be prioritised and (2) that a 'baseline' SKA be defined with possible future 'enhancements'.

As a result of the CoDR the SKA strategy was reviewed during May 2010 and the following major changes were made:

1. The science goals for the SKA Phase 1 instrument (SKA1) were narrowed down and prioritised, and
2. A supporting set of baseline front end technologies, coupled with an Advanced Instrumentation Programme (AIP), were identified.

This revised strategy and guidelines were published in SKA Memo 125. As a result of these changes the system definition had to be adapted. This was done during the remainder of 2010 and into 2011 and culminated in the system delta CoDR (dCoDR) performed during February 2011. The same review panel members were invited back to participate in the dCoDR. They were unanimous in their conclusion that the SKA has indeed managed to focus and narrow down its very wide base, especially for SKA1, and that the milestone has successfully been passed. This achievement set the scene for the performance of the series of CoDR's at the next level of the SKA and forms the focus of the activities during 2011.

The CoDR documentation set is available at:

http://www.skatelescope.org/public/2010-02_System_CoDR_Documents/

The dCoDR documentation set is available at:

http://www.skatelescope.org/public/2011-02_System_delta_CoDR_Documents/

WP2.1.2 SKA Life Cycles studies and analysis

Work within this activity has been initiated. An internal document, addressing the availability requirements for the SKA, has been developed and is under review. This document is an outflow of the work that has been done in support of the site selection process.

WP2.1.3 SKA Science Operations

During both system reviews documents with regards to the science operations have been presented. However, these documents are only first drafts of the concepts and will be developed further during the next phase of the project.

WP2.1.4 SKA Support operations

Progress within this activity has been made and a concept for support operations has been developed and included in the site selection documentation. This work will be continued during the next phase of the project.

WP2.1.5 SKA monitoring and control

During 2010 the lead for this activity has been transferred to the Indian institute, NCRA-TIFR. The philosophy and strategy, as well as a monitoring and control concept, has been presented during both system CoDR's. NCRA-TIFR have committed several resources to this task and good progress is being made. The aim for the remainder of the PrepSKA period is to engage with the wider community in the development of the requirements of the SKA monitoring and control system. This work will culminate in a monitor and control CoDR to be conducted towards the end of 2011. Regular telecons within the monitoring and control design group are conducted to ensure the momentum within this element is maintained.

WP2.1.6 SKA electromagnetic compatibility

A strategy and philosophy with regards to the self generated interference part of this activity has been developed and presented during the system CoDR's. This work will be taken further during the next phase of the project. Good progress with regards to the RFI mitigation within the system has been made and is continuing. This work is being led by OBSPAR and UORL.

WP2.1.7 SKA cost analysis

A Costing strategy and a short 'How To' manual have been developed and published as part of the system dCoDR. These documents form the basis of the cost collection and development within the SKA. Costing information will be presented during each of the element level CoDR's to be conducted during 2011. This information will be rolled up and consolidated at system level. Apart from this information, costing will also be obtained during the site selection process. The aim is to integrate all the costing to provide a comprehensive view of the cost of the SKA. As the project moves forward the costing will be refined.

WP2.1.8 SKA power consumption

During the reporting period two Power Investigation Task Force meetings have been conducted and an additional person has been appointed within the SPDO to coordinate these activities. Power consumption estimates will be presented during the element level CoDR's to be conducted during 2011. This information will be rolled up and consolidated at system level. The aim is to integrate all

the power requirements of the instrument to provide a comprehensive view of the cost of the SKA.

DELIVERABLES									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.1	System Concept Design Review (CoDR)	2.1	Report	9	19.15	PU	T+23	T+34	T+34
	System Delta CoDR	2.1	Report	9	Additional	PU	None	T+34	T+36

MILESTONES					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Delivered
MS7	System Concept Design Review (CoDR)	9	T+22	0	T+34
MS7a	System Delta CoDR	9	T+34	0	T+34
MS8	System Requirements Review (SRR)	9	T+46	10	-
MS9	System Preliminary Design	9	T+ 57	12	-

WP2.2 Dish Array

Objectives

To design, construct and evaluate at least one cost-efficient dish prototype funded and produced by PrepSKA-participating organisations and institutes, using manufacturing technologies having potential application to the SKA. In the context of the SKA system design, to provide a detailed analysis of the antenna in terms of performance metrics, cost-performance trade-offs and flexibility attributes.

Participants

Work package number	WP2.2	**Start date or starting event**		T+9 months			
Work package title	Dish Verification Program						
Activity Type	SUPP						
Participant id	4	7	8	9	10	12	13
Person-months per beneficiary	2	(16)	(14)	(6)	(2)	(96)	(6)
Person months delivered							
Participant id	14	15	NRAO	19	KASI	SPDO	21

Person-months per beneficiary	(6)	(44)	(24)	(8)	(5)	**70**	(18)
Person months delivered							

Progress

Since the previous periodic report the dish array work has been re-structured and separated from the aperture array development activities. Preparations are now in progress for the Dish Array Concept Design Review (CoDR), which will be held on 13/14/15 July 2011 at the NRC-HIA facility in Penticton, British Columbia, Canada.

The SSEC have specified the SKA Phase 1 baseline dish size to be 15 metres diameter, or equivalent. They anticipate there being 250 such dishes deployed in Phase 1. Owing to the high capital cost of dishes it is anticipated that the dish design for SKA Phase 2 will be the same as that for Phase 1, so the Phase 1 dish will be designed to comply with Phase 2 requirements insofar as they are known or can be anticipated.

A critical document in the Dish Array CoDR will be the Dish Array Requirements Specification, which has largely been completed by the SPDO in first draft form. Requirements are derived from the SKA System Requirements document. Some of the key requirements for the Dish Arrays are as follows.

- **Imaging dynamic range**
  - This requires each dish to have extremely stable, predictable beam shape and pointing in extreme desert environmental conditions.
- **Mass manufacturability**
  - Significant improvements in design for manufacture are needed to allow cost effective production of 15 m dishes in quantities of thousands.
- **Operating cost minimisation**
  - Thousands of dish systems (Phase2) will be very expensive to operate unless they are designed for high reliability with minimum maintenance. The maintenance regimes at existing radio astronomy observatories will not be affordable on this scale.
  - Routine maintenance intervals of at least one year are anticipated, including dish mechanics and cryogenics.
- **Rapid installation**
  - Dish systems will need to be installed rapidly using minimal on-site manpower and equipment.
  - This is to minimize the impact on observations, as well as keep down the manpower cost.
- **Feed flexibility**
  - Multiple single pixel feeds and a phased array feed are to be accommodated.
  - A significant means of improving overall SKA system performance will be obtained through enhancement of feeds and receivers, especially in the transition of SKA Phase 1 to SKA Phase 2.
- **Maximum A/T**
  - Maximise sensitivity per €/$ whilst meeting other requirements.

Progress in the various Dish Array sub-tasks is summarised below.

WP 2.2.1 Antenna Design

A combination of the US TDP and NRC-HIA is working on the concept of an offset Gregorian 15 m dish antenna with composite reflectors, aimed specifically at the SKA requirements. Good progress has been made on optical design and mechanical design, with a document being prepared for the SKA CoDR. A very successful CoDR of the design aspects of the Dish Verification Antenna (DVA1) has been conducted during February 2011. The results from this review will flow into the SKA CoDR later this year.

It is hoped that NRAO will also participate in dish development, particularly with verification testing, once contractual difficulties have been resolved. Work on the development and approval of a Letter of Intent in this regard is continuing.

NAOC is coordinating work on SKA dishes in China, via its JLRAT consortium. In addition to developing a 15 m offset Gregorian concept with metal reflectors they are also working on an axi-symmetric option. Documents are being prepared for the CoDR.

ASTRON is working on an axi-symmetric dish design. Details have not yet been received by the SPDO, but ASTRON intends to present a dish concept at the CoDR.

WP 2.2.2 Wide band single pixel feeds

Emphasis has changed here since the SSEC restricted the SKA Phase 1 Dish Array frequency coverage to 450 MHz – 3 GHz, and specified octave band feeds. Phase 1 development is being carried out towards the design of single pixel feed payloads, each comprising feed, ortho-mode transducer (OMT), LNAs, dewar and cryogenics. However, investigative work with regards to ultra wide band single pixel feeds, which are now part of the AIP, is continuing in Sweden (Onsala), TDP and other SKA pathfinders.

WP 2.2.2.1 Feeds

Development of the wide band (multi-octave) feeds is now part of the Advanced Instrumentation programme. The US TDP is working on corrugated horn and OMT designs for Phase 1, as well as on various wide band feeds. Simulations suggest that the system sensitivity of the corrugated horn fed designs will be considerably higher than that of the wide band systems, given the current state of the technology.

WP 2.2.2.2 LNAs

The US TDP is co-ordinating work on LNAs for the single pixel feeds. Various designs have been produced and evaluated; these include differential and single-ended LNAs based on various HEMTs and HBTs. The SPDO has identified a potential industrial partner that could carry out high precision automated manufacture of LNAs for the SKA.

WP 2.2.2.3 Receivers

No resources have been available to carry out development work on single pixel feed receivers. The SPDO has produced a set of requirements for the receivers, in collaboration with CSIRO, and these will be reviewed at the Dish Array CoDR.

WP 2.2.2.4 Cryogenics

Cryogenic development work has been carried out by the US TDP, and options will be presented at the Dish Array CoDR. The SPDO has identified a potential industry partner that could contribute significantly to the reliability and maintenance aspects of the cryogenics sub systems.

WP 2.2.3 Phased Array Feeds

CSIRO is co-ordinating the work on phased array feeds (PAFs) and has set up the PAFSKA group to collaborate on design and produce documents for the Dish Array CoDR and other reviews. This group includes ASTRON, NRC-HIA, NRAO and Brigham Young University (BYU). Prototype PAFS have been successfully demonstrated by ASTRON, CSIRO, BYU and NRC-HIA and very good progress is being made on the development of the ASKAP PAF.

Deliverables and milestones

There are now no deliverables or milestones falling within the reporting period. The tables below show how those originally within the reporting period have now moved with the recent rescheduling. Shaded rows now fall outside the PrepSKA time frame.

Deliverables									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.4	Dish Design Input to CoDR. Report for the dish verification programme (DVP)	2.2	Report	9	15.96	PU	T+27	T+40	-

Milestones					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Achieved
MS35	Dish Design Input to CoDR. Report for the dish verification programme (DVP)	9	T+39	13	-

WP2.3 Aperture Array

Objectives

The objective of this work package is to design, construct and evaluate at least one cost-efficient aperture array (AA) prototype funded and produced by PrepSKA participating organisations and institutes, using manufacturing technologies having potential application to the SKA. In the context of the SKA system design the work package will provide a detailed analysis of the array in terms of performance metrics, cost-performance trade-offs and flexibility attributes, including the use of results from simulations and other existing arrays to predict the performance of SKA-scale stations.

This work package is tasked with developing the aperture array system for the SKA, consisting of at least a sparse low frequency (70 to ~450MHz) and dense mid-frequency (400-1400MHz) array. Since the adoption of the SKA Phase 1 design in April 2008 this work package has raised the emphasis on the low frequency, sparse array while maintaining the effort on the mid-frequency dense array. It is planned to make the arrays as technologically as compatible as possible for efficiency.

Participants

Work package number	WP2.3	**Start date or starting event**				T+ 24 months	
Work package title	Aperture Array Verification Program						
Activity Type	SUPP						
Participant id	4	9	10	13	14	17	21
Person-months per beneficiary	4	(48)	20 (+20)	(48)	(48)	24 (+46)	(12)
Person months delivered							
Participant id	ICRAR	11					
Person months per beneficiary	(126)	(8)					
Person-months delivered							

Progress

General

A workshop focusing on AA science was held in Cambridge from 8-10 December 2010. The workshop had more than 80 attendees. Among the issues discussed between scientists and engineers were the requirements specific to the AA and these are used as input for the AA-CoDR. (website: http://www.mrao.cam.ac.uk/projects/aavp/)

At the end of this reporting period the preparations for the CoDR were in full progress. The review is scheduled for 19-20 April 2011

A project plan involving 4 demonstrators (2 for each bandwidth range) is completed, extending the work of this work package beyond PrepSKA in preparation for the SKA. Can they see the PEP? If so reference.

The demonstrators will prove technological maturity and scientific performance of Aperture Arrays in SKA.

Mid Frequency (400 – 1400 MHz)

There are two alternative designs being developed by two groups:

a) A Vivaldi based design is primarily being done at ASTRON with input from other groups. This is a relatively secure design in that the technology is well understood and is readily capable of being fed by a single-ended LNA. This technology has been shown to operate recently in the EMBRACE demonstrator and is utilised efficiently in a PAF as part of the APERTIF system.

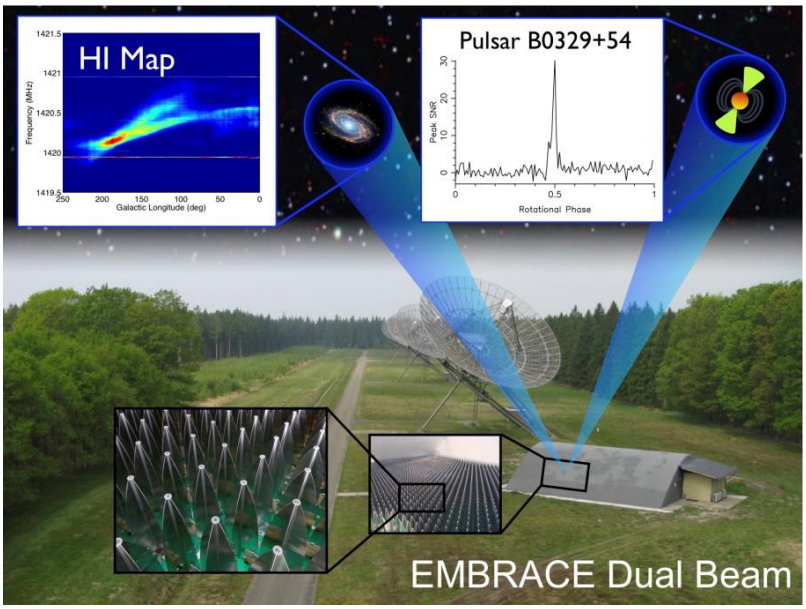
   The EMBRACE has been proven successful in providing astronomical observations using two beams for observing individual objects. It has produced pulsar observations of PSR B0329+54 and an HI sky map has been made using beam-scanning. A second EMBRACE system at the Observatoire de Nancay is being commissioned.

b) A planar system based on Octagon Ring Antennas, ORA, is being developed at Manchester University. In principle these should have very good performance and be easier to manufacture than the vertical Vivaldi style, however, more development work needs to be done. They are also inherently differential output so will either require a differential amplifier or balun.

In both cases the major work is in manufacturing the design to ensure consistency and low cost. One of these elements will be selected and proposed for the SKA.

The array layout is going to be dense, so the design as such is primarily the element spacing, which will determine the A_{eff} as a function of frequency and scan angle.

Other important parts of the development are the LNA, with a single ended commercial fall back. This work continues at ASTRON and Manchester. It has been shown that the system temperature can meet the requirement < 60K. Work is progressing to achieve a Tsys of < 50 K based on APERTIF designs. Further work on the power requirements and the gain of the LNA is ongoing.



EMBRACE simultaneously observing Pulsar B0329+54 and surveying HI map

Differential LNA's required for the ORA and probably beneficial for Vivaldi type antennas are developed but stability and noise performance are still issues that need to be resolved.

Low Frequency (70–450 MHz)

This development has taken on a higher priority as a result of the SKA_1 decisions. The development is concentrating on a trade-off between:

a) a single element solution. Work on a single element is ongoing at Cambridge for the bow-ties, at Curtin on helical spirals and independent Vivaldis in Italy. The single element is expected to be more flexible and substantially cheaper. Small scaled trial versions are planned.
b) a dual element solution. Using two elements either element interleaved, station interleaved or using separate arrays. This will have better performance at the higher frequencies and make LNA matching easier, but this solution is expected to be more expensive.

The trade-off between the single element and dual element solution will be discussed at the CoDR.

Separate research is focusing on the "ideal element "system" This would be a self-contained and self-powered element, which is connected to the rest of the array via optical fiber only. This could be a major benefit for the SKA in minimising RFI and lightning problems as well as eliminating the complexity and cost of a copper power network. This is a long term development which is an opportunity for the SKA.

Signal Processing

In the short term the UniBoard development will be able to meet the requirements for the first demonstrators in the AAVP. Derivations from this system using improved hardware are anticipated for the SKA_1 signal processing.

Deliverables and Milestones in the reporting period

Deliverables									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.6	CoDR Report for the AAVP	2.3	Report	9	20.21	PU	T+31	T+37	-

Milestones					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Achieved
MS59	CoDR Report for the AAVP	9	T+36	0	-

WP2.4 Signal Transport and Networks (STaN)

Objectives

The WP2.4 programme of work will develop and demonstrate signal transport and timing system solutions that will meet the requirements of the SKA. In the case of new design solutions, this will include the development, production and evaluation of prototype systems. Where existing design solutions can be adopted from Pathfinders or Precursors, a detailed study will be undertaken to establish that these designs are compatible with SKA requirements. Work will be undertaken within the programme in order to collate the information required to formulate and assess tenders for turn-key solutions.

Participants

Work package number	WP2.4	**Start date or starting event**			T+13 months		
Work package title	Signal transport and networks						
Activity Type	SUPP						
Participant id	4	7	9	10	11	12	13
Person-months per beneficiary	6	(4)	(12)	(4)	(8)	(12)	(12)
Person months delivered							
Participant id	14	15	21	SPDO			
Person-months per beneficiary	(12)	(4)	(28)	**10**			
Person months delivered							

Progress

Management

- A work breakdown structure [WP2.7.00.00-WBS-001-C] has been developed and agreed with all parties involved in the development of Signal Transport and Networks for the SKA. This plan outlines plans leading to design reviews and is aligned to the System Engineering Management plan [WP2-005.010.030-MP-001] developed for the project.
- Monthly teleconferences are held for all parties involved with the project and STaN pages on the SKA wiki allow the dissemination and sharing of information between groups.
- A gap analysis has been performed for the domain and these are reported in the PREPSKA FP7 Work Package 2 Project Plan [WP2-040.030.002-PLA-001].
- A date has been set for both an internal and external CoDR for the domain. The internal review will take place in Aveiro, Portugal in May 2011 and the external review will take place at Jodrell Bank Observatory, UK in June 2011. An external review panel has been identified, agreed and invited.
- Plans for the next phase of the project, as they relate to the STaN programme have been developed and are described in the Project Execution Plan, Pre-Construction Phase for the Square Kilometre Array [MGT-001.005.005-MP-001(K)].

System Engineering

- The refinement of the description of STaN and how it fits into the SKA system is on-going and will be described in the upcoming STaN CoDR.
- The development of requirements for the STaN domain, derived from a set of top level System requirements is on-going and will be described in the upcoming STaN CoDR.
- The identification of additional work in the STaN domain that will serve the SKA System is on-going and will be described in the upcoming STaN CoDR

Industrial Liaison Progress

- The project was able to see demonstration of the first 100 Gbps systems on the market from Ciena
- A Non-Disclosure Agreement (NDA) was signed with the Centre for Integrated Photonics, UK; a company specialising in integrating photonic devices on chip.
- A Statement of Mutual Interest (SOMI) and NDA was signed with Nokkia Siemens Networks(NSN); a company specialising in all aspects of telecommunications networks. This has lead to a number of meetings developing the interests of both parties. Privilaged information as a result of this work will be available to the project (under the restrictions of the NDA) at the up-coming STaN CoDR

Technical Development

WP2.4.1: Dish cable systems

WP2.4.1.2: STaN for PAF systems:

This work now sits under the re-organised PAFSKA project. Work has been undertaken at CSIRO on the test and measurement of RF over fibre links for ASKAP and this work will be presented at the up-coming STaN CoDR.

WP2.4.1.3: STaN for WBSPF:

A progress meeting was held at ASTRON in May 2010. Groups participating included MPIfR and ASTRON. The requirements for analogue links were discussed and, whilst requirements and allocated budgets for specification in the receiver chain were not available significant specifications for the full frequency band and distance range of interest for these systems were identified.

Technical progress reports were provided by ASTRON and MPIfR and these were internally reviewed by the SPDO project engineer, domain specialist in receptors and Venkat, RF engineer for Kat-7 and MeerKat. This work continues at ASTRON and will be presented at the upcoming STaN CoDR. Work at MPIfR has halted because of lack of resource. MPIfR will not participate in the upcoming STaN CoDR.

WP2.4.2: Central Facilities Fibre Networks

Work in this area has subsumed, not only the central facilities interconnect, but also the network infrastructure design for the central region and the links between the Correlator and the High Performance Computer (HPC) and the HPC to the wider world.

An infrastructure optimisation tool has been developed in conjunction with The University of Cambridge called TrenchCOAT [described in SKA memo 121]. This has been used to examine connectivity and scale of the optimised networks required for design scenarios given a fixed configuration. It has also been used to examine the impact of the SKA extensibility criteria on the networks infrastructure.

A discussion paper describing the network implications of the long baselines in SKA2 has been published as SKA memo 119.

WP2.4.3: Digital Data Backhaul (DDBH)

The University of Manchester are working on architectures for custom built boards for the transmission of data from dishes and stations of SKA1. This will be presented at the up-coming CoDR

IT, Portugal have been working with NSN to look at COTS solutions for the same function. They have identified the functionality provided by COTs systems so that the SKA can identify those aspects of commercial offering that are essential to the system. These aspects of functionality will be developed into requirements for the SKA STaN system. IT have also conducted modelling work for the various link options for the SKA.

WP2.4.4: Local Oscillator and Timing

The University of Manchester have developed a set of functional requirements for the SKA LO and Timing system from the top level requirements highlighted in the DRM. They have identified number of concepts for delivery of these requirements and these will be presented at the upcoming STaN CoDR.

Milestones and deliverables in the reporting period

There are no longer any deliverables or milestones in the reporting period. The tables below are given to show the effect of rescheduling.

Deliverables

Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.8	CoDR for Signal Transport and Networks	2.4	Report	9	5.47	CO	T+27	T+40	-

Milestones

Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Delivered
MS73	CoDR for Signal Transport and Networks	9	T+39	13	-

WP2.5 Signal processing

Objectives

To design and demonstrate the SKA signal processing chain from antenna through to the correlated or time-detected data.

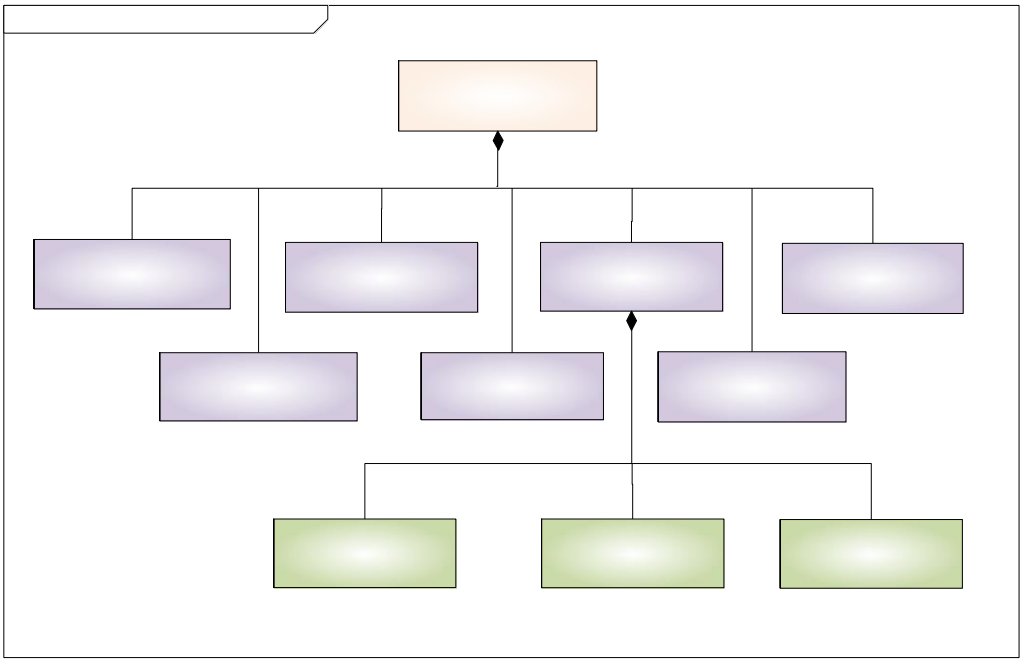
Participants

Work package number	WP2.5	**Start date or starting event**			T+18 months	
Work package title	Digital Signal Processing					
Activity Type	SUPP					
Participant id	4	7	8	9	10	11	12
Person-months per beneficiary	8	(10)	(28)	(24)	8 (+18)	18 (+18)	(8)
Participant id	13	14	15	16	17	18	KASI
Person-months per beneficiary	(24)	(24)	(4)	(8)	(16)	6	(15)
Person months delivered							
Participant id	SPDO						
Person-months per beneficiary	**8**						
Person months delivered							

Progress

Work Break-down Structure

The WP2 Work Break-down Structure, WBS, has changed since the last report and is illustrated in the figure below.



The Signal Processing is now identified as Work Package 2.5 and comprises of:

- WP2.5.1 Correlator and Central Beamforming
- WP2.5.2 Digital Beamformers
- WP2.5.3 Non Imaging Processing

Within these the responsibilities have altered slightly:

- Beam-Forming and data acquisition aspects for the Sparse and Dense Aperture arrays are now the responsibility of and documented by the Aperture Array Verification Programme.
- Data Acquisition for dishes is now the responsibility of and documented by the Dish Verification Programme
- RFI Mitigation is elevated to the system level as a cross cutting aspect of the telescope.

The CoDR for WP2.5 will be held at the University of Manchester in April 2011 (T+36). Progress on the development of the documentation set is very good and available the following web site: http://www.skatelescope.org/public/2011-04_Signal_Processing_CoDR_Documents/

A top down and bottom up approach was adopted for the review content in accordance with system engineering policies. The documentation generated provides an initial framework for the development of each of the engineering concepts within the work packages.

Document	Document number	
Signal Processing Requirements	WP2-040.030.000.SRS-001-1	SPDO
High level description	WP2-040.030.010-TD-001-1	SPDO/ ICRAR/ MPG/ UMAN/ NRAO
Searching for Fast Transients	WP2-040.030.010-TD-002-1	ICRAR

Pulsar Survey with SKA Phase 1	WP2-040.030.010-TD-003-1	UMAN/ MPG/ ASTRON/ UOXF
Technology Roadmap	WP2-040.030.011.TD-001-1	SPDO
Signal Processing Risk Register	WP2-040.010.010.RE-001-1	SPDO
Strategy to proceed to the next phase	WP2-040.010.030.PLA-001-1	SPDO
Software and Firmware Strategy	WP2-040.200.012-PLA-001-1	SPDO
SKA Signal Processing Costs	WP2-040.030.020-TD-001-1	SPDO

Table: Top Down Documentation

WP2.5.1 Correlator and Central Beamformer

Concept options for the Correlator and Central Beamformer have been explored and documented to a level where first pass estimates of cost and thermal dissipation have been provided. These cover a range of technology options including software, FPGA and ASIC implementation based on experience gained from path-finder and pre-cursor projects.

Document	Document number	
Software Correlation Concept 001	WP2-040.040.010-TD-001-1	KASI
Software Correlation Concept 001	WP2-040.040.010-TD-002-1	UCAM
ASKAP Correlator Concept Description SKA2	WP2-040.060.010-TD-001-1	CSIRO
ASKAP Correlator Concept Description SKA2	WP2-040.060.010-TD-002-1	CSIRO
A UNIBOARD Based PHASE 1 SKA Correlator and Beamformer Concept Description	WP2-040.070.010-TD-001-1	JIVE/ ASTRON
SKA CASPER Correlator Concept Description	WP2-040.080.010-TD-001-1	NRF
GSA Correlator Concept Description	WP2-040.050.010-TD-001-1	NRAO
SKA1 ASIC-Based Correlator for Minimum Power Consumption—Concept Description	WP2-040.090.010-TD-001-1	JPL
SKA2 ASIC-Based Correlator for Minimum Power Consumption—Concept Description	WP2-040.090.010-TD-002-1	JPL
Central Beamformer Concept Description	WP2-040.110.010-TD-001-1	NRAO

Table: Correlator and Central Beamformer Documentation

WP2.5.2 Digital Beamformers

Initial digital beamforming concepts for sparse aperture arrays, phased array feeds and central beamforming have been generated and are identified in the table below.

Document	Document number	
SKA Station Beamformer Concept	WP2-040.040.010-TD-001-1	UOXF/ UMAN/ UCAM
A UNIBOARD Based PHASE 1 SKA Correlator and Beamformer Concept Description	WP2-040.070.010-TD-001-1	JIVE/ ASTRON
PAF Beamformer Concept Description	WP2-040.140.010-TD-001-1	CSIRO

Table: Digital Beamformes Documentation

WP2.5.3 Non Imaging Processing

Work on the Non-Imaging processing work package has had an emphasis on identifying the engineering parameters required to satisfy the science. This is largely reflected in the top down documentation which includes algorithmic options for pulsar processing including binary searches and transient detection. The concept descriptions identified in the table below have been documented and provide initial estimates for cost and thermal dissipation for pulsar search and timing.

Document	Document number	
SKA Non Imaging Processing Concept Description: GPU Processing for Real -Time Isolated Radio Pulse Detection	WP2-040.130.010-TD-001-1	UOXF
A Scalable Computer Architecture for On -Line Pulsar Search on the SKA	WP2-040.130.010-TD-002-1	MPG
An Architecture for Incoherent Dedispersion	WP2-040.150.010-TD-001-1	ICRAR
Pulsar Signal Processing on UNIBOARD	WP2-040.170.010-TD-001-1	UMAN
Benchmarking Pulsar Searching Algorithms on Disparate Computing Platforms	WP2-040.160.010-TD-001-1	UMAN

Table: Non-Imaging Processing Concept Description Documents

Milestones and deliverables in the reporting period

Deliverables									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.11	CoDR Report for Digital Signal Processing	2.5	Report	9	14.89	PP	T+27	T+37	-

Milestones					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Delivered
MS90	CoDR Report for Digital Signal Processing	9	T+36	10	-

WP2.6 Software and Computing

Objectives

To formulate and document strategies for the implementation of SKA software and computing hardware, including calibration and imaging techniques, non-imaging data processing, post processing, data storage distribution of science results, and development of interfaces for users and operators.

Participants

Work package number	WP2.6	**Start date or starting event**			T+13 months		
Work package title	Software and computing						
Activity Type	SUPP						
Participant id	4	7	9	10	12	13	14
Person-months per beneficiary	10	(4)	(24)	(42)	(12)	(24)	(24)
Person months delivered							
Participant id	15	16	19	20	KASI	SPDO	ICRAR
Person-months per beneficiary	(24)	(4)	(4)	(18)	(5)	**59** (+30)	(90)
Person months delivered							

Progress

Most lead organisations have participated in regular S&C teleconferences and by email.

Some 30 Work Breakdown Structure (WBS) elements has defined and published on the S&C Domain Wiki. Lead organisations have been asked to project manage their defined WBS areas. This has not yet been successfully accomplished. Organisations contributing to this domain are facing numerous challenges and have been slow to adopt the processes defined in the SEMP.

As a result progress in this domain has been slower than expected mainly because of availability of resources. However, a face to face meeting is planned for April this year to reinvigorate and create more momentum within this domain. It is expected that a CoDR will be conducted during October 2011.

As system-level requirements are further identified and documented S&C Domain requirements will become more easily elicited, documented and managed including formal change control.

WP2.6.1: Software Engineering and Architecture Development

A draft strategy for software development and a list of requirements for a requirements management tool has been prepared. However organisations with interests in software development activities and tools have their particular favourites. Furthermore, as yet there is no pressing issue to force the adoption of uniform software engineering methods or tools. Nevertheless, progress on selection of tools for requirements management and other activities is being made at the system level.

Software development for the SKA is being informed by lessons learned from radio astronomy existing facilities and projects in progress, large scale development of software systems for both industrial applications and other scientific domains such as for the LSST and CERN. In addition, the ASKAP Software Lead is participating in the International Exascale Software Project series of meetings and has initiated potentially useful interactions with key IESP members.

A review of documentation for several existing facilities and projects in progress that use off the shelf solutions and other solutions that could be re-used, has been developed and published by the SPDO. But a complicating factor is that the effort involved in integrating existing solutions is highly

dependent on the detailed requirements for interfaces and modes of operation. These have not yet been defined in detail for SKA1.

WP2.6.2: Computing Hardware Architecture Development and WP2.6.7: Exascale Computing and Hardware

Industry and academic literature on High Performance Computing (HPC) is scanned on a regular basis and the results are published on the S&C Domain Wiki. In addition, Precursor and Pathfinder projects regularly engage with HPC vendors on equipment pricing and delivery matters, and the results of these engagements are monitored. However the required HPC parameters for SKA1 are not yet sufficiently stable to engage with industry on a similar placement-of-order basis.

A model for estimating the required size of the required HPC has been prepared, and analyses of existing calibration and image processing algorithms have been published by TDP-CPG. However, based on these and other analyses SKA1 is estimated to require hundreds of petaflops of HPC, well beyond SKA1 affordability in the 2014 to 2016 timeframe. Further work is required in this area.

WP2.6.3: Calibration and Imaging Techniques

A spreadsheet model which includes key cost driver parameters and likely pessimistic-optimistic ranges has been prepared. The model includes:

- baseline length
- receptor diameter
- number of receptors
- number of frequency channels
- maximum allowed smearing
- HPC efficiency
- estimated price reductions
- required number of flops per u-v sample to achieve required dynamic range

However, the last parameter – the required number of flops per u-v sample ("flops per float") – is highly uncertain and non-deterministic for existing algorithms and both TDP-CPG and ASKAP to have been requested to undertake further work to characterise the image processing requirements – in terms of flops per float and other key metrics – for existing and proposed image processing algorithms.

Further characterisation of image processing requirements is identified in the WBS elements for lead organisations in image processing areas.

WP2.6.4: Non-Imaging Data Processing

Work in this activity has not progressed during. Due to a lack of resources the lead institute, CSIRO, had no alternative but to withdraw from this activity. No alternative lead has been identified yet.

WP2.6.5: Data Products, Data Storage and Data Distribution

Work within this activity will primarily be focussed on the delivery of concepts during the CoDR.

WP2.6.6: Interfaces for Users and Operators

The UCAL CyberSKA project has continued to develop.

WP2.6.7: Exascale Computing and Hardware

See WP2.6.2: Computing Hardware Architecture Development and WP2.6.7 Exascale Computing and Hardware above.

Milestones and deliverables in the reporting Period

Deliverables									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.13	CoDR Report for Software and Computing	2.6	Report	10	28.42	PU	T+34	T+44	-

Milestones					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Delivered
MS104	CoDR Report for Software and Computing	10	T+43	10	-

WP2.7 Management

Objectives

This project provides support for the WP2 engineering study in terms of project planning, reporting, and financial and related interactions between UMAN (SPDO) and regional SKA programs.

Participants

Work package number	WP2.7	**Start date or starting event**			T+0 months	
Work package title	WP2 design study management					
Activity Type	MGT					
Participant id	SPDO					
Person-months per beneficiary	**32**					

Progress

During the reporting period the management structure within WP2 has been enhanced and strengthened with the creation of the WP2 Management Team. The team was established during June 2010 and is aimed at ensuring a coherent and transparent effort across WP2. The team conducts regular telecons (every two weeks) and have already had two face to face meetings. Details are posted on the UMAN(SPDO) WIKI (http://wiki.skatelescope.org/bin/view/Main/WebHome).

During the last quarter of 2010 and first quarter of 2011 the management team developed and published the WP2 Project Plan. This document forms the basis for the management of the effort during the remainder of PrepSKA. In addition to the WP2 effort the management team has supported the development, publication and review of the Pre-construction Project Execution Plan. Considerable effort went into aligning the two management documents to facilitate a smooth as possible transition between the phases of the project during 2012.

During the reporting period several progress reports to both the PrepSKA Board and the Project Director have been developed and published.

The Coordinating Committee including the PrepSKA management, and the Coordinators of WPs 2/3, 4, 5 and 6 has met when required, the last meeting being in connection with rescheduling the deliverables. UMAN(SPDO) have continued to make visits to the WP2 participating organisations, in order to gather information and to participate in reviews of WP2-related technical work. Within the SPDO regular technical and management meetings are conducted to ensure a continuous focus and visibility of the progress within WP2. A very successful WP2 annual meeting has been held in Oxford during October 2010. The next annual meeting will take place in October 2011 in Manchester.
The personnel in the SPO have been increased during the reporting period as shown in the table below, which helped to alleviate some of the work pressure.

Staff

UMAN(SPDO) WP2 TEAM MEMBERS	
Designation	**Name**
Program Director (WP2 Coordinator)	Richard Schilizzi
Project Engineer	Peter Dewdney
Project Scientist	Joe Lazio
Project Manager*	Kobus Cloete
Executive Officer	Colin Greenwood
Office Manager	Lisa Bell
Office Assistant	Greta Collins
Project Management Officer*	William Adams
Domain Specialist Signal Transport and Networks*	Roshene McCool
Domain Specialist Receptors*	Neil Roddis
Domain Specialist Software and Computing*	Duncan Hall
Domain Specialist Digital Signal Processing*	Wallace Turner
Systems Engineer*	Tim Stevenson
Site Engineer and Power Specialist	Georgina Harris

* funded by PrepSKA:WP2

The progress during 2011 is encouraging and it is expected that all the CoDR's will be completed on schedule.

Milestones and deliverables in the reporting period

Deliverables									
Del. no.	Deliverable name	WP no.	Nature	Lead beneficiary #	Estimated indicative person months	Diss. level	Delivery Date (orig.)	Delivery Date (updated)	Date Delivered
D2.16	Periodic WP2 progress report 2	2.7	Report	9	0.7	PP	T+36	T+36	-

Milestones					
Milestone number	Milestone name	Lead beneficiary #	Due date	Slip since last report	Date Achieved
	1st Annual project plan for WP2 tasks		T+21		
	2nd Annual project plan for WP 2 tasks		T+33		
MS129	Periodic WP2 progress report 2	9	T+36	0	-