SKA Organisation eNewsletter edition 36 – December 2017

Editorial from the Director-General ................................................................. 3

Reports from the Consortia ............................................................................. 5
Central Signal Processor .................................................................................. 5
Low-Frequency Aperture Array ...................................................................... 12
Mid-Frequency Aperture Array ....................................................................... 21
Signal and Data Transport ................................................................................ 26
Infrastructure Australia ................................................................................... 27
Infrastructure South Africa ............................................................................. 29
Wide Band Single Pixel Feeds ......................................................................... 33
Assembly, Integration & Verification ............................................................... 33
DISH .................................................................................................................. 37
Science Data Processor .................................................................................... 43
Telescope Manager .......................................................................................... 50

News From Precursor & Pathfinder Facilities ................................................. 52
ASKAP Report ................................................................................................... 52
MeerKAT Report ............................................................................................... 58
MWA Report ....................................................................................................... 63
HERA Report ..................................................................................................... 67
JIVE/EVN/VLBI Report ..................................................................................... 70
Parkes Observatory Report .............................................................................. 76

Updates from the Science Working Groups ..................................................... 78
Epoch of Reionization ..................................................................................... 78
Pulsars ............................................................................................................... 79
Dear Colleagues,

Welcome to the new edition of the SKA eNews, through which we try to bring you news from across the international SKA project demonstrating the excellent progress both in the design and science activities, as well as relevant developments in SKA Observer countries.

I start by welcoming Dr Catherine Cesarsky as the new independent Chair of the SKA Board. Catherine was elected following the untimely passing of Nanni Bignami, the previous Chair, as reported in our previous edition of eNews. Catherine has had a wide-ranging career, including the following senior positions: Head of Astrophysics at the Commissariat à l’Energie Atomique, CEA (1985-93); Director of CEA basic research in physics and chemistry (1994-97); Director General of the European Southern Observatory, ESO (1999-2007) and then High Commissioner for Atomic Energy in France (2009-12). She is also a high-level advisor to many bodies, including CEA, CERN, ESA and the Académie des Sciences in France.

Catherine has already chaired her first SKA Board meeting, which was held in Bologna, Italy from 8-9 November; she has also spent three days at SKA HQ meeting the staff and attending a face-to-face meeting of the SKA Science and Engineering Advisory Committee (SEAC). I look forward to working closely with such a distinguished person as the new Chair of the Board, especially as we move into a very complex period for the SKA. I would like to express my strongest thanks and appreciation to Prof Lars Börjesson, who stepped in as interim Board Chair at a difficult time following Nanni’s untimely passing. It was a pleasure working with Lars.

On another personnel matter, following a global search, I have appointed Dr Joe McMullin as SKA Programme Director; Joe will start in his new post on 8th January 2018. His role will be to take over from Alistair McPherson (who will be remaining as Deputy D-G through 2018) and lead the engineering team into SKA1 construction. Joe is a radio astronomer by training and has worked at NRAO for several years on aips++, CASA, ALMA and the EVLA; for the past 6 years, he has been the project manager for the construction of DKIST, the US$344M optical solar telescope nearing completion on Haleakala, Hawaii.

A few weeks ago, Rosie Bolton (SKA Regional Centre Project Scientist) and I had the privilege of giving the keynote presentation at SuperComputing17 (SC17), which this year was held in Denver, Colorado. SC17 was a huge meeting, with about 13,000 attendees and exhibitors. Our keynote talk was entitled ‘Life, the Universe and Computing: The Story of the SKA Telescope’. The SKA Comms team did a fantastic job in generating all of the material for the massive screen (47m
wide!!), which dwarfed Rosie and me, and in producing the script for the talk itself. An LA-based production company turned the material we had provided into something which looked great on the huge screen. If you have a chance, it is worth watching the video, which lasts just over 45 minutes.

I hope you enjoy eNews and don’t forget that you can find a summary of the recent SKA Board meeting, and the most recent project bulletin.

Professor Philip Diamond, SKA Organisation Director-General.
Reports from the Consortia

Central Signal Processor

**Design of the SKA Central Signal Processing (CSP) Element**

**Who are we?**

The “Central Signal Processor” (CSP) Consortium is comprised of 13 signatories from 8 countries with more than 10 additional participating organisations. The Consortium includes a rich mixture of engineers, scientists and managers from various academic institutions, industry and government labs spread over 5 continents (see [https://www.skatelescope.org/csp/](https://www.skatelescope.org/csp/) for more details). As might be expected, it has been a challenge to proceed efficiently with such a diverse and distributed team.

The lead organisation of the Consortium is the National Research Council of Canada (NRC). NRC has contracted MDA Systems Ltd. (MDA) to assist in leading the Consortium.

**What are we designing?**

The CSP Element includes the design of the hardware and associated firmware/software necessary for the generation of visibilities, searching for new pulsar candidates, and pulsar timing data from the telescope arrays. More background on the CSP can be found in the previous eNews submissions: [http://newsletter.skatelescope.org/category/pdf-version-of-enuews/](http://newsletter.skatelescope.org/category/pdf-version-of-enuews/)

**Current Status of Design Activities**

Since the last eNews submission in August, the CSP Team has completed another round of costing in September and has been updating the ICDs and progressing the requirements to pave the way to CDR.

The sub-element design teams have continued to progress with detailed design and prototyping as they approach their CDRs. There has been continued activity on the system engineering side (requirements, ICDs, modelling, processes, standards, ILS/RAMs). There are still challenges in finalising the Level 1, 2, and 3 requirements required for efficient progression to CDR.
Key Sub-element Design Development

**Local Monitoring and Control (LMC)**

The CSP Local Monitoring and Control (LMC) Sub-element is responsible for coordinating all the CSP processing functions according to commands from the Telescope Manager (TM), reporting the overall CSP status based on the reports from the processing sub-elements, and configuring and sequencing the sub-elements. This sub-element is being led by NRC with assistance from INAF and NCRA. The CSP LMC team is actively supporting SKAO-led initiatives to define SKA standards and guidelines for implementation of the SKA Control System and the SKA software engineering process. The CSP LMC team is leading the effort on the definition of states, modes, commands and configuration and contributing to the definition of the design patterns for generation and handling of logs and alarms. Significant progress has been made on the definition of interfaces. The INAF team developed a prototype based on the SKA Control Systems Guidelines v1.0; work on the Prototype Report is well under way.

**LOW Correlator and Beamformer (Low.CBF)**

Since the SKA Engineering meeting in Rotterdam June 2017, the Low.CBF team has continued meetings, scheduled telecons, weekly status updates and ad hoc technical discussions. There has been steady progress in working towards CDR deliverables in parallel to addressing remaining cost control initiatives, assessing ECPs, reviewing requirements and working on internal and external ICDs.

A new FPGA code developer joined AUT in July. Norbert Abel, who came from industry (Endace Ltd) has joined Will Kamp, also from industry, to make-up AUT’s FPGA developer resource contribution. Norbert has been assigned to work on Low.CBF. AUT visited CSIRO in August to meet the Perentie team which was a good opportunity to review the coming two-year work plan, and map out FPGA code development schedules and resource assignments during the period between CDR and C0 start. The visit also coincided with two engineers from ASTRON working on site, Koos Kegel and Leon Hiemstra, working on FPGA code prototyping and System Engineering based CDR documentation deliverables.
John Bunton, our Low.CBF & Low System Engineer, attended the Construction Schedule face to face meeting on 4 October. John presented the Low CSP plan for construction and attended a number of planning meetings.

Finalising ICDs and gaining closure for CDR submission has been problematic. The large workload across the consortium and looming deadlines has made it difficult for some to make closing off these documents a high priority, both intra-consortium, inter-consortium and SKAO. The main prototyping activities over the last three months has been centred around Monitoring and Control (MACE) FPGA and software code integration, MACE software development, development in Tango GUI, Gemini GUI and protocol, Gemini support modules, Automated Register Generation prototyping and documentation and Gemini LRU cooling prototyping.

CDR documentation has progressed despite resources been extended to focus on L2 Rev 4 requirements reviews. This has now been baselined and the Low.CBF has been working on L3 flow-down. This is close to finishing which will enable submission for EA-1 Requirements Specification for sub-element CDR.

Detailed Design document has received great attention in the last month with a three-week workshop at ASTRON. This has progressed well in critical sections of the document and is now being consolidated with supporting sections and reference documents.
The Perentie international collaboration involving AUT, ASTRON and CSIRO received an award from CSIRO for their efforts. The team has achieved much in the past two years and the future looks broader following CDR and into construction.
CDR Element L2 documentation is progressing in parallel to L3 Sub-element documentation. CSIRO Low Systems Engineer is responsible to ensure completion for CDR submission in April 2018, whilst contributing to other CDR documents owned by others in CSP Consortium, e.g. EMI/EMC document, Power Quality documents, Safety Hazard documentation.

**MID Correlator and Beamformer (Mid.CBF)**

The Mid.CBF Sub-element is led by NRC and is based on a Stratix 10 FPGA solution. This is a joint effort with MDA and NZ Alliance.

With the Cost Control Project complete, the Mid.CBF team is working full speed ahead on the Frequency Slice Architecture design. The team has been working on two fronts: CDR deliverable documents and prototyping. CDR delivery will occur in two stages: a December 11th, 2017 pre-CDR delivery, followed by the complete CDR package delivered on January 22nd, 2018. Two key documents for the pre-CDR delivery, the Detailed Design Document and Signal Model, are nearing completion.

The focus of the Mid.CBF prototyping activities is as follows:

- **Firmware design to progress high risk areas of firmware development**
  - Excellent progress made on implementation of the following key IP blocks:
    - X-Part correlator IP block
    - PSS beamformer block
    - Digital Resampler+Delay/Phase tracker IP block
    - Parameterizable Corner Turn in DDR4 IP block
    - Channelizer and tunable filter IP blocks (Intel developing reference designs)
  - In all cases, resource usage and target clock rates are being met

- **Monitor and Control Software running on embedded processors**
  - TANGO successfully running on Arria 10 embedded processor
  - Further progress made on Linux underlying drivers for M&C of FPGA IP blocks and FPGA configuration
  - TANGO devices and GUIs under development to complete M&C software stack

- **Hardware design of TALON-DX Processing Board**
  - TALON-DX Processing board contains the following key components:
    - Intel Stratix 10 SX210 System-on-Chip FPGA
    - 4 x DDR4 DIMMs @ rates up to 2666 MT/s
    - 5 x FCI LEAP mid-board optical modules (12x25G bi-direction SERDES links each)
    - 2 x QSFP28 cages for external interfaces
  - Design complete and first prototypes received using an engineering sample Stratix 10 GX280 FPGA (no embedded processor).
  - Fabrication of TALON-DX boards with engineering sample Stratix 10 SX280 FPGAs (with embedded processor) planned for December.

- **Mechanical/thermal modelling and design work**
  - Custom 2U 19” rack mount server box containing
    - 2 x TALON-DX processing boards
    - 1 x Simple power distribution / isolation module
    - 1+1 Redundant COTS ATX power supply
- 4 x hot-swappable fans (LRU can function using only 3)
  - Detailed modelling of air-cooling which is now the baseline design.
  - Detailed design for the TALON LRU packaging.
  - Prototype server boxes being manufactured and expected in November

This past quarter, the hardware design for the TALON-DX board completed and two prototypes have been built using engineering sample Stratix 10 GX280 FPGAs (no embedded processor). The two boards have been received and are currently going through a "bring-up" procedure. So far, power rails have been verified and FPGA has been successfully programmed. SERDES/Optical Modules and DDR4 testing will commence shortly.

The Mid.CBF Team is on track for Sub-element CDR submission in January 2018, with the review to follow in March.

Figure 4. TALON-DX Signal processing board populated with DDR4, FCI LEAP Mid-board Optical Modules and QSFP28 100GBASE4-SR Modules on the bench at NRC.
Pulsar Search Engine (PSS)

The Pulsar Search Engine is a large sub-element of the CSP used to search for pulsars and fast transients that will have almost identical instances for both SKA Mid and Low. The design team is led by the University of Manchester, University of Oxford and the Max Planck Institute for Radio Astronomy supported by input from INAF Italy, NZ Alliance, ATC Edinburgh, and ASTRON.

In the last few months, we have been concentrating on preparing our documentation for CDR. Our prototype PSS cluster, protoNIP, is deployed in the Karoo Array Processing Building. We have been developing the infrastructure and the software to be able to deploy our entire software stack across the nodes, another crucial learning step for the construction phase. This has been done in conjunction with SKA-SA who have provided excellent support.

We are continuing our work on the end-to-end pipelining of our software, this has enabled us to put together two complete pipelines, one for single pulse search and the other for time domain acceleration pulsar search. These are implemented in Cheetah and will soon be rolled out on protoNIP.

Our test vector machines and continuous integration process are now using a Virtual Private Network that allows us to virtually place our testing servers, physically located at our different institutes, on to the same virtual network. We are using this infrastructure to demonstrate how collaborative code development, continuous integration, and careful unit testing, allow us to develop high quality code across an international collaboration. We have also developed a set of web interfaces to enable the easy access to the test vectors for ourselves and collaborators.

Our work with Covnetics on the development of a version of the Fourier domain acceleration search on a FPGA based board continues. They have made excellent progress in the convolution modules and data throughput and extraction across the PCIe interface. We are interacting with them by reviewing intermediate documents and providing test vectors and cross-checking the output results. We are also working on the installation of the firmware on boards in Linux based PCs ready for use with protoNIP.

Pulsar Timing Engine (PST)

The Pulsar Timing Sub-element (PST) will perform high-fidelity, high-precision timing observations of known pulsars for both Low and Mid telescopes. The primary task performed by this instrument is phase-coherent dispersion removal, a computationally intensive algorithm that requires performing many large Fast Fourier Transform operations in real time. The PST design is based on commodity off-the-shelf (COTS) hardware with graphics processing unit (GPU) accelerators, and an early version of this solution is currently being commissioned at the MeerKAT telescope. We recently completed successful benchmarks of our prototype software on a system composed of an IBM POWER8 multiprocessor, NVIDIA P100 GPUs with dual-lane NVLink 1.0 high-speed interconnect, and Mellanox ConnectX-4 100 Gb Ethernet. These tests demonstrate that the PST design and prototype implementation are sufficiently flexible to adapt to future COTS architectures and exploit the advantages of procuring cutting-edge hardware during the construction phase. By the time this article is published, the PST team will have delivered all of our design artefacts for Critical Design Review in early February 2018.
Path to CDR
Overall, the CSP Consortium has made good progress since August. The focus is to “freeze” the requirements and ICDs to support efficient progression to sub-element CDRs followed by element level CDR. The team is focused and working hard to prepare the required materials.

Report provided by the CSP consortium

Low-Frequency Aperture Array

During a 10-day installation campaign from 6th to 17th November, an international team from Australia, Italy, The Netherlands and the United Kingdom installed all remaining antennas of the AAVS1 main station, along with debugging some of the already installed antennas at the Murchison Radio-astronomy Observatory in outback Western Australia, the hosting site of the Murchison Widefield Array, MWA.

The on-site team progressed very well during the trip, being split into two sub-teams, to move forward on both deployment and on debugging. Besides the field work, updates were also implemented on the AAVS1 TPMs and processing system, located inside the correlator facility.

Figure 1. The AAVS1 station
Figure 2. The Tile Processor mapping on the antenna locations.

Figure 3. The cabling inside the Antenna Power Interface Unit: the fibre cables (blue) and the DC-power cabling (red/black).
The last few months have been a busy time for the digital signal processing (DSP) work-package inside LFAA. The installation of the 16 tile-processing modules in the MRO led by the AAVS-1 team proved to be more complex than expected with the usual teething problems that a new system brings along with it. Having manually sawn off parts of the chassis in order to fit them in the rack, 4 iTPM(s) per subrack were installed and individually tested. The final configuration is shown in Figure 4 below.

![TPMs installed at the MRO site](image)

The iTPM installed is the Sanitas-designed iTPM version 1.2, running firmware and control software that has been designed as joint effort between INAF and the Universities of Oxford and Malta. Through the Monitoring and Control Software developed, the signal integrity of each path can be recorded and used to test the stability of the chain over time and temperature. Figure 5 shows a typical output from 8 signal chains in the field.
During the cost control activities of late 2016 and first half of 2017 an action was placed on the LOW antenna. After an optimisation process and a selection process for the best possible performance and cost, an evolution of the SKALA antenna (arXiv:1512.01453v1), SKALA4 (Figure 6), was considered the best option to take forward to Critical Design Review (CDR) by an ad-hoc panel of experts tasked to undertake the performance evaluation of various antenna designs. The Antenna and LNA work package of LFAA (led by Cambridge, UK) worked on an evolution of the Log-Periodic Dipole Array antenna designed for SKA1-low. After the latest update in 2016 for improvement of the bandpass smoothness (SKALA3, arXiv:1702.05126v2), SKALA4 has been optimised to further improve on that smoothness at all scales (narrow as well as wide frequency bands), cross polarisation, sensitivity, etc. This antenna looks like a perfect match to the demanding SKA1-low scientific and technical requirements. SKALA4 has also been designed to preserve the current LFAA architecture and to be compatible with existing interfaces. The SKALA4 LNA is an evolution of the current SKALA3 LNA with minor tuning on the input matching network.
SKALA4 was considered in this selection process together with SKALA3, the MWA dipole and a Vivaldi antenna. The different candidates were measured against a set of requirements presented to the design team by the SKAO. These requirements included both functional and nonfunctional figures of merit in order to measure cost, manufacturability, maintainability, projects risks, technical risks, etc. as well as performance parameters. Following the analysis and advice from a panel of experts, the SKAO endorsed the panel recommendation of selecting SKALA4 as the best possible candidate for SKA1-low and provided a set of recommendations for its final tuning. The antenna is now being further developed mechanically (Figure 7) by the LFAA consortium to be ready for CDR and the SKA1-low production. This process has counted on the participation from several consortium partners (Cambridge, ASTRON, INAF, ICRAR, STFC, Oxford) and the SKAO.
The improved sensitivity of single station of the new SKALA4 antenna, compared with SKALA3 and the L1 requirement, is given in Figure 8.

September also saw the visit of KLAASA to Lord’s Bridge to test their own developed TPM. Tests using a drone showed that their system is capable of channelizing the bandpass into 512 different channels and beamforming each channel separately as is required by the LFAA specifications. This progress prompted the need to hold an Aperture Array Convention in Hefei, China, where future directions of signal processing architectures and contributions from KLAASA were discussed.
With guidance of Professor WU Manqing, KLAASA (Key Lab of Aperture Array and Space Application) completed CTPM (Chinese Tile Processing Module)—Pre-AAVS1 integration test at Lord’s bridge during the 21st September to 3rd October. In cooperation with Cambridge University, Dr. CAO Rui led a team of 10 successfully verifying the multi-channel digital beamforming (DBF) function of CTPM. The test culminated in a 2-day meeting reviewing results and discussing the next development steps.
CTPM features three-stacked Harmonica Structure and integrates 32 channels on the 6U board, capable of 16 dual-pol antenna signals. The polarised signals are transferred through 2 MPO connectors from tile to the receiving sub-system where CTPM performs O/E conversion, signal filtering and amplification. Further processing as AD conversion, channeliser, digital beamforming (DBF) and monitor and control are realized in the signal processing subsystem.
KLAASA developed DBF algorithm on CTPM firmware by compiling more than 100,000 lines of codes, which animates the module with polyphase filtering, channel selection, calibration and tile beamforming and station beamforming.

The testing campaign included bench testing carried out at Cavendish lab and far-field testing with SKALA-2 facility. CTPM captured data from SKALA-2 array and produced antenna patterns while the UAV hovering at array zenith at different altitude and flying cross the array. Figure 6 and 7 depict respectively the pattern of 80 m and 35 m UAV altitude. The UAV shook with wind at higher altitude and thus led to differences between test results and simulation.
CTPM captured data from 8 SKALA-2 antennas and produced antenna patterns while the UAV hovered at array zenith and flew cross the array.

Gaps in results with angle deviations are due to the inaccurate UAV positioning as single GPS signal instead of D-RTK was adopted as the positioning input. Figure 8 and 9 shows the test and calculated results of DoA (Direction of Arrival)

![Figure 8 and 9 Simulated and tested DoA results with 17.4° angle deviation from array zenith (left) and with -45.5° angle (right) (Calculated value is -45.5° while test result is -46.7°).]

The CTPM development project is part of Key Technology Development and Verification of Digital Array in SKA Low Frequency Radio Telescope Project funded by Ministry of Science and Technology (MoST) of China. CTPM is expecting its upgrading design of higher processing capability and even lower power consumption next year.

Report provided by the AADC consortium

**Mid-Frequency Aperture Array**

![Mid-Frequency Aperture Array]

**Overview**

The AAMID Consortium, working on the Mid-Frequency Aperture Array (MFAA), an Advanced Instrumentation Work Package, aims to demonstrate the feasibility, competitiveness and cost-effectiveness of MFAA technology for SKA2. The key advantage of Aperture Arrays (AAs) is the
capability of realising a very large Field of View and sensitivity, which results in an unsurpassed survey speed. Furthermore, AAs are capable of generating multiple independent FoVs, enhancing the efficiency of the system, for calibration and for multiple concurrent observations.

**Aperture Array Summit**

The SKAO and CETC-38/KLAASA organised an Aperture Array Summit in Hefei (China) in the last week of October. The summit was well attended and included a broad representation from industry, universities, the local government, AA consortium partners and the SKAO. At the Summit, progress on MFAA technology development and plans for future directions have been discussed (Figure 1).

![Figure 1. Aperture Array Summit in Hefei, China.](image)

**Progress on MFAA Front-End Design**

The University of Manchester is closely collaborating with Station de Radioastronomie de Nançay in France to test a true-time delay beamformer board (four 4:1 beamformer chips on each beamformer PCB). The board is currently being integrated into a beamformer rack (Figure 2) that can handle a 64-elements dual polarised tile.

![Figure 2. Beamformer rack.](image)
CETC-38/KLAASA has developed a next iteration of their Vivaldi antenna tile for MFAA. The tile has $9 \times 8 \times 2 = 144$ antenna elements operating in the $300 – 1500$ MHz frequency range and uses extrusion techniques to reduce the costs.

November has been a busy month for the Maltese team, who have been focused on the arrival of more than $100m^2$ of mid-frequency antennas to be assembled in the field and tested. Figure 4 shows the print-screen of the antennas and the sheets of antennas being printed.

The assembly of the antennas onto a polystyrene base is shown in Figure 5. This is done to provide a mechanical support for the antenna array, which is then placed onto a chicken-wire ground plane and assembled on top of metallic frame.
The assembly of the structure is shown in Figure 6. The entire array is then placed within a dome structure to protect the array from wind and rain (Figure 7). The team then carried out electromagnetic simulations on the metallic frame and the dome structure to understand the effect of these support structures on the array’s electromagnetic performance.
Throughout December, the team will be working on taking beam measurements of the array using a UAV system, coupled with GPS, to determine the array’s exact performance and compare it with the electromagnetic simulations.

Station de Radioastronomie de Nançay has assembled and tested several new integrated custom IC’s and circuit board for MFAA. Figure 8 show a feed module of a Vivaldi antenna using two ASIC’s (an LNA and an active balun filter) of which 270 pieces are now available for integration. Figure 10 shows a Vivaldi array of ASTRON with the feed modules from Nancay. Also, 20 BeamFormer boards have been assembled and ready for testing. These board use the latest true-time delay custom integrated circuits.

Figure 8 (left). Feed module with MFAA ASIC’s by Nancay. Figure 9(right). BeamFormer board containing 4 custom true time delay chips.

Figure 10. Integrated feed module and Vivaldi array.

Report provided by the AAMID consortium
Signal and Data Transport

SaDT is responsible for the transmission of SKA data and the provision of timing, across two telescope-wide networks.

The Signal and Data Transport (SADT) Consortium has been focussing on completing and internally reviewing the documentation that describes the detailed design of the SKA networks. This documentation will be submitted for Critical Design Review (CDR) early in the New Year. The major milestone that we achieved over the last period was completion of the technical down-select of the frequency distribution sub-system for the telescope. This downselect was conducted by an independent panel of experts, and we would like to thank Dr. Bill Shillue, Dr Miho Fujieda, Dr Sven-Christian Ebenhag for their extremely thorough review of the Body of Evidence material submitted by the applicants. The panel’s conclusion was a recommendation for the adoption of the solution developed by Tsinghua University for the SKA-low telescope; and for the adoption of the solution developed by the University of Western Australia for the SKA-mid telescope. These recommendations were adopted by the Consortium and endorsed by the SKAO.

The Board of the SKA’s SADT consortium had also selected the synchronisation distribution system designs to be used for both SKA telescopes, endorsing the decision of a panel of leading experts in the field of time synchronisation. You can read the press release here.

Report provided by the SaDT consortium
During this quarter significant progression of the design packages was achieved. A series of one-day workshops were undertaken between CSIRO and Aurecon to progress the infrastructure design towards CDR in mid-2018. A first stage of this work towards CDR is an internal Infrastructure Australia “design walkthrough” in December 2017, where the team will spend three days going through all aspects of the design works, with some additional review provided by Martin Austin, Adriaan Schutte and Tracy Cheetham.

The recent workshops address many of the design elements, including the central processing facility (CPF) design and location, HV and LV layouts around the site, and fire safety compliance. Significant progress was specifically made in the areas of flood studies for important input to infrastructure location decisions as well as in the CPF’s design configuration including the building floor plans and RFI shielding requirements. In terms of shielding, appropriate advances were made in design options to counter any potential RFI implications caused by power cabling to the building and an initial theoretical report modelling this scenario was also drafted. Assessment of this draft is presently underway to assist in identifying the best approach. In addition, 'RFI shielding requirements' versus 'fibre cabling length' cost studies have been completed providing a sense of the most practical optimum range for the CPF location from the SKA1-low core.

In addition, other key elements of the CPF design. For the maser area of the building a vibration model was created to inform the structural design package. Critical cooling and power solutions were developed, along with a reliability study of these components.

Remote Processing Facility (RPF) design work has also been concurrently underway, focusing on optimising floor layout, cooling solutions and further work on remote power options for the RPFs.
CSIRO and Aurecon also met most recently at CSIRO in Sydney to discuss the HV and LV electrical layouts around the site as well as looking at maximising the common use of trenches for power and fibre to minimise overall project cost. INAU have developed a model for optimising trenching which has the potential to provide significant benefit to the project. Outcomes of this discussion were positive with identified actions that will address the final design to be presented for upcoming workshops. Additional workshops have been held on safety in design and asset protection requirements and basis, including fire suppression.

Development of access road and track details also continued during this period, looking at several options for the primary access track. In addition, significant work has been completed on ground preparation requirements for the Low core with overlays on the INAU digital platform. INAU has also been busy working with the Australian Government (DIIS) on providing input to options around the location of the temporary construction camp, power station etc. INAU has also worked towards having all ICDs including LFAA, SaDT, CSP and TM signed off. Agreement has been reached with all the interfacing consortia with two documents signed while the remaining two will be put through signature in the near future by SKAO. At this technical phase of the project, this has required many communications between the various consortia and the SKAO to allow prompt resolution of outstanding questions.

Whilst progress towards CDR continues, INAU is also considering the path from CDR, through System CDR to tender document creation, procurement and construction.

Finally, the calendar year ends, INAU will hold a design walkthrough to be held at the Aurecon offices in Perth from 11-13 December 2017. This workshop is intended to be a final check on the design work, progressing towards CDR in early 2018. In particular, it will provide confirmation of suitability of design, through Level 2 compliance with requirements, and integration of appropriate ECPs.

Report provided by the Infrastructure Australia consortium
The INFRA SA Consortium is responsible for the design of the Infrastructure & Power Sub-elements for SKA1-mid in South Africa. This includes Access (roads, civil works), Buildings, Communication, Site Monitoring, Security, Antenna Foundations, Vehicles, Power, Water and Sanitation.

**SYSTEM ENGINEERING**

The Consortium has updated the Level 2 requirements based on the Level 1 Rev 11 requirements. A few partial/non-compliant requirements are being discussed with the SKAO.

Good progress has been made on all the Level 3 requirements for each sub-element as well as internal interface definition.

There has also been good progress on updates to the external Interface Control Documents, with only the TM/INFRA ICD remaining the least mature.

The Consortium has submitted an ECP to the SKAO to update the Stage 2 Milestones and Deliverables.

**POWER**

The SKAO Configuration Board has approved the ECP which considers the trade-off in life cycle costs between providing stand-alone PV plants as opposed to overhead power distribution lines to the last 5 dishes in each spiral arm (design baseline).

A PV design engineer and RFI specialist have been appointed by INFRA SA to undertake the detailed design of the PV plants.

Aurecon South Africa has been undertaking further Digsilent modelling to look at what upgrades are required to the existing 33kV overhead power line. Further discussions have also been held with the South African power utility, Eskom regarding the Notified Maximum Demand which can be made available to the SKA at the Karoo substation.

Further work is underway on the structuring loading of the overhead power lines and the first draft of the RAM/ILS modelling for the power system has been submitted for review.
SKA-mid ANTENNA FOUNDATION PROTOTYPE

The SKA-mid antenna foundation prototype stability testing was undertaken on the 2nd of August and the 20th of September 2017. The measured tilt from the first test ranged from 2.473 to 2.681 arcsec while the results from the second test ranged from 2.063 to 2.269 arcsec, both below the 10.4 arcsec specified for the operational conditions. It should however be noted that the governing case is the lateral stiffness, not tilt. For the maximum applied load (calculated for both MeerKAT and SKA antennas) the displacement on MeerKAT antennas was in the order of 11 arcsec, while for the SKA prototype foundation it is 3.919 arcsec when subjected to a 25ton load (refer figure below).

Photo 1: Antenna Prototype Testing
The detailed design of the antenna foundations has now been finalised and an internal review date will be confirmed in due course.

UPGRADE TO CENTRAL PROCESSING AND POWER FACILITY

A preliminary design review has taken place on the proposed solutions to the Central Processing Facility and Power Facility. Work is now progressing on the detailed design of the upgrades required to both facilities.

SKA1-mid PHYSICAL CONFIGURATION

The Consortium has submitted proposed changes to the SKA1-mid physical configuration following interaction with the power line route surveyor and landowners in the spiral arms. The Consortium will submit an ECP to the CCB for approval.

SITE CHARACTERISATION STUDIES

The geotechnical contractor has completed the Phase 2 drilling on site as an input to the detailed design of the antenna foundations. The geo-hydrological contractor has been on site determining yield values from boreholes as an input to the geo-hydrological modelling and Water & Sanitation sub-element.
EMC/EMI CONTROL PLANS
The Consortium has developed an overarching EMC/EMI Control Plan which has been reviewed and approved by the SKAO.

HEALTH & SAFETY HAZARD ANALYSIS
Work has commenced on a detailed hazard analyses for the infrastructure and power products. This work will be discussed with the SKAO to ensure compliance to the SKA requirements.

COST PLAN UPDATES
The Consortium submitted its updated Cost Plan to the SKAO on the 2 October 2017. Capital costs have decreased as a result of the implementation of the ECP from the Cost Control Project on the introduction of stand-alone PV plants for the last 5 dishes on each arm.

DETAILED DESIGN WALKTHROUGH
The Consortium will be undertaking a detailed design walkthrough from the 4-8 December 2017 in South Africa. Detailed design drawings and reports will be reviewed, general progress assessed as well as possible gaps identified in the design which still need to be addressed.

E.C. HORIZON 2020 SUBMISSION AND CDR SUBMISSION
The Consortium will be submitting its detailed design packs to the EC Horizon 2020 at the end of January 2018 (funding was received for Stage 2 from the EC Horizon 2020). A meeting will be held in Brussels on the 14th March 2018 to assess the completeness of deliverables.

The Consortium will be submitting its Critical Design Review pack to the SKAO at the end of April 2018. This will be followed by CDR in June/July 2018.

Report provided by the Infrastructure South Africa consortium
Wide Band Single Pixel Feeds

The Wide Band SPF consortium is in preparation for PDR for early 2019. Prototype component developments including the Band A prototype feed is ready for assembly. Band B, as described in the August eNews still has issues on one polarisation which requires resolution. We have opened discussion with NRC in Canada for the possibility of testing Band B on the DVA2 dish. Receiver work led by France is tracking SKADC Band 5 with a well-founded concept. The French team are also reviewing the latest ADC developments.

Having concluded the detailed design review (DDR) in September, the band 1 team is currently in final process to complete their qualification model. This update can be found in the Dish consortium report.

The consortium also is considering a revised work programme following PDR that will continue in 2018 and 2019. The programme will include revised deliverables which also includes a new consortium name. We are negotiating to involve new members that will work on cooling concepts and feed design.

Report provided by the WBSPF consortium

Assembly, Integration & Verification

Introduction
The Assembly, Integration and Verification (AIV) work package represents one of nine key elements that will make up the SKA1 Telescope. Whereas the other eight elements are tasked with designing key components of the SKA1 Telescope, the AIV element is tasked to perform all
necessary planning to integrate these key components into a telescope system that meets the engineering (Level-1) requirements.

The SKA1 Telescope will consist of SKA1-mid, which will be located in South Africa, and SKA1-low, which will be located in Australia. SKA1-mid will consist out of approximately 133 SKA1-mid Dishes, plus a further 64 MeerKAT Precursor Dishes. The AIV work package therefore also includes the planning for integrating the MeerKAT Precursor into the SKA1-mid Telescope. SKA1-low will consist out of 512 SKA1-low Stations, which will include a total of approximately 125,000 individual low-frequency antennas.

The member organisations of the AIV Consortium are SKA SA, CSIRO and ASTRON, with SKA SA leading the consortium. All three member organisations have significant experience in building radio telescopes, and therefore have a vast amount of integration and verification know-how that is benefiting the AIV work package.

**SKA System Pre-CDR**

During November 2017 the SKA Office conducted a System Pre-CDR (Critical Design Review) with the objectives to:

- Re-focus the attention to the system
- Prepare feedback for consortia and inform their Element
- Inform the construction planning
- Measure the progress on System CDR preparation (system readiness level).

The AIV Consortium provided the following documents for the System Pre-CDR:

- Roll-Out Plans for SKA1-low and SKA1-mid (Revision 5A)
- Integration & Verification Plans for SKA1-low and SKA1-mid (Revision 1)
- Verification Requirements (Revision 2)
- Product Hand-Over Process
- MeerKAT Integration Plan and MeerKAT ICDs
- System Integration Test Facility (co-authored with INFRA-AU and INFRA-SA)
- AIV Safety Management Plan
- EMC Control Plan for AIV

This set of documents is a comprehensive encapsulation of the AIV Consortium’s work during pre-construction. It includes large and detailed documents that have been developed in close consultation with subject matter experts from other consortia, and documents which are used by the SKA Office to assist with their overall construction planning.

**Updates to the Roll-Out Plans**

The Roll-Out Plans (currently at draft Revision 5A) have had a significant make-over and include the following updates:

- Inclusion of actions from the Construction Schedule workshop that the SKA Office held in October 2017
OAR comments received from the SKA Office on Revision 5
Description of the SAFe agile framework for developing and rolling-out software
Configuration roll-out of Dishes/Stations
Functionality provided by TM, SDP, CSP and SaDT
Functional allocation to roll-out milestones
Deployment Baseline
Refined definition of “Array Releases”

The configuration roll-out identifies the Dishes/Stations that are included in each of the four Array Assemblies. For example, Figure 1 shows the array configuration of Array Assembly 1 for SKA1-mid and SKA1-low.

ECP-170050 has been submitted to bring the Roll-Out Plans to Revision 6.

Integration & Verification Plans
Revision 1 of the Integration & Verification Plans for both SKA1-mid and SKA1-low have been released. These documents describe the integration and verification activities for the two telescopes in detail. They cover:

- The conduct of the AIV Contractors, roles and responsibilities, strategies, tools and processes for Integration and Verification.
- The identification of individual test cases that will be performed on each Array Assembly.

It is this second facet, the identification of individual test cases, along with the hierarchical nature of AIV planning, which provides an excellent basis for bottom-up analysis of AIV activities:

- Inputs and dependencies for commencement of each test have been defined.
- Resources have been assigned to each test case to develop an overall picture for AIV resourcing.
- Time has been assigned to each test case to develop an overall AIV schedule (Gantt chart).

Figure 2 shows an example schematic from the SKA1-low Integration and Verification Plan showing the relationships between low-level test cases for Array Assembly 1. As can be seen, the
dependencies are clearly identified. By assigning a duration to each test case a Gantt chart can be created for this section.

Since the AIV Consortium is looking at system-level integration and verification activities, the schedule derived from the Integration and Verification Plan must be reconciled with the overall SKA Project Construction Schedule. Working closely with the Project Management group within the SKA Office and with project managers from other consortia, the AIV Consortium has been able to discuss and negotiate product delivery schedules that align closely with the planned integration.

![Example schematic from the SKA1-low Integration and Verification Plan.](image)

**Figure 2:**

**Challenges**

Experience with other radio telescopes has consistently shown that the roll-out activities and AIV work scope is often under-estimated, even at component level, and often causes delays in deployment, due to re-engineering and retrofitting of components. This may significantly increase the total cost of the system.

Many issues that are discovered during “downstream” integration and verification are the result of “upstream” neglect. Early in the project, during the design stage, science requirements need to be accurately translated to Element-level requirements, and interfaces between products need to be accurately defined.

*Report provided by the AIV consortium*
In the past few months, the Dish Consortium has completed the management hand over from CSIRO, Australia to JLRAT, China. The new Dish Consortium Lead, Wang Feng (JLRAT), and the Management Forum are now administering and serving the Dish Consortium towards its milestones.

While this path is conceivably rough, after months of coordination the Dish schedule was subsequently baselined on the 24th October and an ECP was issued to update the Dish Consortium Milestones. Currently the schedule is being updated and evaluated in real time. No schedule slip has occurred to the critical path since this ECP.

In fact, the progress in the Dish elements is promising and inspiring.

The Local Monitoring and Control (LMC) has undergone a period of change in organisation since August 2017 and is now led by INAF. Meanwhile, the activities have been focused on the software development for the Dish and, in particular, in the finalisation of the internal interfaces documents and test. An important step has been the “early integration test”, of which the integration with the Single Pixel Feed (SPF) and Receiver systems have been successfully concluded with identified actions. This exercise should be significant risk mitigation for future Dish system integration. The Test Readiness Review (TRR) for the LMC is planned in December 2017, and the team is fully involved in the preparation of the documents.

Having concluded the detailed design review (DDR) in September, the band 1 team is currently in final process to complete their qualification model. The band 1 feed is completely at ambient temperature and at the heart of their performance is a pair of very impressive Low Noise Amplifiers (LNA) designed by Low Noise Factory in Sweden as shown below. The following pictures show the current band 1 design and also the results of most recent measurement in preparation for their TRR. This review will be the signal commencement of their formal qualification test phase. Preparations are underway for the shipment of the Band 1 feed to South Africa for RFI qualification testing and follow up test on MeerKAT antenna.
The Band 2 SPF TRR has been successfully concluded and approved. SPF Band 2 and services team of EMSS Antennas have almost accomplished the setup of the qualification testing, followed by measurements of receiver noise temperature and resulting telescope receiving sensitivity (for ideal reflectors) as a function of zenith angle and frequency. The average sensitivity over frequency and tipping angle from zenith up to 30° above the horizon is above 10.9 m$^2$/K for both polarisations, well above the 7.1 m$^2$/K specification. Some other tests such as RFI testing and water spray testing are also in process for the preparation of the first critical design review (CDR) planned on 6th - 7th December in Stellenbosch, South Africa.
The Band 345 team is in process to refine their preliminary design. Since achieving a partial pass of their preliminary design review (PDR) in July, the team has been continuing with investigations of the vacuum and cold plumbing design. Additional lab tests have been performed to mitigate the key risks that were highlighted at the PDR and all documents have been updated, waiting for the delta PDR in January 2018.

![Figure 3. Band 345 turbo pump connections](image1)

![Figure 4. Band 345 turbo pump testing](image2)

The Band 123 Receiver is closing out the Delta DDR. One major issue is holding up the closure of this baseline, namely the loss in array coherence when changing to Band 3. This issue is being discussed between the consortium and the SKAO to find a resolution while the team is continuing with the construction of the Qualification Model. The Band 5 Receiver is tied to the Band 5 SPF development. All documents are completed and are waiting for the delta PDR. Meanwhile, Dish Fibre Network (DFN) is now in the process of ordering the parts that will be needed for the pre-qualification and later installation on the SKA-MPI.

The Dish Structure (DS) team has been concentrating on further detail design of the two SKA Dish Prototypes. Manufacturing of major components in China, Germany and Italy has been starting and is progressing very well. The Dish Structure team has established a successful cooperation between the members from China (JLRAT), Germany (MTM), Italy (SAM) and South Africa (ITC & SKA SA office). This proven cooperation was underlined by the Dish Structure Group Ceremony held in Mainz Germany in the summer of 2017. The SKA-P Dish Structure ceremony in China will be held in the first quarter of 2018.
The feed indexer has been further improved with more delicate layout, leading to the major progress on cables and the hoses routing on the feed indexer. Preparation of the Feed Indexer TRR on 30th November is almost accomplished, of which the outcomes will conduct the FAT test in Italy and China. The first SKA-P Feed Indexer will be ready for air-shipment to the integration Center in China before Christmas.

The servo designs of cabinets, actuators, servo sensors, encoder I/O units are about to be finalised. The azimuth driving system, encoder units, most of the sensors and all cables have been delivered to the servo integration facility in Germany. Most of the DS EMI/RFI testing will be conducted in MT Mechatronics and the Max Planck Institute in Bonn. The First concepts for EMI/RFI testing of the complete system have been discussed and the DS EMI TRR is planned for early next year.
The intensive manufacturing is in progress in China. The total 132 main reflector panels for two dishes have rolled off the production line. For now, 67 percent of these high-accuracy panels have been measured, showing 100 percent of acceptability. The sub-reflector moulds have been accomplished and the sub-reflector panels are being fabricated, of which the central segment shows very promising surface accuracy. The main structures of pedestal have undergone the heat treatment, waiting for the final machining, painting and assembly.
In September, with the financial support and manpower resource from CETC54, a filming team from SKAO came to JLRAT to record the manufacture of SKA dish prototype. After 5 days of effort, 40 hours of filming and 1000 kilometres of travelling, an amazing 2’30” teaser film has been produced. The film will be available shortly on the SKA YouTube channel. Stay tuned!
With several TRRs about to come and fully prepared element design reviews, the Dish Consortium is heading towards the hardware tests and the Dish CDR steadily. Although the unexpected difficulties can actually be foreseen, there are more and more hardware, testing and results emerging from the endeavours, which gives the Dish Consortium confidence and inspiration.

Report provided by the DISH consortium

Science Data Processor

M19 - All things Architecture

The next significant milestone for the SDP Consortium is M19 on the 30th November. M19 is a lightweight review of the current state of the SDP software architecture and forms a checkpoint with the SKAO to present the current state of the architecture and progress towards Critical Design Review (CDR).

All relevant SDP SEI style views and other supporting documentation for functionally close blocks of architecture will be reviewed. The goal is to present the information in sufficient detail to facilitate immediate use by a knowledgeable audience member.

In preparation for this review, a Stakeholders Overview will take place. The required participants will include key members of the SDP architectural design team and knowledgeable stakeholders from SKAO. This review is to ensure that the high-level architecture documentation, for the purposes of providing an introductory, high-level explanation of the design, is sufficiently complete. In preparation for this overview, key members of the SDP Architecture design team recently selected a collection of views for review and this information has been distributed to the SKAO.

Comments and or suggestions made during the Stakeholder Overview and the official M19 review will guide further architectural priorities ahead of M20 (Element pre-CDR).
Figure 1 - collection of SDP Architecture views ready for review with SKAO

SC17 – Denver, Colorado
SuperComputing 2017 (SC17) was held in Denver, Colorado, during mid-November. It is the last such conference to be held before the SDP CDR. The keynote presentation of the conference was given by the SKA Director General, Professor Phil Diamond, and SKA Regional Centre and SDP Project Scientist, Dr Rosie Bolton. They explained the background and relevance of radio astronomy, the aspirations and developments of the SKA and in particular the computing challenges it faces.

The timing of the conference and the topic of the keynote was ideal as the SKA consortia CDRs begin in the coming months and the organisation gears up for construction. The conference provided opportunities for attending SDP members to test industry views on SKA, such as the desire to use Scaled Agile approaches for software construction (especially SAFe), gain insight into vendor roadmaps and where feasible pursue collaborative work on applicable prototyping activities.

The conference also provided an opportunity for SDP Consortium members to meet and get feedback from leading industry experts in Birds of a Feather (BOF) sessions related to SKA computing, and contribute to workshops on topics of direct interest to the community.

**SDP Construction Planning**

Since the last eNews submission significant progress has been made on the SDP Construction Plan and its supporting documents. This progress consists of:

- Completion of the Roll-out Plan that encapsulates the schedule for Construction.
- Formulation of the framework and direction of the Construction Plan to ensure alignment with the SAFe framework.
Completion of an initial high level Construction Plan based on the framework described above.

Completion of an initial Work Breakdown Structure (WBS) in accordance with SAFe ideologies. The Product Breakdown Structure is not affected at this stage.

Delivery of a webcast to SDP Consortium members to present the current status and key points of the Construction Plan including the Roll-out roadmap (refer to figure below). This was well-received with additional discussion points raised for further investigation and consideration.

Figure 2 – SDP Construction Schedule and Roadmap. The SDP Commissioning needs to be in-step with other aspects of the telescope which is provided by an Assembly Integration and Verification (AIV) system.

Significant progress has been made, but the Construction Plan remains a work in progress. The final version will be ready for April 2018 ahead of the SKA System Review.

**SIP – SDP Integration Prototype**

The SDP Integration Prototype (SIP) is an active project to produce a lightweight horizontal prototype for the SDP system, providing a verification of the SDP architecture, and a test of all major internal and external SDP interfaces. SIP is under active development by a small distributed Agile team, working closely with the SDP architecture design group and the SDP hardware prototype, an OpenStack software-defined bare metal private cloud.

To take a practical approach towards delivering an initial working system, we have chosen to develop SDP components as a set of independent deployable (and testable) microservices, which make use of container orchestration (currently utilising Docker Swarm). These provide a modular, highly available, and horizontally scalable deployment of the SDP domain specific and platform services. In turn, this set of services support the core functions of the SDP, namely, the real-time and batch science pipeline workflows, and data ingest from Central Signal Processor (CSP).
The SIP team is currently at work developing a minimal set of services and a select number of science pipelines and data ingest workflows with the aim of deploying a system prototype on the SDP test hardware system towards the beginning of 2018. To this aim, we are currently focused on critical services such as the SDP execution control, logging and monitoring (including the Tango interfaces with the Telescope Manager - TM), and prototyping of science workflows which will provide a fairly complete test of the system: visibility ingest from CSP, and two different imaging and calibration pipelines. We then plan to then use the lessons learnt from this first working system to iterate on the design, and develop the prototype further.

OpenStack

Housed at Cambridge University, the ALaSKA SDP Performance Prototype Platform has been quick to take advantage of the Big Data Cooperation Agreement signed over the summer with CERN. (https://skatelescope.org/news/ska-signs-big-data-cooperation-agreement-cern/). ALaSKA uses OpenStack to deliver a flexible but performant bare metal compute environment to enable SKA project scientists to experiment with and explore software technologies and make objective performance comparisons.

The ALaSKA system uses several OpenStack technologies that are already in full-scale production at CERN. Conversely, to develop ALaSKA’s capability some advanced technologies have been developed by the StackHPC team managing ALaSKA. The CERN team have identified several areas where ALaSKA’s experience can inform the ongoing development of CERN’s compute infrastructure.
An informal collaboration has already borne fruit, and that collaboration was jointly presented by Belmiro Moreira from CERN and Stig Telfer from StackHPC at the recent OpenStack summit in Sydney (https://www.openstack.org/videos/sydney-2017/future-science-on-future-openstack-devel).

Figure 4: View of code submits into OpenStack coming largely from work within the SDP Performance Platform Prototype work.
Figure 5: Cover of the latest edition of the OpenStack Cloud Computing for Scientific Workloads book.

Report provided by the SDP consortium
Telescope Manager

Overview:
As we are marching towards our CDR submission milestone (Jan 2018), we are busy getting ready the design documentation. Three of the five important milestones on this path have been already accepted by the SKAO; for other milestones the design documentation has been either reviewed or being reviewed. One milestone which consists of a number of reports is in progress, though delayed a bit, but nevertheless getting ready for the submission ahead of the Review Readiness Notice (RRN) aimed to be completed by the mid of December. In the meantime, one more version of the TM Cost estimate was submitted, ahead of the November SKA Board meeting. Similarly, Requirements Engineering and External Interfaces have seen good progress over the last few months. The summary of the work taken up since the last reporting, key events and accomplishments are as follows:

Revised TM Cost Estimates:
The revised cost estimates for TM were submitted in October, as inputs for the November 2017 SKA Board meeting, with a reduction of ~ 5 M Euros, bringing down the TM cost within the TM cost cap (i.e. 38.8 M Euro)! However, during the SAFe Construction Planning Workshop it was advised to increase the effort for Product Owner role, due to which the TM Cost has again increased somewhat. Further, TM plans to submit the revised cost model ahead of the RRN, with an increase in the cost due to addition of the cost of Authentication and Authorisation and Audit (AAA) functionality, now included under the scope of TM.

Progress in Architecture and Design:
- The Milestone M30, which deals with all the TM and AAA Requirements, has been accepted and the last few outstanding observations from the review are being addressed.
- Similarly, milestone M31, which deals with the architecture data pack for the “TM Services” software module, has also been accepted, and revisions required to address observations received against it are in progress.
• The architecture data pack for the Telescope Monitor and Control (TMC) software module and the Design Information Pack for the GUI module was submitted against milestone M32, and the same has been accepted subsequently.

• As part of milestone M33, the architecture data pack for Observation Science Operations (OSO) and AAA has been submitted recently. The OSO part of it was reviewed with no major issues. The AAA data pack is being reviewed currently.

• The last milestone, M34, against which we have to submit a number of reports has been progressing well, and we plan to complete significant submission ahead of the RRN scheduled around mid December.

Prototyping:

The GUI prototyping work has been completed. The LINFRA prototyping work has been started, but the next level of prototyping requires procurement of new hardware which is in progress.

ADASS Conference and ALMA Visit:

A team of five people (3 from GMRT/NCRA India and 2 from INAF, Italy) from the TM consortium attended ADASS Conference in Oct in Santiago, Chile in early November. Following the conference, the team visited ALMA Operations Support Facility (in San Pedro de Atacama, Chile) and Santiago Central Office (SCO) to get insights into ALMA Architecture and Operations. They were also joined by Nick Rees, the SKA Head of Computing and Software. The purpose of the visit was to understand ALMA software architecture and User Interfaces in operations. The team had useful interactions with the operators and system engineers during their visit, and a detailed report on the visit is being prepared.

ICALEPCS Conference:

The TM Consortium was well represented in the latest ICALEPCS Conference, held from the 8th to 13th of October. Following are the details of the papers and presentations made by the members of the TM Consortium at the conference.

• A joint team of TCS Research and Innovation (TCS R&I) — Pune, National Centre for Radio Astrophysics (NCRA) — Pune and SKA South Africa — Cape Town published a paper on "Control System Simulation Using DSEE High-Level Instrument Interface and Behavioural Description". The paper describes the details of the simulation library developed by the MeerKAT team by the name TANGO Sim-Lib. It explains how it can be used in conjunction with the Domain Specific Engineering Environment (DSEE) developed by TCS R&I (with inputs from NCRA-TIFR) to achieve the simulation needs of a telescope such as the SKA.

• Also, TCS R&I presented the DSEE work at the TANGO collaboration meeting, held as an associated workshop coupled with the ICALEPCS conference. The focus of the presentation was to discuss the potential benefits of extending the TANGO framework with a supporting DSEE which would enable Model Driven Development of Control Systems using TANGO. It highlighted the DSEE that was already developed as part of the SKA India team and how it can be taken forward for TANGO through NCRA's contribution to the TANGO community. The presentation was well-received by the TANGO community.
The TM.LMC Team of INAF — Italy presented posters about TM SERVICES and TM Fault Management Using AI and the TM.GUI Team (from INAF) made a presentation about Usability for the Control Room UI.

Report provided by the TM consortium

News From Precursor & Pathfinder Facilities

ASKAP Report

ASKAP’s “particularly incredible” Image

CSIRO’s Australian SKA Pathfinder (ASKAP) telescope was in the media spotlight this week with the release by ANU Professor, Naomi McClure-Griffiths, of this ground-breaking image of the Small Magellanic Cloud (SMC).

Image caption: Atomic hydrogen gas in the Small Magellanic Cloud as imaged with CSIRO’s Australian Square Kilometre Array Pathfinder (ASKAP). The Small Magellanic Cloud, only 200,000 light years away, is one of our nearest galactic neighbours and visible to the naked eye in the Southern sky. Credit: ANU & CSIRO

SKAO eNewsletter December 2017
www.skatelescope.org
In her Twitter feed, Naomi remarked that it’s particularly incredible that this ASKAP image of the SMC is a single field of view! The last time the SMC was imaged in HI it took 320 pointings of the Australian Telescope Compact Array.

The Small Magellanic Cloud, which is a tiny fraction of the size and mass of the Milky Way, is one of our nearest galactic neighbours and visible to the naked eye in the southern sky. Thus the significance of this image to astronomers but also to the general public. We can all look up and see the stars from this dwarf galaxy and now have a detailed image that reveals its hydrogen make-up.

The new image reveals more gas around the edges of the galaxy and these features are more than three times smaller than we were able to see before. This is enabling examination of the detailed interaction of the SMC and its neighbouring galaxies.

The image was taken using 16 of ASKAP’s 36 dish antennas and is being described as a teaser for what’s to come when the full array comes on-line next year.

The bad news however according to Naomi, is that the outlook for this dwarf galaxy isn’t great - it’s likely to be gobbled up by the Milky Way.

**H’array for ASKAP**

The pop of a champagne cork isn’t a noise that’s likely to cause any radio frequency interference but it’s nevertheless rarely heard on site at CSIRO’s Murchison Radio astronomy Observatory (MRO).

But on 21 November, the Observatory team turned up the gas on the barbie and got together to celebrate the installation of the 36th and final phased array feed (PAF) receiver on the Australian SKA Pathfinder (ASKAP) telescope!

This milestone marks the completion of the installation of ADE MKII receivers for ASKAP-36.
“As usual it was a real team effort. There was something special about being able to sit there at the antenna after the final PAF went up. The weather was unbelievably nice to us and although the sun was a factor, the breeze kept the flies away (mostly)!” said Brett Hiscock, MRO Site Leader.
ASKAP Director Ant Schinckel, congratulated the team on this milestone achievement.

He thanked the team for their hard work and said these are the finishing touches for the mechanical construction of ASKAP, with the final digital systems expected early next year and then the ramp through software releases soon to follow – allowing full operation of the 36 antenna array.
CSIRO will also be shipping a PAF to the Jodrell Bank Observatory, for installation in the Lovell Telescope, after having delivered a PAF to the Max Planck Institute for Radio Astronomy, for the Effelsberg radio telescope, in 2016.

**Astronomical excursion for the Students from the Pia Wajarri School**

As part of the Indigenous Land Use Agreement (ILUA) between the Australian Government and the Wajarri Yamaji - traditional Owners of the land on which the Murchison Radio astronomy Observatory (MRO) is located - CSIRO's Rob Hollow, Dr Shi Dai and Dr Zoe Taylor, took an annual trip to *Pia Wajarri Remote Community School*; and travelled with the students and teachers to the MRO.

Shi, a young astronomer, talked to the students about his career in astronomy and about how stars and galaxies form in the Universe.

Zoe talked about why she’s interested in software engineering and inspired the students talking about her work on the Australian SKA Pathfinder telescope. Zoe also introduced coding to the students with Spheros (the programmable robot).

Zoe and Rob used the Sphero robots to demonstrate coding and showed the students how to write their own simple programs. But the fun really began when Rob brought out the alka-seltzer water rockets and set up a challenge to see whose could fly the furthest.

Out at the MRO, the students and teachers got up close to ASKAP and learnt about how the dishes are operated and saw the many different directions they can point to in the sky. Rob managed to squeeze in a scale exercise, asking the students to estimate the size of the dishes.
At the control building, CSIRO’s James Hannah was working on some of the cool and colourful electronics boards and gave the young locals a close-up look at these high-tech electronics.

The party headed back to Pia via the MWA and also saw the AAVS1 test array, where they heard all about the world’s biggest telescope, the Square Kilometre Array which will be built right there in their beautiful ‘backyard’.

Report provided by Annabelle Young, CSIRO

MeerKAT Report

SKA SA finds a new home under SARAO

The Minister of Science and Technology of South Africa, the Honourable Naledi Pandor, has announced the simultaneous withdrawal of the Hartebeesthoek Radio Astronomy Observatory (HartRAO) as a National Research Facility and the declaration of the South African Radio
Astronomy Observatory (SARAO) as a National Research Facility under the National Research Foundation of South Africa (NRF).

Dr Rob Adam is the Managing Director of SARAO. SARAO will incorporate HartRAO and all instruments currently operated by Square Kilometre Array South Africa (SKA SA), including the MeerKAT, the Karoo Array Telescope (KAT-7), and the AVN as well as the associated human capital development and commercialisation endeavours. SARAO will operate as a National Research Facility within the NRF and will be responsible for carrying out South Africa’s radio astronomy and space geodesy research and construction programmes.

64 MeerKAT antennas standing in the Karoo

On 18 October 2017 the last of the 64 MeerKAT dishes was lifted onto its pedestal, a major milestone for Square Kilometre Array South Africa. The next key milestone for MeerKAT will be the integration of 32 antennas using the SKA Reconfigurable Application Board (SKARAB) correlator, which will allow for 32-dish dual polarisation observations. This will place the project well on its way to successfully meet the scheduled deadline of having all 64 antennas integrated by the end March 2018.
**MeerKAT makes its debut scientific contribution on an international collaboration and major discovery.**

An unprecedented international collaboration of telescopes has led to the first direct detection of gravitational waves – ripples in space and time – in conjunction with electro-magnetic radiation from the spectacular collision of two neutron stars. The discovery marks the first time that a cosmic event has been viewed in both gravitational waves and electromagnetic radiation (light, radio waves and x-rays).

The discovery was made using the U.S.-based Laser Interferometer Gravitational-Wave Observatory (LIGO); the Europe-based Virgo detector; and some 70 observatories on the ground and in space observing the event at their representative wavelengths. Square Kilometre Array South Africa’s new MeerKAT telescope, still under construction, contributed by observing the location of the astronomical location on three separate days between 26 August and 17 September 2017. The sensitive MeerKAT observations indicate that on those days the source was very faint, no brighter than 60 micro-Janskys at a frequency of 1.3 gigahertz. The Southern African Large Telescope (SALT) obtained a spectrum of the light from the collision.

The LIGO-Virgo results were published in the journal *Physical Review Letters* on the 16th of October 2017 and a separate paper published on the same day in *The Astrophysical Journal Letters* includes the results obtained by MeerKAT.
MeerKAT construction recognised by industry at 2017 Logistics Achiever Awards

The MeerKAT radio telescope was recognised by the construction industry on the 7th of November 2017, when it was presented with a Special Platinum Award. The awards aim to recognise professionalism and excellence in the effective application of strategic, tactical, and operational logistics and supply chain management principles, concepts and practices in Southern Africa; to encourage all companies and organisations in Southern Africa to review, evaluate and upgrade their current logistics and supply chain management practices; and to create a greater awareness and understanding of the value of effective logistics and supply chain management.
SARAO receives ISO 9001 certification

ISO 9001 is the international standard that specifies requirements for a quality management system. The Bureau Veritas Certification Holding SAS – UK Branch has certified that the Management System of SARAO has been audited and found to be in accordance with the requirements of the management system standards.

Report provided by SARAO
MWA Report

MWA Status

Phase II expansion complete!
The Murchison Widefield Array achieved a major milestone in October with the completion of the "Phase II" expansion - the first major upgrade of the MWA since operations commenced in mid-2013. The upgrade consisted of installing 128 new phased-array antenna "tiles", which doubles the resolution and sensitivity of the MWA for continuum imaging, and brings almost an order of magnitude improvement in sensitivity for the EoR power spectrum key science case.

The first stage of the upgrade installed 72 tiles in two compact regular hexagonal configurations, and was completed in September 2016. The second stage of the upgrade installed 56 remote tiles to double the diameter of the array. The new remote tiles contain novel hardware, signal transport and solar power systems suited for autonomous self-contained operation in the Murchison.

Photos of new long baseline tiles with solar power and beamformer controller units:
https://photos.app.goo.gl/jqWzy9ztFTq0Jjo63
https://photos.app.goo.gl/SToyfroKrAyZhtYj1

For more information, see: http://news.curtin.edu.au/media-releases/major-milestone-key-radio-astronomy-project/

MWA Science

The MWA continues to be scientifically productive and there are now over 90 collaboration-led publications since the commencement of operations in mid-2013. The publications cover a diverse range of science areas, from solar science through to the Epoch of Reionisation.

The following are some science highlights from the recent quarter.

4D Data Cubes from Radio-Interferometric Spectroscopic Snapshot Imaging

Low radio frequency solar emission spans a very large range in intensity, as well as temporal, spectral and spatial scales. Often multiple processes are going on simultaneously at different locations on the Sun, giving rise to different emissions. These emissions can differ greatly in their strengths and till recently one could usually only study the most intense of these sources. The significantly improved imaging dynamic range of the MWA is now making it possible to study comparatively weaker emissions in presence of more intense ones. In order to facilitate such studies, Dr. Divya Oberoi and his student Atul Mohan have recently developed a new data product which will enable scientists to study the frequency and time variations of the emission coming from any specific patch on the Sun. Called SPREDS, an acronym for SPatially REsolved Dynamic
Spectrum; it is named in analogy with the usual definition of a dynamic spectrum, which shows the variations of the emission in the time-frequency plane. They also presented the first flux calibrated solar images from the MWA, made with a resolution of 0.5 s and 160 kHz.

![Image of solar radio images and dynamic spectrum]

Caption: the top left panel shows a radio image of the Sun with some regions of interest marked on it; the top right panel shows the dynamic spectrum for the entire Sun, the most commonly used radio data product at these frequencies; the remaining panels show the SPREDS from the corresponding regions marked on the solar disc. Note that the colour scale for these panels is in log scale, the differences between emissions from different regions on the Sun are self-evident.

The Spectral Energy Distribution of Powerful Starburst Galaxies I: Modelling the Radio Continuum

Star forming galaxies, like their name suggests, are galaxies that are actively producing young stars. Because they are normally faint at radio wavelengths, astronomers have often been restricted to looking at fairly local, and rare, representative galaxies. The Square Kilometre Array will be probing a volume of the Universe for the first time, where these types of objects are far more common.

In preparation, using data from the Murchison Widefield Array and the Australian Telescope Compact Array, Western Sydney University PhD student Tim Galvin and collaborators studied a set of starburst galaxies in detail from low to high radio frequencies. The study shows that the radio emission as a function of frequency in these galaxies is far more complex than typically assumed, and overly simple models may overestimate the expected radio emission at low frequencies (most relevant to SKA Low) by a factor of up to 12. The combination of data over a broad frequency range
from multiple radio telescopes, including the MWA, provides the full picture of the astrophysics underlying the radio emission for these star forming galaxies.

[Spectral Flattening at Low Frequencies in Crab Giant Pulses](https://arxiv.org/abs/1709.03651)

Pulsars emit beams of radiation along their magnetic axes, which we see as a series of periodic bursts (or pulses) each time those beams sweep over our line-of-sight. The young and energetic pulsar that resides in the Crab Nebula (PSR J0534+2200) has been of special interest to both observers and theorists alike. Unlike the vast majority of known pulsars, the Crab pulsar was discovered through its "giant pulses" – extremely bright, very short-duration bursts, whose energetics are many orders of magnitude higher than those of regular pulses. These giant pulses therefore provide excellent avenues to explore how pulsars emit in the first place. The strength of the pulsar emission (brightness or flux density) rapidly declines with increasing frequency, and can be characterised in terms of spectral energy distributions (SEDs), which describe how much energy is produced as a function of frequency. For regular pulsar emission, this generally follows a power-law, and in some cases tends to exhibit either a break or turn-over at lower frequencies. Similar characterisation has been inherently difficult in the case of giant pulses because of their sporadic nature.

Curtin University PhD student Bradley Meyers and co-authors leveraged the wide frequency coverage that is achievable via simultaneous use of the MWA and the CSIRO Parkes radio telescope to study the Crab pulsar’s giant pulse emission, spanning frequencies from ~100 MHz.
(MWA) to ~4 GHz (Parkes). This study shows that the SED of Crab giant pulses is not well described by a single power-law over such a large range in frequency, and instead, flattens at low frequencies. An important implication of this is that giant pulses are not as bright as expected at low frequencies. Moreover, the physical processes that give rise to such a spectral flattening in giant-pulse emission also remain unknown. This result makes a compelling case for undertaking similar studies for other giant-pulse emitters, and if it holds up, may also have implications for the detectability of pulsars in external galaxies (via giant pulses), or potentially for certain models of Fast Radio Bursts, where they are thought to be ultra-luminous giant pulses.

Caption: example of a single Crab giant pulse over an order of magnitude in radio frequency.

A First Look for Molecules between 103 and 133 MHz using the Murchison Widefield Array
Tremblay et al. [http://adsabs.harvard.edu/abs/2017MNRAS.471.4144T](http://adsabs.harvard.edu/abs/2017MNRAS.471.4144T)

Led by ICRAR/Curtin University PhD student Chenoa Tremblay, the largest ever low-frequency spectral line survey of the Galactic Plane has recently been completed and has found evidence for Nitric Oxide (NO). The NO molecule is a key ingredient for forming amino acids, which in turn are building blocks for the DNA that powers all life on Earth. The NO molecule, along with a detection of the mercapto radical (SH), was found in cold gas surrounding evolved stars. This evidence was found thanks to the development of a new data-processing pipeline which allows the Murchison Widefield Array to study the chemistry of our Galaxy. This new capability is now being put to use in order to study the complex and interesting gas, dust and stars in the Orion constellation.
Caption: the field around the galactic centred observed by the MWA for low frequency molecular line transitions.

Report provided by Randall Wayth

**HERA Report**

HERA currently comprises 57 of the eventual 350 elements, with construction proceeding apace. The contract to install the rest of the support poles has been awarded, with the work to be completed before the end of the year. Regular science operations have been underway since mid-October. With the site construction teams set, focus has turned to finalising the new architecture, which will start to be installed in early 2018.

The new architecture features field-deployed “nodes” that can each accommodate 12 antennas. Each node contains a post-amplifier (the “PAM”) and a digitiser/channeliser/packetiser (the “SNAP”) for each signal path. Being deployed throughout the array allows for either:

(a) short lengths of coaxial cable (keeping them short to try and keep the reflections at short timescales) or
(b) longer lengths of analogue optical fibre (keeping them long to keep the reflections at long timescales) to be used.

Both options keep the reflections out of the desirable mid-length timescales. The default approach is to use the long lengths (of order 500m) of optical fibre.
The outputs from the node are 10 gigabit ethernet fibres with the channelised data, which are sent back to the Karoo Data Rack Area (KDRA) back in the Karoo Array Processor Building (KAPB). RF quietness is obviously a key specification, and measurements are on-going to ensure compliance with the stringent site specs. Currently one prototype is deployed for testing and is shown below (with the RF-tight door removed for the photo).

![Deployed prototype "node" with RF-tight door removed. Underground forced air is used for thermal regulation of the chamber. (Credit David DeBoer).](image)

HERA recently held its annual workshop in October — this year hosted by NRAO at the Domenici Science Operations Center in Socorro, NM. The growing team may be seen in the picture below. The team held a comprehensive review of the full system and looked at commissioning data. Software pipelines and finalising specifications for the next generation equipment were key goals. A comprehensive review of the new feed options was conducted, and a Vivaldi-based design from Cambridge University was down-selected.
The new Vivaldi has a 5:1 bandwidth, which allows HERA to instantaneously measure redshifts from about 4 - 27, so the entire evolution from the early Dark Ages through to full reionization is accessible. The image below shows the first design drawing of a deployable structure — the design is currently being finalised with final trade-offs between performance and manufacturability. On-antenna testing will commence in January.

HERA is a partnership to conduct an experiment to detect and characterise the Epoch of Reionization. Partner institutions in the collaboration are Arizona State University, Brown University, University of California Berkeley, University of California Los Angeles, University of Cambridge, Massachusetts Institute of Technology, National Radio Astronomy Observatory, University of Pennsylvania, Scuola Normale Superiore de Pisa, SKA-South Africa and the University of Washington. Additional collaborators are Cal Poly Pomona, Imperial College, Harvard-Smithsonian Centre for Astrophysics, University of KwaZulu Natal, Rhodes University and University of Western Cape. HERA is an SKA precursor instrument. HERA is funded by the US National Science Foundation, the Gordon and Betty Moore Foundation with additional support from the partner institutions.
Report provided by David De Boer, University of Berkeley

**JIVE/EVN/VLBI Report**

**Science frontiers for SKA-VLBI**

Since last reported, a series of fascinating scientific results have demonstrated the relevance that the high-resolution component for the SKA telescope will have. Additionally, key technical advances that have taken place recently will pave the way towards a successful collaboration of the SKA with the VLBI networks. This report outlines the most important achievements during 2017.

**EVN telescopes zoom in on gravitational wave detection**
For the first time, scientists have directly detected gravitational waves in addition to light from the collision of two neutron stars. The discovery was made using the U.S.-based Laser Interferometer Gravitational-Wave Observatory (LIGO); the Europe-based Virgo detector; and some 70 ground- and space-based observatories.

Neutron stars are the smallest, densest stars known to exist and are formed when massive stars explode in supernovas. As these neutron stars spiralled together, they emitted gravitational waves that were detectable for about 100 seconds; when they collided, a flash of light in the form of gamma rays was emitted and seen on Earth about two seconds after the gravitational waves. In the days and weeks following the collision, other forms of light, or electromagnetic radiation - including X-ray, ultraviolet, optical, infrared, and radio waves - were detected.

While still too faint to be detected on baselines of thousands of km, these observations are part of ongoing efforts to localise the source of transient radio emission in the sky as it becomes brighter, with the highest precision to date, and with improve sensitivities, like the ones that will be provided by the SKA.

The collaboration between LIGO/Virgo and EVN/e-Merlin is part of the ASTERICS project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653477.

Figure 1. Localization of the binary system of colliding neutron stars, source of the detected gravitational waves and the electromagnetic radiation.
EVN localization of recurrent Fast Radio Burst FRB121102

Fast Radio Bursts (FRBs) are very short duration (a few milliseconds) dispersed radio signals of unknown origin. The high dispersion measure indicated that FRBs are most likely extragalactic in origin. If true, these signals could be used to probe the distribution of baryonic matter in the Universe, fundamental to cosmological models. The only way to reliably measure the position of an FRB is direct, interferometric detection of a burst. At JIVE they have developed a technique to localize ms-duration signals with the EVN (see Paragi 2016, arXiv 1612.00508). The discovery of repeated bursts from FRB 121102 (Spitler et al. 2016, Nature, 531, 202) provided an excellent opportunity to demonstrate this technique. EVN and Arecibo observations performed in September 2016 resulted in the detection of four bursts, the brightest of which clearly showing that the source of the bursts and the persistent radio source are co-located within about 10 mas (see Fig. 2, from Marcote et al. 2017, ApJL, 834, L8). The persistent radio source itself is located in a dwarf galaxy at a redshift of z=0.1927 (Tendulkar et al. 2017, ApJL, 834, L7).

This mode of observations and the special processing of the VLBI data at JIVE (dedispersion, high time/frequency resolution correlation, gating) is available to the whole EVN community.

Figure 2. Marcote et al. 2017, ApJL, 834, L8: Individual burst locations (grey: weak bursts; red: the brightest burst ever detected in FRB121102) and the weighted mean burst location (black) with respect to the persistent radio source (contours: 18cm, color scale: 6cm EVN images).
Successful combined use of linear and circular polarizers in the e-EVN.

Pioneering e-EVN observations at C-band demonstrated how SKA will be able to contribute to the VLBI networks with its linear polarization receivers, without additional signal processing. The observation EO014 was carried out on December 2016, in a "mixed polarization" basis (i.e., where stations with linear and circular polarizers are observing simultaneously). Effelsberg antenna used a receiver with linear polarizers, whereas the other 6 participating e-EVN stations were using circular-polarization receivers. Fringes were successfully correlated in this "mixed polarization" basis and the program PolConvert (Marti-Vidal et al. 2016) was used to calibrate and transform these fringes into a pure circular basis (see Fig. 3).

![Figure 3. Fringes of a snapshot of the polarization calibrator (J0927+3902) between the Lovell telescope and Effelsberg. Left, output from the correlation (i.e., in a "mixed polarization" basis). Right, after running PolConvert.](image)

Towards the African VLBI Network of radio telescopes.

The African VLBI Network (AVN) will play a key role for the successful inclusion of the SKA telescope in VLBI observations, providing intermediate length baselines to the SKA to improve the uv-coverage for observations with the EVN.

A first milestone in the development of the AVN has been the demonstration of fringes during a VLBI test experiment with the EVN and a 32-m converted telecommunications antenna at Kuntunse, Ghana (Fig. 4). The fringes were found by combining data from Kuntunse and other participating EVN stations using the SFXC software correlator, designed by the Joint Institute for VLBI ERIC (JIVE). This experiment is one of three positive detections, with the other two successes including methanol maser detection and pulsar observations, showing that the Kuntunse antenna can be used as a radio telescope for single dish observations and as part of a VLBI network.
Recent VLBI meetings and workshops with relevance for the SKA

**e-MERLIN and EVN in the SKA era (JBO, 11-12 September 2017)**

This meeting has been the second of a series of open meetings and workshops to allow the astronomical community to discuss and contribute to the future developments and operations of the UK’s National Radio Astronomy Facility, e-MERLIN and the European VLBI Network (EVN). The main purpose of the meeting was to inform the community of the existing and upgraded capabilities of e-MERLIN and the EVN and discuss the scientific and technical priorities for these facilities in the coming years. The meeting took place at Jodrell Bank Observatory, 11-12 September 2017. For further details, see http://www.jb.man.ac.uk/meetings/JBOinSKAeraII

**6th International VLBI Technology workshop (9-11 October 2017)**

Rapid advances in technologies relevant to VLBI are foreseen in many fields: data recording, transmission, correlation and data analysis. It has, in some cases, brought about a major re-thinking of the traditional ways of the VLBI observing technique and how we make prominent
scientific progresses in both astronomy and geodesy. In addition to reports on current and near-term VLBI technology plans and achievements, an important focus of this meeting will be the opportunity for forward-looking views of VLBI technology in the decade of the 2020s. The meeting took place in Bologna, Italy, 9-11 October 2017. For further details see: https://indico.ira.inaf.it/event/2/overview

JUMPING JIVE Project

The EC Horizon2020 project “Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE” (“JUMPING JIVE”) took off at the beginning of 2017. This project aims to prepare and position European VLBI in the SKA era, with JIVE and the EVN as globally recognized centres of excellence in radio astronomy. Detailed information on the project can be found at: http://www.jive.eu/jumping-jive

The project work packages cover a number of topics, two of them are especially relevant for SKA:

- 'Integrating new elements' work package has already demonstrated fringes with the Kuntunse telescope in Ghana, being the first operational element of the future African VLBI Network (AVN) and,
- ‘VLBI with SKA’ work package to support the SKA VLBI scientific working group, thanks to a liaison scientist, Cristina Garcia-Miro, that works at the SKA Organisation to discuss the technical and operational issues for doing VLBI experiments involving the SKA telescope.

The kick-off meeting of the project took place on February 20-21 2017 in Leiden, the Netherlands, Fig. 5. Rene Vermeulen (ASTRON) was elected as chair of the JJ board, and John Conway (Onsala Space Observatory) as vicechair.

Figure 5. Kick-off meeting of the JUMPING JIVE project, Leiden, the Netherlands, February 20-21 2017.

Report provided by Cristina Miro Garcia
Parkes Observatory Report

The Ultra-wideband Low (UWL) receiver (700MHz to 4GHz) was tested on the Parkes 64-m telescope between the 31st July and 2nd August 2017. This installation allowed CSIRO to confirm that the receiver could easily be installed and to demonstrate that we could observe astrophysical sources with the receiver. We also measured the beam shapes and studied the radio interference environment within the wide band.

The tests were remarkably successful.

Within an hour of the telescope becoming available we were able to observe our first astrophysical source: the pulsar J1644-4559.

The final system will include new LNAs, a completely new digitisation system (enabling the entire band to be digitised) and a GPU astronomy-backend system.

We are carrying out research into RFI mitigation methods and calibration procedures for wide band receivers. The intention is for this to be a National Facility instrument in the Apr 2018 semester.
CSIRO engineers installing the Ultrawideband Ultra-wideband Low receiver on the Parkes Telescope

Report provided by Annabelle Young, CSIRO

Updates from the Science Working Groups

Epoch of Reionization

The Ruder Bošković Institute in Zagreb, Croatia, formed the venue for a meeting of the Cosmic Dawn / Epoch of Reionization Science Working Group on 28th and 29th September. About 30 members of the group participated. Many of them would meet again at the IAU Symposium 333 “Peering towards the Cosmic Dawn” which was held in Dubrovnik the week after.

The first day of the meeting was dedicated to presentations of recent developments in SKA, as well in theory and observations with precursors. The second day was used to further develop the Blind Challenge for 21-cm power spectrum extraction codes. The idea is to release a small number
of “corrupted” 21-cm image cubes and ask the different teams to report back the 21-cm power spectrum which will then be compared to the chosen input signal, which will be unknown to those submitting results. In this first phase the corruptions will only be noise and foreground signals but in the future they will include instrumental effects, RFI, as well as the ionosphere. This challenge is one of the steps of arriving at a complete end-to-end pipeline for the future measurements with SKA-low.

The meeting was organised by Vibor Jelić and the statue seen in the picture is of professor Balthasar, a cartoon character from the seventies, created in Zagreb. Those of us who know the cartoons surely wish that some of his magic could be applied to our endeavours.

---

Report provided by Eor SWG

Pulsars

Main meetings/events from August 2017 to November 2017

The members of the SKA Pulsar Science Working Group (SKA-PSWG) met at various meetings during this period. Among those, the largest and most prominent event was the IAU Symposium 337, which was held at the Jodrell Bank Observatory from Monday 4th September to Friday 9th September. In fact, 2017 marked the 50th anniversary of the discovery of pulsars and the conference was an exciting opportunity to reflect on what we have learnt from these unique physical laboratories and to look forward to the intriguing perspectives opened by their study in the next half century. The title of the conference was “Pulsar Astrophysics: The Next Fifty Years”, and over 200 scientists from all over the world participated. They presented a wealth of new results – some of them made public for the first time – and described how new facilities, among which SKA1 stands in a primary position, will be able to produce a new revolutionary phase in pulsar astrophysics in the near and mid term future.
Pulsar Astrophysics: The Next Fifty Years
IAU Symposium 337 - 4th-8th September 2017 - Jodrell Bank Observatory, University of Manchester

Image: The group picture of the IAU meeting 337, which took place at the Jodrell Bank Observatory during the second week of September. In the background, the Lovell Telescope is visible. Credit: Ant Holloway.

Publications related to the PSWG from August 2017 through November 2017

During this period, the members of the PSWG and their collaborators have published and/or submitted to international refereed journals many tens of papers relevant to the scientific objectives of SKA1. A selection of some of the papers is below.

a) Graikou, E., Verbiest, J. P. W., Oslowski, S., Champion, D. J., Tauris, T. M., Jankowski, F., Kramer, M., 2017, Limits on the mass, velocity and orbit of PSR J1933-6211, Monthly Notices of the Royal Astronomical Society, http://cdsads.u-strasbg.fr/abs/2017MNRAS.471.4579G, MNRAS, 471, 4579G This paper reports on high-precision timing analysis of PSR J1933-6211 using data from the Parkes radio telescope. The authors have accurately measured the polarization properties of this pulsar and then applied the matrix template matching approach in which the times of arrival are measured using full polarimetric information. With this technique, they achieved timing residuals with a weighted root-mean-square of 1.23 μs, corresponding to a 15.5 % improvement compared to the total intensity timing analysis. This result is very promising for the precision timing
capability of SKA1, the sensitivity of which will enable application of full polarimetric info to a very large sample of pulsars.

b) Kelley, L. Z., Blecha, L., Hernquist, L., Sesana, A., Taylor, S. R., 2017, *The gravitational wave background from massive black hole binaries in Illustris: spectral features and time to detection with pulsar timing arrays*, Monthly Notices of the Royal Astronomical Society, http://cdsads.u-strasbg.fr/abs/2017MNRAS.471.4508K, MNRAS, 471, 4508K The authors of this work use comprehensive massive black hole merger models based on cosmological hydrodynamic simulations to predict the spectrum of the stochastic gravitational wave background (GWB) and apply real time-of-arrival specifications from the International Pulsar Timing Array (IPTA) to calculate realistic times to detection of the GWB across a wide range of model parameters. Even with merger models that use pessimistic parameters, if the current rate of PTA expansion continues, the authors found that the IPTA is highly likely to make a detection within about 10 yr. This will enhance even more the capabilities of SKA1 to exploit the observations of a suitable number of millisecond pulsars in order to perform gravitational wave astrophysics.


d) Zhang, F., Saha, P., 2017, *Probing the Spinning of the Massive Black Hole in the Galactic Center via Pulsar Timing: A Full Relativistic Treatment*, The Astrophysical Journal, http://cdsads.u-strasbg.fr/abs/2017ApJ...849...33Z, ApJ, 849, 33Z SKA is expected to reveal pulsars around the massive black hole (MBH) in the Galactic center (GC). Using a full relativistic framework with the pulsar approximated as a test particle, this paper investigates the constraints on the spin of the MBH by monitoring the timing of surrounding pulsars. For GC pulsars orbiting closely around the MBH (e.g., ≤1000 au), the authors find that full relativistic treatment is necessary to accurately account for their timing signals. Although usually there is degeneracy among MBH spin parameters, the achievable constraints on the spin of the MBH are still very tight.

e) Ambrosino, F., Papitto, A., Stella, L., Meddi, F., Cretaro, P., Burderi, L., Di Salvo, T., Israel, G. L., Ghedina, A., Di Fabrizio, L., Riverol, L., 2017, *Optical pulsations from a transitional millisecond pulsar*, Nature Astronomy, http://cdsads.u-strasbg.fr/abs/2017NatAs...1E.266A, NatAs, 1E, 266A A few transitional millisecond pulsars that swing between an accretion-powered X-ray pulsar regime and a rotationally powered radio pulsar regime in response to variations of the mass in-flow rate have been recently identified. They are interesting targets for the high instantaneous sensitivity of SKA1. This paper focuses on the first detection of optical pulsations from a transitional millisecond pulsar.

f) Dyks, J., 2017, *The geometry of a radio pulsar beam*, Monthly Notices of the Royal Astronomical Society, http://cdsads.u-strasbg.fr/abs/2017MNRAS.471L.131D, MNRAS, 471L, 131D A full understanding of the still unclear mechanism(s) of the pulsar radio emission and the related origin of the large variety of pulse profiles seen from these objects is one of the aims of SKA1. In this paper, it is proposed that the underlying geometry is that of a flaring spiral that makes several revolutions around the pulsar magnetic dipole axis on its way to leave the magnetosphere. Such geometry is consistent with a stream of out-flowing and laterally drifting plasma.
g) Rajwade, K. M., Lorimer, D. R., Anderson, L. D., 2017, *Detecting pulsars in the Galactic Centre*, Monthly Notices of the Royal Astronomical Society, \url{http://cdsads.u-strasbg.fr/abs/2017MNRAS.471.730R}, MNRAS, 471, 730R. In this paper a detailed analysis of both the canonical and millisecond pulsar populations in the Galactic Centre is presented. The authors consider free-free absorption and multipath scattering to be the two main causes of flux density mitigation. They demonstrate that the sensitivity limits of previous surveys are not sufficient to detect the Galactic Centre pulsar population and that the optimum frequency for future surveys is in the range of 9-13 GHz. In particular, future deeper surveys with SKA1 will probe a significant portion of the existing radio pulsar population in the Galactic Centre, which could consist of up to 52 canonical pulsars and 10 000 millisecond pulsars.


The timing capabilities of SKA1-MID will be able to strongly improve on these measurements and extend the technique to many globular clusters.

I) Mingarelli, C. M. F., Lazio, T. J. W., Sesana, A., Greene, J. E., Ellis, J. A., Ma, C.-P., Croft, S., Burke-Spolaor, S., Taylor, S. R., 2017, *The Local Nanohertz Gravitational-Wave Landscape From Supermassive Black Hole Binaries*, Nature Astronomy, doi:10.1038/s41550-017-0299-6, [http://adsabs.harvard.edu/abs/2017arXiv170803491M](http://adsabs.harvard.edu/abs/2017arXiv170803491M), published online Nov. 13. The authors use the 2MASS all-sky catalogue and galaxy merger rates from the Illustris simulation to predict the number of continuous-wave gravitational-wave sources in the local Universe and to estimate their detectability by the International Pulsar Timing Array project. They find that these local sources can provide up to 20% anisotropy in the gravitational-wave background and predict that the IPTA could detect at least one of these sources within 10 years. Adding in the sensitivity of the SKA1 will greatly help the prospects for this science.


Report provided by Pulsar SWG

**Solar, Heliospheric & Ionospheric Physics**

Anticipating in-situ and SKA observations of solar storms

Often observations with a single instrument provides incomplete pictures of an astrophysical phenomena. This is particularly true when tackling challenging science questions like magnetic reconnection and corona heating. The multi-instrument and multi-wavelength observations yield richer and more comprehensive look at the astrophysical objects.

Anticipating the launch of new solar missions, the emerging observational opportunities for joint SKA and in-situ observations from NASA Parker Solar Probe and ESA Solar Orbiter were discussed in France at the international Steinbeg workshop last month.

[https://jlsworkshop.sciencesconf.org/](https://jlsworkshop.sciencesconf.org/)

While the space probes will travel into the inner heliosphere for in-situ measurements, the SKA will be able to provide radio coverage of the same phenomena in the inner heliosphere. Jean-Louis Steinbeg (Meudon, France) is one of the pioneers in this field of radio astronomy. Co-founder of the Nancay Observatory, he was also inspired by the observations from many space missions. A series of talks have been presented to cover the new developments in the discipline, which may come with merging in-situ and remote radio observations of the Sun and the heliosphere.

Report provided by Solar, Helio & Iono SWG
ICRAR Report

Community

- ‘Funarium’, an inaugural family-oriented event took place during the July school holidays. ICRAR staff and students delivered a range of astronomy and space themed hands-on activities in the ‘Cosmic Science Zone’ for more than 5,500 visitors over 3 days.
- ‘A Cosmic Perspective’, an event with Neil deGrasse Tyson hosted by ICRAR’s Dr Luke Davies, took place at the Riverside Theatre (Perth Convention Centre) in early July. 2,500 people attended, generating excellent exposure for ICRAR.
- A regional ‘Astrofest’ event was delivered for Mt Magnet—one of the closest towns to the Murchison Radio-astronomy Observatory—in late August. ICRAR coordinates this event every year, which involves collaborating organisations such as Scitech, Perth Observatory and the Astronomical Group of WA. The event includes an astrophotography exhibition, science shows, inflatable space domes, a dozen telescopes and night sky tours. 150 people attend—which is most of the town. Interestingly, a number of attendees from out-of-town had travelled there just for the event—from places such as Geraldton (several hundred kilometres away)—or were passing through Mt Magnet and decided to stay for longer in order to attend.
- As part of National Science Week, WA’s inaugural ‘Battle of the Brains’ event was held at the Astor Theatre in Mount Lawley. Described as an intellectual obstacle involving the best, brightest, and funniest physicists in the land, the featured Luke Davies, Ryan Urquhart, Ronniy Joseph, Pikky Atri and Robin Cook from ICRAR and was a full house.
- ICRAR’s annual astrophotography exhibition was on display at the Western Australian Museum in Geraldton from the end of July to the beginning of September, where it was viewed by more than 5,000 people.
- At the end of September, the Director General for the European Space Agency gave a free public talk titled ‘Space Exploration: The next generation’. The event was attended by 250 members of the public. An expert panel featured after the talk, taking questions from the audience about Australia’s future in space. This event was also live-streamed to a national audience via Australia’s Space Channel—the first time ICRAR has done this.
- During this period, we also began recoding, producing (all in-house) and airing a fortnightly Vodcast called ‘Astro Morning Tea’. This light-hearted look at astronomy and general science stories making the headlines, goes out to online audiences via Australia’s Science Channel and is hosted by Dr Luke Davies and Greg Rowbotham.

Excursions (visits to schools)

In addition to the usual talks for students at local high schools, the following activities took place during this period:

- A talk for high school students was delivered at the US Consul General’s Residence in central Perth. 18 students in years 10 and 11, from 4 schools, attended.
- A programme was delivered at Mt Magnet District High School for students in Years 7 to 9.
At the ‘Frontiers of Science’ Schools Forum, Dr Luke Davies spoke to almost 200 high school students about his path into astronomy and about galaxy evolution galaxies.

ICRAR’s Gemma Anderson and Charlotte Sobey participated in a speed networking type event for young female high school students (and their parents) called the ‘Innovator’s Tea Party’ at FLUX, a co-working space located in the Perth CBD.

Work Experience Students

- Jackson Booth, a Year 10 student from Helena College, Grade 10.
- Miah Gardner, a Year 10 student from St Mary’s Anglican.
- Jude Chrulew, a Year 9 student from Living Waters Lutheran.

All 3 students spent 4 days at ICRAR during September, working with researchers and outreach staff across a wide range of tasks and experiences.


ICRAR’s remote telescopes, SPIRIT I & II, have been used during term 3 and 4 by a number of students, including Masters (Swinburne), under-graduate (UWA) and local schools including St. Joseph’s School Northam, Perth Waldorf School, Mater Dei College.

ICRAR is currently assembling a 3rd SPIRIT telescope, to be installed in a dark sky site an hour north of Perth.

---

Report provided by ICRAR

**SKA SA Report**

**SKA SA hosts Junior FIRST Lego League Competition (29 July 2017)**

SKA SA hosted the SKA SA Junior FIRST Lego League competition in Carnarvon, Northern Cape Province on 29 July 2017.

SKAO eNewsletter December 2017

www.skatelescope.org
For Inspiration and Recognition of Science and Technology (FIRST) is a global initiative to harness young children’s inherent curiosity and to direct it towards solutions for real-world challenges.
The SKA SA Junior FIRST Lego League Competition required teams from primary schools in the six towns surrounding the SKA SA Karoo operational area to use Lego pieces to solve pre-set mathematics problems and to build a robot that can perform certain tasks using WeDo 2.0 sets provided.

**RD9 Solutions: Introduction to Robotics (21-28 October 2017)**

RD9 Solutions hosted two robotics workshops for 28 Grade 8-11 learners at South Peninsula High School in Cape Town, Western Cape Province on 21 and 28 October 2017.

RD9 Solutions is a company established by SKA SA Systems Engineer, Tyrone van Balla, funded through the SKA SA start-up competition, StarBiz.
Learners were introduced to the basic concepts of electronics, programming and robotics, and were given the opportunity to build and programme a MiiA robot using their smartphones.

“As opposed to lecturing, our workshops employ a self-learning strategy,” says Van Balla. “Learners complete course material and exercises on a digital platform that allows them to chat anonymously via text to one of the course facilitators, submit their work, receive feedback and make corrections if necessary. By using a means of communication with which learners are familiar, and ensuring anonymity, we were able to reduce the formality and pressure that learners sometimes face in traditional classroom settings.”

**Learners explore opportunities in astronomy and big data with SKA SA**

SKA SA participates in career expos in its area of operations in order to introduce learners, educators and undergraduate students to the SKA and MeerKAT, the variety of careers available in radio/astronomy and big data, and the SKA SA bursaries and graduate employment programmes.

Participants in the iSTEM Youth Indaba, Midrand, Gauteng Province as well as the Sol Plaatje University Career Fair and Nelson Mandela Career Development Festival in Kimberley, Northern Cape Province engaged with SKA SA content specialists and bursary holders through panel discussions, motivational talks and interactive exhibitions.

Grade 10 learners from Kimberley Girls' High School, Duduetsang Tlhomelang, was exposed to the field of astronomy for the first time at the Nelson Mandela Career Development Festival. “I love to observe the stars at night and learning that the Northern Cape is home to two of the world’s best telescopes is so exciting. It was also interesting to listen to the SKA staff talk about careers I did not know about or do not even exist yet!”

**SKA SA supports South African science festivals**

Science festivals promote the public awareness, understanding and appreciation of science, technology and innovation through a programme of unique, interactive events that allow leading scientists the opportunity to share their work, make science accessible within the reach of ordinary people, network with one another, provide career guidance and act as role models for the youth, in order to encourage the youth to embark on careers and become leaders in these fields.
SKA SA continues to support science festivals in South Africa and participated in the recent Eding International Science Festival, Klerksdorp, North West Province; Sasol Techno X, Secunda, Mpumalanga Province; and Hluhluwe Science Festival, Hluhluwe, KwaZulu-Natal Province.
The festivals saw SKA SA content specialists engage with learners of all grades and the general public through public talks, interactive exhibitions and workshops, including the newly developed “Build your own MeerKAT dish” and “Make your own spectroscope” workshops.

**National Science Week 2017**

National Science Week (NSW) is an initiative of South Africa’s Department of Science and Technology (DST) and a nationwide celebration of science involving various stakeholders and/or role players conducting science-based activities during the week.

SKA SA participated in and hosted a number of activities in various places around the country during the focus week from 5-11 August 2017.

**NSW 2017 Launch**

NSW 2017 was launched by South Africa’s Minister of Science and Technology, Naledi Pandor, at the Nelson Mandela University (NMU) in Port Elizabeth, Eastern Cape Province on 5 August 2017.

SARAO was invited to exhibit at the event, which allowed content specialists and bursary holders the opportunity to promote the awareness, understanding and appreciation of SKA and MeerKAT amongst learners, educators, undergraduate students and the general public.

**Township School Tour**

SKA SA and the National Science and Technology Forum (NSTF) collaborated to implement a tour of township schools in Cape Town, Western Cape Province from 7-11 August 2017.

The tour visited Fezeka High School in Gugulethu, Silikamva High School in Imizamoyethu, Spine Road Secondary School in Khayelitsha and Ikamvalethu Secondary School in Langa.

The daily programme included motivational talks by 2017 NSTF Award winners and interactive workshops that support the Physical Science curriculum facilitated by SKA SA content specialists.

**Site Visits**

SKA SA hosted Grade 9 learners and educators from Brandvlei, Carnarvon, Fraserburg, Loxton, Van Wyksvlei and Williston at the SKA site, Northern Cape Province from 7-16 August 2017.

The site visits, facilitated by SKA SA staff members and visiting Klaus-Jürgen Bathe Fellows, aim to promote the awareness, understanding and appreciation of radio astronomy and the SKA amongst learners and educators in the Northern Cape.

Visitors were provided with an introduction to SKA and MeerKAT; allowed supervised access to the KAPB facility, KAT-7, MeerKAT and HERA; afforded the opportunity to ask questions about the science, technology and innovation of SKA and MeerKAT, as well as the impact of the projects on their local communities; and provided with information about the SKA SA Schools Programme.

**NSW @ AIMS**

SKA SA participated in the NSW programme hosted by the African Institute for Mathematics Sciences (AIMS) in Cape Town from 7-11 August 2017. AIMS is a strategic partner of SKA SA in human capacity development and science engagement.
The programme saw SKA SA content specialists and visiting Fellows engage with learners of all grades and the through motivational talks, an interactive exhibition and workshops, including the newly developed “Colour by numbers” and “RFI Detective” workshops.

**SKA SA celebrates World Space Week**

SKA SA contributed to South Africa’s World Space Week celebrations by hosting and participating in various events around the country from 2-13 October 2017.
The United Nations (UN) General Assembly declared 4-10 October as World Space Week in 1999, and it has since grown to be the largest public space event on Earth. The objective of the SKA SA World Space Week programme was to contribute to the public awareness, understanding and appreciation of astronomy and space science, HartRAO, MeerKAT and SKA; as well as to support educators and learners in the content of the “Earth and Beyond” topic in the curriculum, which is taught and examined in the fourth term.

SKA SA hosted NASA Deputy Chief Technologist (Ret.), Jim Adams, who visited schools in the Gauteng and Western Cape provinces on a two-week space tour. Each school visit consisted of a talk by Adams about the various NASA missions to planets in our Solar System in which he was involved; an interactive workshop by SKA SA staff which supports the “Earth and Beyond” topic in the curriculum; as well as a Q&A session which focussed on careers in astronomy and space science and SKA SA bursary opportunities.

Adams also presented public lectures at Sci-Bono Discovery Centre, Johannesburg and Kirstenhof Primary School, Cape Town, and assisted SKA SA staff in two educator support workshops hosted by the Department of Basic Education at the Oprah Winfrey Leadership Academy for Girls, Johannesburg and Moorreesburg Koringboere Beperk (MBK) Hall, Moorreesburg, respectively.

SKA SA staff also presented astronomy and space science content during the Space Adventures Holiday Programme at SciBono Discovery Centre and the Eskom Expo for Young Scientists International Science Fair in Gauteng; while collaborators Dr Alvaro Gonzalez of the National Astronomical Observatory of Japan (NAOJ) and Dr David DeBoer of the University of California (UC) Berkeley, USA presented talks at public events at the Cape Town Science Centre in the Western Cape.
The National Science and Technology Forum (NSTF) and SKA SA co-hosted a Science Café for young women in science at the Bandwidth Barn Khayelitsha in Cape Town, Western Cape Province on 9 August 2017.

The Science Café, held in celebration of National Women’s Day, used an informal coffee shop setting to bring together three successful female scientists in various stages of their career and female learners in Grades 9-11.

Human Sciences Research Council (HSRC) Research Director, Professor Nancy Refliwe Phaswana-Mafuya; NSTF Media Liaison Officer, Fulufelo Gelebe; and SKA SA Junior Commissioning Scientist, Isabella Rammala, answered
questions about their personal journeys into science, what an ordinary day at work in their field is like, how to build a personal brand, and what their career advice for learners would be.

Learners were also afforded the opportunity to have one-on-one conversations with the three scientists, in order to ask individual questions and advice, and to exchange contact information with the scientists.

**Scope X 2017 (16 September 2017)**


Scope X is an annual event that aims to promote public interest in astronomy, telescope making, astrophotography and other related disciplines within Southern Africa.
SARAO content specialists engaged with the general public through public talks, an interactive exhibition and various workshop titles.

**IAU, SKA SA collaborate to promote science communication in Mauritius and Ghana**

The International Astronomical Union (IAU) Office of Astronomy for Development (OAD) and SKA SA collaborated to host science communication training workshops for 25 African postgraduate astronomy students, as well as 10 staff members of the Ghana Atomic Energy Commission (GAEC) and Ghana Space Science and Technology Institute (GSSTI), in August 2017.

The workshops, held in Belle Mare, Mauritius from 12-13 August 2017 and Accra, Ghana from 16-18 August 2017, were an extension of the IAU OAD-funded Big Data in Astronomy: A Potential Tool For Social Innovation (BAriSta) Joint Exchange Development Initiative (JEDI) Workshop and West African International Summer School for Young Astronomers (WAISSYA), respectively.

Participants in each science communication training workshop were introduced to the theory of science engagement; required to complete various practical components in message strategy, public speaking, science journalism, social media, and science engagement project design; and introduced to strategic communications.

The workshops, coordinated by the SARAO Communications Unit, were co-facilitated by IAU OAD staff, BAriSta and WAISSYA faculty members, SKA SA communications staff, and science communicators from Mauritius and Ghana.

The workshops support the SKA AVN Communications Strategy by contributing to the development of content specialists for use by SKA AVN partner countries in their own science engagement activities.
CSIRO visits South Africa to promote pulsar research and outreach

Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO) Education Officer, Robert Hollow, and Parkes Team Leader, Dr George Hobbs, visited Cape Town, Western Cape Province from 21-25 August 2017 to implement various PULSE@Parkes activities.

The aim of the visit was to support pulsar research and outreach in Africa by developing new collaborations and implementing interactive training workshops related to observing, data processing and science engagement with SKA SA and other groups.

Hollow and Hobbs presented a colloquium on pulsar research in Australia followed by an observing session for 40 second-year undergraduate students from the University of Cape Town; a full-day pulsar workshop for postgraduate students from South African universities and SKA SA staff members which included the simultaneous observation of a pulsar with Parkes and MeerKAT; as well as an observing session for learners from Manzomthombo High School, Khayelitsha and training session for education staff at the Cape Town Science Centre.

“A highlight of our trip was being involved in the first simultaneous Parkes and MeerKAT observations of pulsars. The students enjoyed comparing the results and discussing the similarities and differences between the two telescopes. We also used high-precision pulsar Parkes data sets to help identify timing issues currently in the MeerKAT system and discussed future collaborations and research relating to time calibration,” said Hobbs.

Learners debate SKA in National Schools Debates Competition

SARAO partnered with the South African Association for Science and Technology Advancement (SAASTA), Hydrogen South Africa (HySA) and the Nanotechnology Public Engagement Programme to implement the National Schools Debates Competition from August to October 2017.
The competition provides a platform for Grade 9 to 11 learners in South Africa to engage with information about science, technology and innovation research that impacts their everyday lives, and to contribute to the development of science policy and research (STI) in South Africa.

SARAO decided to partner in the competition in order to promote the awareness, understanding and appreciation of the Hartebeesthoek Radio Astronomy Observatory (HartRAO), MeerKAT and Square Kilometre Array (SKA) amongst learners, but also, in the long term, to contribute to the development of learners into responsible citizens who carefully consider information and differing viewpoints, contribute to societal debate, make an informed decision, and hold leadership accountable.

The competition consisted of three rounds, namely a training workshop held in each province in early August, a provincial final held in each province in early September, and a national final held in Gauteng on 6 October 2017.

The objective of each debate is not for each team to propose/oppose a motion and win a vote, but rather for each team to propose and defend a different perspective on the STI development in question, i.e. Applications and Benefits, Economic, Political and Socio-Cultural.

SKA SA and HartRAO implemented the provincial training workshops of the competition in the Northern Cape and North West provinces, respectively, on 5 August 2017. One hundred and fifty learners from 30 schools, including Carnarvon, were trained in the structure of the competition as well as communication and debating skills that would enable them to innovatively communicate accurate and well-balanced content with clarity and charisma. Participating teams in all nine provinces were required to prepare debates as part of a qualification round for the provincial final, and the top 10 qualifying teams were then offered the opportunity to interact with SKA SA content specialists in preparation for the provincial final.

Dimitri de Waal, a Grade 11 learners at Carnarvon High School, believes participation in the competition helped him to develop his self-confidence as well as his research, speech-writing, public speaking and debating skills. “Preparation for the provincial final also taught me how to verify whether information I hear or read about SKA is correct, and provided me with a balanced view of the impacts of SKA on my community,” he says.

The top 10 teams in each province gathered again for the respective provincial finals at the start of September, in order to debate how the investment of public resources in a mega-science project such as the SKA can contribute to the eradication of poverty and sustainable development in South Africa and the African continent.

At the provincial finals in the Northern Cape and North West, held in Kimberley and Klerksdorp respectively on 2 September 2017, it was the teams from Kimberley Girls' High School and High school for Girls Potchefstroom who talked their way into the national finals.

SARAO congratulates the team from Kimberley Girls' High School, who were placed third at the national final of the competition held on Pretoria on 6 October 2017, as well as the all-girl team from SJ van der Merwe Technical High School in Lebowakgomo, Limpopo who were placed first.

**SKA SA hosts San field guiding students**

SKA SA hosted San field guiding students and training staff from the !Khwatuu Educational and Cultural Centre at the SKA site at Losberg on 27 September 2017.
The site visit formed part of a five-day tour of the Karoo, during which students visited various astronomy and scientific tourism sites, and received training in cultural astronomy, basic stargazing and modern astronomy in South Africa.

The !Khwa ttu Educational and Cultural Centre, situated on the West Coast of South Africa, trains up to 30 San youth from Botswana, Namibia and South Africa in field guiding every year, and assists students to find placements at game lodges or nature reserves in the region upon completion of their training.

“MeerKAT makes me so proud to be from the Northern Cape and South Africa,” said Nashville Rens, a student who hails from the ‡Khomani San in Upington, after his visit to the SKA site. “This tour has also allowed me to find a place for my heritage within the story of astronomy in Southern Africa.”
The tour is an initiative of SKA SA to contribute to the development of San youth as required in the Memorandum of Understanding between the facility and the Southern African San Council, and also formed part of SKA SA’s celebrations of Heritage Day and the 2017 International Year of Sustainable Tourism for Development.

**DST Mini Science Forum ignites conversations about big science**

A colourful circus, lively panel discussion, wacky science exhibits and interactive workshops have set the tone for the run-up to the Science Forum South Africa (SFSA) 2017.

This line-up of events formed the first in a series of Department of Science and Technology (DST) Mini Science Forums, which was hosted at the Cape Town Science Centre in Cape Town, Western Cape Province on 1 November 2017. Other Mini Science Forums will take place around the country leading up to the official SFSA to be held at the CSIR International Convention Centre in Pretoria, Gauteng Province from 7-8 December 2017.

The SFSA is an open science event that aims to create a platform for vibrant debate on the role of science, technology, innovation in society in South Africa and Africa. The annual event is proposed by South Africa’s Minister of Science and Technology, Naledi Pandor, and implemented by the DST. For more information visit [www.sfsa.co.za](http://www.sfsa.co.za).

The Mini Science Forum in Cape Town was a collaboration between the Cape Town Science Centre, Chevron, the Human Sciences Research Council (HSRC) and SKA SA.

SARAO Science Engagement Manager, Anja Fourie, co-moderated a panel discussion with Afrika Magogotyi, a Grade 9 learner from Masibambisane Secondary School, Delft. The panel discussion, titled *Science transforming society*, allowed Grade 9 learners to engage with scientists on the panel about the definition of “society”, the nature of the gap between science and society in South Africa, the scientists’ research and work, how learners in Delft can...
access big science in South Africa, and how big science can contribute to transformation in their community and South Africa.

The panel included HSRC Research Director: Education and Skills Development, Dr Thierry Luescher; IAU Office of Astronomy for Development (OAD) Postdoctoral Fellow, Dr Wanda Diaz-Merced; and SARAO Stakeholder Manager: Northern Cape, Dr Anton Binneman.

SKA SA staff members Niesa Burgher, Dimpho Lephaila and Vereese van Tonder, also facilitated an interactive exhibition and “Make your own spectroscope” workshops during the Mini Science Forum.

**Minister Naledi Pandor opens new road to Losberg site, meets with residents of Carnarvon and surrounding communities**

The Minister of Science and Technology, Naledi Pandor, opened the new road from Carnarvon to the SKA Losberg site, followed by an Imbizo and public participation programme with the SKA SA and the communities of Carnarvon, Williston, Vosburg, Brandvlei, Loxton, Calvinia and Van Wyksvlei on Saturday, 18 November 2017.

During the visit, Minister Pandor officially opened the upgraded road connecting Carnarvon to the SKA core site; and Northern Cape Premier Sylvia Lucas and a senior delegation of the provincial government visited the SKA Klerefontein base where the SKA SA Electrician Artisan Training Centre was opened.

The purpose of the Imbizo was to celebrate the benefits that the astronomy project brings to the area in the form of jobs, academic bursaries and technical training for the communities. The new Electrician Artisan Training Centre at Klerefontein, managed by the SKA SA Human Capital Development programme, will provide in-depth on-site training for electrician artisans who have been studying on bursaries provided by SKA SA.

SKA SA also opened the first SARAO|SKA SA Information Centre on the day of the Imbizo. The new centre is a temporary incubator for the envisaged SKA Carnarvon Exploratorium.

**SARAO participates in Science Centre World Summit 2017**

The Japanese word tsungari means “connection” and is the spirit in which professionals from science centres and museums around the world met at the Science Centre World Summit (SCWS) 2017 on Tokyo, Japan from 15-17 November 2017. The summit, held at the National Museum of Emerging Science and Innovation (Miraikan), saw 828 participants from 98 countries discuss how science centres and museums can be relevant to the communities in which they are based, as well as workshop new approaches for the sector to contribute to the achievement of the United Nations Sustainable Development Goals.
SARAO Science Engagement Manager, Anja Fourie, attended the SCWS and participated in the session titled Communicating Big Science, where she presented a paper co-authored with SARAO Head of Communications and Stakeholder Relations, Lorenzo Raynard. The presentation outlined how science engagement and stakeholder relations are entrenched in policy and strategy in South Africa, the NRF|SARAO and SKA SA; the lessons learnt and best practice developed by SARAO in science engagement and stakeholder relations; as well as the role that science centres and museums and their regional networks can play in communication and stakeholder relations for the SKA project.

Report provided by SKA SA

UK Outreach Report

UK SKA Science Community Workshop
Royal Observatory Edinburgh, 7 Sept 2017

More than 50 astronomers from almost 20 institutions around the UK attended a 1-day science community workshop at the Royal Observatory Edinburgh on 7 September 2017. The meeting, organised by the UK SKA Science Committee, provided an opportunity to update the UK astronomy community on the recent developments affecting the SKA. These included the SKA cost control programme, the planning and development of Regional Processing Centres and the UK Radio Astronomy Review, which has been instigated by the Science and Technology Facilities Council (STFC) Science Board.
The meeting included an update on the status and capability of the SKA, from the SKA Science Director Robert Braun, as well as presentations on some of the science being done by the SKA precursors and pathfinder facilities such as ASKAP, MeerKAT, LOFAR and e-MERLIN, in preparation for the SKA.

The meeting concluded with discussion on the strategic priorities for radio astronomy within the UK.

*Dark Matter, Bright Stars at the Royal Observatory Edinburgh*

September 2017 saw the historic Royal Observatory Edinburgh welcome the public to its yearly open weekend, part of the Edinburgh ‘Doors Open Day’. More than 3,300 members of the public visited the Observatory on Saturday 23rd and Sunday 24th September and enjoyed the opportunity to engage with the scientists and engineers who are designing and building some of the world’s greatest telescopes, such as the SKA and the James Webb Space Telescope.

![The Royal Observatory Edinburgh](image)

*SKA Outreach at the University of Cambridge*

SKA staff and students at the University of Cambridge have been promoting the SKA at a series of events aimed at giving the public an opportunity to engage with the University’s scientists and engineers.

*Physics at Work*

The Physics at Work programme is a 3-day event, showcasing the wide variety of ways that physics can be used in everyday life. This free event is open to all school pupils aged 14-16 and aims to inspire the physicists of the future and encourage wider participation in physics.
Nicolas Fagnoni and Dr Hardie Pienaar, of the University’s Cavendish Laboratory, took part in the event, engaging with around 270 students. They gave presentations on radio astronomy, their research and their involvement with the SKA project. They also took time to answer questions from the students.

**Alumni weekend**

Both Nicolas and Hardie also took part in the University of Cambridge Alumni Festival on 22nd-24th September. Whilst engaging with alumni they were able to show some prototype antennas for both the SKA Low Frequency and Mid Frequency Aperture Arrays (LFAA and MFAA) and the prototype for a new Vivaldi feed for the SKA precursor the Hydrogen Epoch of Reionization Array (HERA).

![Image of the SKA and HERA stand at the University of Cambridge Alumni Festival](image)

**Cambridge Science Centre**

Dr Eloy de Lera Acedo, a Senior Research Associate at the Cavendish Laboratory, also took part in a family astronomy event at the Cambridge Science Centre. As well as showing some of the hardware he is designing for the SKA he also gave a talk to around 30 members of the public.

**Ogden Trust Interns working with the University of Manchester**

Staff at the University of Manchester are developing particle detectors to be deployed alongside the SKA-low antennas. This SKA Custom Experiment will study radio emission from cosmic-rays interacting in the atmosphere above the telescope and enable the composition of primary cosmic rays to be measured with unprecedented accuracy. Two undergraduate students, from the University of Durham and the University of St Andrews, spent six weeks working on this project with Professor Ralph Spencer and Dr Justin Bray, as part of the Ogden Trust Internship Programme.
The students helped to assemble a prototype particle detector and use it to detect high-energy muons. They soldered together the component circuitry, tested different layouts for the optical components, and determined the optimum input characteristics for the radio-frequency-over-fibre links that will be required for transmitting the data. They also simulated the performance of the network of detectors that will be based on this design and deployed alongside SKA-low.

Report provided by Hilary Kay, UK SKA Outreach Officer

News From Observer Member Countries

News From France

First SKA France Day

The first SKA France Day took place on October 16th, 2017 in the Jaurès amphitheatre of the ENS Ulm, Paris.

With 120 participants, including representatives from SKAO, the Ministry for Higher Education, Research and Innovation, organisations and institutions, as well as researchers and industrial partners, the meeting offered an important opportunity for exchanges and questions about the SKA project.
The presentation of the French SKA White Book (see below) clearly showed a wide awareness within the French community about the great challenges offered by the SKA project, both for research laboratories and for private companies.

The presentations from the SKA by Philip Diamond (SKA DG) and from SKA France by C. Ferrari (SKA France coordinator) were followed by ten talks illustrating some of the most original scientific and technological French contributions to the project. The meeting ended with the presentation by G. Marquette (SKA ILO) of the “Maison SKA France”, a new structure towards which the SKA France coordination is evolving, created as an instrument in response to the necessity of an innovative, financial approach for large research infrastructures.

All presentations are available at the SKA France web page.

French SKA White Book

The preparation of the French SKA White Book begun at the beginning of 2017 with the aim of illustrating the scientific and technological interests of the French community for the SKA project. The White Book was completed during the summer, and its main content was presented during the First SKA France Day, on October 16th.

This work includes the contribution of 176 authors from 40 research laboratories and 6 private companies. Their fields of interest cover all topics of the international SKA Science Working Groups,
as well as the main ambitious technological challenges of the SKA.

The main body of the book is introduced by a short presentation of the project and a summary of the French situation and interests. Two conclusive chapters illustrate the fascinating interdisciplinary nature of the SKA and the “Maison SKA France” (see above).

The French SKA White Book is now freely available online.

---

A logo for SKA-France

The SKA-France coordination now has a logo that has been designed in collaboration with the SKAO Communications team. It will be adopted during the preparation phase towards a possible French official membership in the SKA project.
Paris Observatory officially involved in the SKA AADC Consortium
Paris Observatory has just officially joined the SKA AADC Consortium. Its contribution is based on the internationally recognised expertise of the electronic team of the Radioastronomy Station of Nançay.
Since the SKA re-costing activity of spring/early summer 2017, the Nançay team is working on the realisation of a LND (Low Noise Delay) to decrease the power consumption, with the same RF performances and a better integration.
The same team has been deeply involved in the conception of mid-frequency aperture arrays since 2004. This led to the construction of the EMBRACE prototype in collaboration with ASTRON (NL), to the ANR project “Aperture Array Integrated Receiver” (AAIR), and, in 2013, to the official involvement of Nançay in the SKA AAMID consortium.

Letters of support
Over several months, the SKA-France coordination is receiving important support letters from French industrial partners, which are available for download at the SKA-France web page.
In this perspective, after Ariane Group, ATOS, Callisto, DDN Storage, Engie, FEDD and NVIDIA, two relevant expressions of interest were sent in the last months to the SKA-France coordination by:
- **Thales Alenia Space (TAS)**, a joint-venture of the groups Thales and Leonardo, worldwide known in the fields of telecommunication, navigation, Earth observation, and construction and operation of orbital infrastructures
- **Air Liquide**, a worldwide known company in gases, technologies and services for industry and health, has expressed its strong interest in developing renewable energetic solutions to face the cooling and energetics needs of the SKA in a fully innovative way.

Meeting about French participation to SKA Band 5
A workshop hosted by the French company Callisto took place on July 26, 2017 in Toulouse.
The main objectives of the meeting were:
• to describe the cryogenic solutions that could be provided by Callisto and of interest for the Phase 1 of the SKA project;
• to discuss and identify possible French funding for collaborative projects between Callisto, other companies and research laboratories, in particular the Laboratoire d’Astrophysique de Bordeaux (LAB), already deeply involved in Band 5 developments.

Following these two objectives, the meeting included representatives from Callisto, SKA-France coordination, LAB and Sysmeca Ingénierie (an SME offering scientific and technical expertise in research and development, with manufacturing capabilities).

Visit of SKA-France and Ariane Group to SKA Headquarters
On September 12, 2017, the SKA-France coordination and French representatives of Ariane Group were hosted at the SKA Headquarters to exchange ideas & best practice in large projects. Five engineers and managers of Ariane Group joined and gave presentations about lessons learned from big projects and of interest for the SKA.

SKA-France HPC and Data Management Meeting
On September 19, 2017, SKA-France organised a meeting with the French companies interested to talk about how to face and be prepared to the future High Performance Computing and Data Managing SKA challenges.

Over several months SKA-France is coordinating a collaboration between Bull-ATOS and French researchers working on algorithm developments, with the main aim of optimising the hardware architectures and the parallelisation of the codes conceived by the scientists.

Our objective is now to take a step forward and have a more coordinated approach between all the French companies interested in the whole chain between the signal acquisition and validation, the image processing phase and the data storage. Representatives of Bull-ATOS, DDN Storage and Thales Alenia Space participated to the meeting.
SKA in the French news

An interview of the SKA-France coordinator about the SKA project and SKA-France activities has been published in the September issue of the French magazine “Ciel & espace”. The interview is inserted within a reportage concerning the beginning of operations of MeerKAT, the South African SKA precursor telescope.

On October 20th, 2017, a delegation of the association of scientific journalists from the information press (AJSP) visited the Radioastronomy Station of Nançay (Paris)
Observatory/CNRS/Orléans University). This was an opportunity to talk about radio astronomy in general, the Station, the results of its existing instruments, the construction of NenuFAR and the SKA project. A successful visit under the sun, which gave rise to an article on the national press concerning also the SKA project.

Report provided by Chiara Ferrari, Coordinator of SKA-France

News From Portugal

1st All-Hands Engage-SKA meeting
8th November 2017, Aveiro, Portugal

Last November took place the formal kick-off meeting of the new Portuguese research infrastructure Enabling Green E-Science for the Square Kilometre Array (Engage-SKA), coordinated by Domingos Barbosa of the radio astronomy Group, Telecommunications Institute, Aveiro, Portugal. This infrastructure is part of the Portuguese Research Infrastructure Roadmap of Strategic Relevance and started officially in 2017. ENGAGE SKA team is the national node for SKA. It involves a team dedicated to the scientific and industrial participation in SKA and for the next three years will target in broad terms the Scientific, Technological and Innovation capacity towards radio astronomy and spin-off impacts, with the development of Portuguese participation in SKA. The meeting counted with senior delegates from institutional nodes discussing the ENGAGE SKA roadmap, and the presentation of new fellows engaging in SKA SWGs and Design Consortia. New members have just joined, namely the researchers Sonia Anton (expert in extragalactic subjects), Alan Alves and Tjarda Boekholt (experts in computational Planetary Systems and Dynamics), Valerio Ribeiro (expert in transients and Novae), Bruno Morgado (expert in cyber systems for radio astronomy and HEP) and Miguel Bergano (expert in receiver systems and industrial procurement).

The project is a partnership between Telecomunication Institute, the University of Aveiro, the Faculty of Sciences of the University of Porto, the University of Évora and the Beja Polytechnic Institute. ENGAGE SKA is also an interlocutor for the broad Portuguese astronomical community.
News From Malta

November has been a busy month for the Maltese team, who have been focused on the arrival of more than 100m² of mid-frequency antennas to be assembled in the field and tested. Figure 1 shows the print-screen of the antennas and the sheets of antennas being printed.
The assembly of the antennas onto a polystyrene base is shown in Figure 2. This is done to provide a mechanical support for the antenna array, which is then placed onto a chicken-wire ground plane and assembled on top of metallic frame.
The assembly of the structure is shown in Figure 3. The entire array is then placed within a dome structure to protect the array from wind and rain. The team then carried out electromagnetic simulations on the metallic frame and the dome structure to understand the effect of these support structures on the array's electromagnetic performance.

![Figure 3: Antenna array assembled inside the dome structure with the ground plane (chicken wire) visible.](image)

Throughout December, the team will be working on taking beam measurements of the array using a UAV system, coupled with GPS, to determine the array's exact performance and compare it with the electromagnetic simulations.

![Figure 4: Dome structure being erected to protect antenna array from the elements.](image)

*Report provided by Kristian Adami*
News From Spain

Activities in Spain

Several activities have taken place in Spain since the last eNews.

Science

The conference *Galaxy Clusters 2017. Theory, observations & future developments* held in July in Santander, counted with the participation of Robert Braun.

In September, a meeting on *Fundamental Cosmology* took place in Teruel. Mario G. Santos (UWV, SA) gave a talk about "Cosmology with the SKA".

In October, Laura Tolós (IEEC-CSIC) participated in the organisation of the workshop "*New perspectives on Neutron Star Interiors*" held in Trento (Italy), where Jeff Wagg (SKAO) talked about SKA.

On the 6th-7th November, a conference entitled: "*Physics opportunities with a new universe’s view: the SKA radio telescope*" was held in the Instituto de Física Corpuscular (IFIC-CSIC/UV) in Valencia (sponsored by the Spanish Network of Astronomy Infrastructures, the IFIC Severo Ochoa Excellence Programme and the Instituto de Astrofísica de Andalucía, IAA-CSIC). It gathered about 50 participants from 16 Spanish and 6 international institutions who worked on maximising the interplay between the SKA Science and the Particle, Astroparticle, Planetary Sciences, Astrobiology and the Cosmology Spanish communities, going beyond radio astronomers and even astronomers.

The conference was opened by the Secretary of State of Research, Development and Innovation (MINECO), Carmen Vela, the President of CSIC, Emilio Lora-Tamayo, the Coordinator of the Spanish Participation in the SKA (IAA-CSIC), Lourdes Verdes-Montenegro, the Rector of the University of Valencia, Esteban Morcillo, IFIC/CSIC-UV Director, Juan José Hernández and the RIA Coordinator (Observatori Astronòmic, UV), Vicent Martínez. Afterwards, the SKA Director-General Phil Diamond gave an overview about the current stage of the SKA project and Lourdes Verdes-Montenegro presented the Spanish participation in the SKA including a summary of the activities performed in the areas of science, engineering and outreach during the last years. Topics covered included the formation of stars and their planets, astrobiology or our solar system as part of the cradle of life area, different aspects of galaxy formation and evolution, as atomic gas studies, magnetic fields or star formation history of the Universe, the transient universe, pulsars or cosmology studies, including the Epoch of Reionization. It is to emphasise that this conference showed the potential for synergies that SKA generates, extending the Spanish scientific community interested in SKA exploitation to a new community: The Particle Physics one. As a sign of the incorporation of this new community to the SKA-Spain initiative, topics like astroparticles or neutrinos within the SKA context were covered, as well as synergies with future key facilities as CTA and Athena.
Credits: IFIC (CSIC-Universitat de València). Opening of the conference “Physics opportunities with a new universe’s view: the SKA radio telescope”. From left to right: Lourdes Verdes-Montenegro (Coordinator of the Spanish Participation in the SKA (IAA-CSIC)), Emilio Lora-Tamayo (President of CSIC), Esteban Morcillo (Rector of the University of Valencia), Carmen Vela (Secretary of State of Research, Development and Innovation (MINECO)), Juan José Hernández (IFIC-CSIC/UV Director) and Vicent Martínez (RIA Coordinator (Observatori Astronòmic, UV)).

Regarding the Spanish participants in the SKAO, we are very happy that another Spanish scientist has joined the Organisation: Cristina García Miró, as a VLBI scientist. Congratulations, Cristina!

Also in the renewal of roles of the SKA Science Working Groups (SWGs), Lourdes Verdes-Montenegro (IAA-CSIC) has become a co-chair of the HI Galaxy Science Group.
Engineering

In October, a series of activities related to the SKA Regional Centres (SRCs) were held at the IAA-CSIC (Granada), scheduled around the first AENEAS All-hands meeting. These activities were:

- A Meeting of the SKA Regional Centre Coordination Group (SRCCG).
- A colloquium in which the AENEAS IP (Michael Wise) gave a talk on how SRCs network will constitute a platform to carry out SKA science and astronomy. In addition, the head of computer network of the LHC (Ian Bird) gave a talk about the recent collaboration agreement signed between SKA and CERN. The audience of these talks were mostly astronomers and engineers from IAA.
- An SKA-Link project meeting: SKA-Link project is CSIC’s i-Link that IAA coordinates, setting up a collaboration with teams involved in the SKA Science Data Processor, SKAO and European experts in e-Science. They are working on a document with a set of best practices aiming to contribute to make of SKA a reference in scientific methodology. The SRCCG will incorporate to its deliverables the SKA-link documents.
- AENEAS plenary meeting, attended by more than 40 people.

Picture of the participants of the first AENEAS All-hands meeting celebrated at the IAA-CSIC, Granada, Spain.

- To conclude the week, there was an Open forum to discuss some aspects related to the design of future e-Science infrastructures

Miguel Andrés Sánchez Carrasco (IAA-CSIC) has been invited to participate in the Dish Band 2 Feed system CDR review panel, as a mechanical engineer expert in cryogenics.

Outreach

The Spanish SKA mini-site keeps growing. We have now included a section where Spanish participants in Science Working Groups can explain their scientific interests on SKA.
In September, Lourdes Verdes-Montenegro was interviewed for a Documentary called “Buscando vida” (Looking for life), a project formed by 3 individual documentaries that will give a broad perspective of the work that is currently being performed to find other types of life out of our planet. These documentaries are produced by two Spanish production companies: Planeta 9 and Synopsis 103.

The European Researchers’ Night: on the 29th of September, for the second time in a row, Lourdes Verdes-Montenegro gave an outreach talk about SKA in the stand that IAA-CSIC set for the event. About 10 000 people visited the tents.

![Picture taken during Lourdes Verdes-Montenegro’s talk in the European Researchers’ Night celebrated in Granada.](image)

On the evening of the 6th of November, Lourdes Verdes-Montenegro gave an outreach talk in the City of Arts and Sciences of Valencia, with more than 180 people registered to attend it.

We have translated into Spanish the little leaflet about SKA, to hand it out in the outreach activities. Valencia was the first place where we offered them and people loved it.

![Cover in Spanish of the SKA leaflet.](image)

Report provided by Marina Fernández-Peña Mollá (IAA-CSIC)