**Work Package Title:** Digital Signal Processing

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| **Work package number** | WP2.5 | | **Start date or starting event** | | | | | T+18 months | | |
| **Work package title** | Digital Signal Processing | | | | | | | | | |
| **Activity Type** | RTD | | | | | | | | | |
| **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 | | 24 | UMAN (SPDO) |
| **Person-months per beneficiary** | (24) | (24) | | (4) | (8) | (16) | 6 | | (15) | 8 |

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

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| **Description of work**:  The SKA is an Information Technology telescope, and much of the instrument’s projected performance gains will come from new signal processing techniques and technologies. This project extends work underway in Precursors, Pathfinders and Design Studies, giving insight into the design of the very powerful, scalable processing platforms needed to make the SKA a reality.  WP2.5 is divided into three tasks as set out below. All tasks are coordinated by UMAN (SPDO), with the Signal Processing domain specialist being the WP2.5 project leader.  WP2.5.1: **Correlator and Central Beamformer**  This task will evaluate the feasibility and merits of various architectures, given SKA cost and scalability requirements.  The correlator is literally central to the SKA system and will be built progressively with the implementation schedule of the telescope, in order to benefit from improvements of technology over time. A staged and parallel plan for the roll-out of the correlator is to be adopted using technology appropriate to the phase of the project but within the same framework. This allows time for developing solutions that can scale to the full extent of Phase 1 and Phase 2 whilst at the same time providing a correlator system during all stages of the project. As part of this a software or path finder correlator may utilised as an “early correlator”.  In addition to the correlator, a digital beamforming subsystem is required for forming beams from a subset of the antennas, typically the central core, to form a “virtual” dish. Many beams on the sky can be formed in this way from the same set of antennas. These beams will be used primarily to feed the non-imaging processor (WP2.5.3). (Because this beamformer will likely utilize part of the correlator, it has not been described as a separate sub-task in WP2.5.2).  WP2.5.1 will evaluate the feasibility of various architectures, select an extensible system and produce an associated cost model. Available technology will be reviewed in close collaboration with WP2.5.3.  Participants: NRC-HIA will lead this task, drawing on their wide experience in correlator design, most recently with the EVLA and e-MERLIN correlators. Contributors will be the UK (UCAM, UOXF, UMAN), with correlator experience and the DSP design, JIVE with extensive operational knowledge and Cornell (TDP) (folding in US experience) and KASI with interests in software correlators.  WP2.5.2: **Digital Beamformer**s  Digital beamformers have applications in several parts of the SKA. In essence, a beamformer produces a weighted sum of the signals from individual or small groups of antennas (dishes or array elements of PAFs or AAs), resulting in a single data stream. In most cases compensation for geometrical delay is also required. The weights are used to form and steer a synthesized beam directed to the sky or to the reflector of a dish. The weights are in general functions of frequency.  This part of WP2.5 is closely connected with WP2.2.3 (DVP - PAF task) and WP2.3.2 (AAVP application). These are potentially large scale aspects of the SKA design and require the same rigorous application of digital signal processing techniques as correlators or other digital processors. In all cases there will be a strong emphasis on balancing operational with capital costs (total cost of ownership), which in the case of digital equipment indicates consideration of low-power designs.  WP2.5.2.1: Phased-Array-Feeds (PAFs): As noted above, this task is principally a component of the PAF aspect of the DVP (WP2.2.3). This task will be to coordinate the design of the PAF beamformer with that of the correlator, and to ensure a uniformity in the approach to digital technology and design techniques across the SKA design.  Participants: The WP2.5.2.1 leader will be CSIRO (ASKAP). Contributors will be ASTRON and NRC-HIA.  WP2.5.2.2: Aperture Arrays (AAs): As noted above, this task is principally a component of the AAVP (WP2.3.2). This task will be to coordinate the design of the AA beam-former with that of the correlator, and to ensure uniformity in the approach to digital technology and design techniques across the SKA design.  Participants: The WP2.5.2.2 leader will be the AAVP group.  WP2.5.2.3: Station Beamformers: This task will provide the design for a cost and power-effective DSP solution for beam-forming dishes across each SKA outlying station. Algorithms for the station DSP functions will also be developed and tested. A small correlator at each station will likely be required in order to “phase up” the dishes within the station. This task will link closely with the correlator development in WP2.5.1.  Participants: The WP2.5.2.3 leader will be UK (UCAM, UOXF, UMAN),with station DSP experience in SKADS. Contributors will be MPG, ASTRON, NRC-HIA, INAF and NRF (MeerKAT), all of whom have substantial DSP resources.  WP2.5.3: **Non-Imaging Processors**.  This task will design and verify new signal processing techniques required to make observations in observing domains little investigated by previous radio arrays. Some of the most exciting SKA science is expected to come from observations that do not result in images. These include the search for, and timing of, pulsars; searches for radio transient phenomena, a field which is largely unexplored; and the Search for Extra Terrestrial Intelligence (SETI). The SKA (including Phase 1) will have a superb ability to observe and monitor large areas of the sky, and its non-imaging processors must maximize the returns from these capabilities.  WP2.5.3 will have strong links to other WP2.5 tasks, and will define specialist signal processing techniques to be implemented using station and correlator systems, as well as additional special-purpose hardware platforms. Links will also be in place to WP2.6, ensuring that imaging and non-imaging applications are well-integrated at the SKA post-processing level.  Participants: This work will be led by UK (UCAM, UOXF, UMAN) together with MPG, both which have extensive experience in designing pulsar processing systems. Contributors will be ASTRON, CSIRO (ASKAP), NRF (MeerKAT), OPAR and UORL, all of which have backgrounds in time-resolved astronomy. |

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| **Deliverables:**  WP2 deliverables will be structured according to a series of standard Design Reviews (DRs), as laid out in the introductory part of this document. The documentation from all Work Plan sub-system tasks will be combined into an integrated document set for the particular review in question. A DR report on each review will be produced by an independent review team. The WP2 deliverable for each DR will be a report written by the UMAN (SPDO) referencing the DR report and all the input documentation. The items below describe the deliverables expected in the PrepSKA period. Subsequent DRs will take place after the end of the PrepSKA period (T+45 months).  1. CoDr Report for Signal Processing.  *Type*: Report. *Delivery*: T+26  2. Final PrepSKA Wrap-up Progress Report (not a DR report).  *Type*: Report. *Delivery*: T+45 |