SKA newsletter
Volume 25 - November 2012

The Square Kilometre Array
Exploring the Universe with the world’s largest radio telescope

www.skatelescope.org
Project news
A message from the Director General

I write this short note for the SKA Newsletter after having been Director-General for only a few short weeks. The project is, as it seems to have been for some time, in a transitional phase. However, with the ratification of the site decision on November 14th by the Members of the SKA Organisation, with the move into the new SKA HQ at Jodrell Bank, with the beginnings of a wave of recruitments into the office and with my appointment, I hope that the community of scientists, engineers and government officials driving the SKA can see momentum building.

My first few weeks on board have been both exciting and busy. I have been building up a detailed picture of the state of the project; have initiated a review of the system engineering plans (scheduled for November 27-29, 2012; chaired by Jason Spyromilio of ESO); and have formed a working group to further develop the SKA Concept for Operations. In between I found time for a one week visit to South Africa, the purpose of which was to gain a detailed understanding of the MeerKAT project, to develop views on how MeerKAT might be incorporated into the SKA and to discuss the South African role in the pre-construction phase. The visit to the MeerKAT site in the Karoo was the highlight of the trip. I would like to thank the team in South Africa, who devoted their week to helping bring me up to speed.

While I was in the Southern Hemisphere the SKA staff were moving into our new headquarters at Jodrell Bank. The building, constructed by the University of Manchester
from the office of the SKA Organisation

for the SKA, is of the quality one would expect for an international project. The picture shows Prof Steve Watts, Head of the School of Physics and Astrophysics, welcoming the SKA to the building. I’m sorry I missed the champagne! The building will be formally opened in early 2013.

Activities over the coming months will be focused around the rapid development of the system engineering approach to the SKA design; preparing for the issuance of the Request for Proposals to participate in the pre-construction phase; and the formal start of discussions between the Board, represented by the SKA office, and the two host countries, Australia and South Africa, on the details of the hosting agreements. This will be a complex process covering all areas necessary to establish an international, mega-science facility in the two host countries. The SKA Organisation’s negotiating team will be led by Michiel van Haarlem, who has kindly agreed to continue with the SKA office on a 50% basis. I would like to say thankyou to Michiel for his extremely competent guidance of the SKA Organisation through its formative months; he undertook a difficult job with calm professionalism and it is a pleasure to continue to work closely with him.

Phil Diamond, SKA Director General.

A message from the former interim Director General

Following the setting up of the SKA Organisation and the announcement of the result of the site selection process, the SKA Board took the important next step of appointing Professor Philip Diamond as the new Director General of the SKA Organisation. He took over from me on 15 October 2012. Phil is no stranger to the SKA Project, having chaired the International SKA Steering Committee and served on the SKA Science and Engineering Committee. Most recently he was Chief of CSIRO Astronomy and Space Science (CASS) and before that Director of Jodrell Bank Centre for Astrophysics. Phil has over 30 years experience in radio astronomy. He takes over at a very important and also exciting time in the project as the pre-construction phase gets underway and the work package consortia prepare to help move the project to construction readiness over the next few years. I want to take this opportunity to congratulate Phil on his appointment and wish him all the best for the future of the SKA.

One of the outcomes of the SKA site selection process was the decision to incorporate the two SKA precursors in Australia and South Africa into Phase one. The office was asked by the Board to take the lead in assessing how this integration should proceed. An important element in this process was a visit to each of the two sites. After travelling to South Africa in September a similar visit to
Australia followed in October. In South Africa the team from the SKA Office met with the MeerKAT team at their headquarters in Cape Town and visited the site in the Karoo where preparations for MeerKAT’s construction are taking place. In Australia, the team visited management and the engineers in Sydney and Perth, before travelling to the Murchison Radio Observatory which hosts the Australian SKA Pathfinder (ASKAP). The information gathered during these visits will be used to develop, in partnership with the Australian and South African teams, a detailed implementation plan for the integration of the ASKAP and MeerKAT precursor telescopes, and associated infrastructure, into phase one of the SKA.

The summer was a busy period for SKA outreach around the world - not just for the SKA office in Manchester. The site decision generated a lot of interest in the project. The SKA was well represented at the IAU General Assembly which took place in Beijing, China from 20-31 August. The stand was visited by many delegates throughout the two week conference. A new and refreshed version of the SKA project’s web site (www.skatelescope.org) went live in early October.

William Garnier was appointed as the New SKA Chief Communication Officer over the summer and will join the SKA office on 19 November. We say goodbye to Jo Bowler who set up the SKA office’s outreach activities and was previously also the SPDO’s Outreach Officer. We thank Jo for her tremendous contributions over the past three years and wish her all the best for the future.

As I handed over to Phil Diamond, the Office of the SKA Organisation was getting ready to move into its new offices at Jodrell Bank Observatory in Cheshire - some 30 km south of Manchester. Work on the building has progressed rapidly despite a very wet English summer. It has been an exciting time over the last year setting up the SKA Organisation and making the transition from the SKA Programme Development Office. I hope to stay involved in the SKA project and look forward to visiting these offices and hope to see many of you over the next few years as the project moves steadily towards construction.

Michiel van Haarlem, former interim Director General
The SKA is a complex ‘big science’ project and, having recently visited the SKA sites in Australia and in South Africa, and assessed the implications of the dual site agreement, the SKA Organisation engineering team is now identifying the detailed requirements that will inform the overall system engineering plan. Definition of the major SKA sub-systems, which will be designed by consortia of contributing organisations, is also underway. In addition, the SKA office will be recruiting in the coming months and encourages individuals with relevant qualifications to apply.

The concept phase and concept design reviews (CoDRs)

Earlier this year the last of the CoDRs for the various major sub-systems was held. System concept development is the first stage of the design process. The concept stage began with the development of the overall telescope level concept, which had been reviewed earlier, and concepts for the major subsystems followed on from this through 2011 and the early part of 2012. Although less formal than the system now being put in place, the lead and supporting institutions put a great deal of effort into preparing and presenting the concepts to the review panels. The output of these is a very important record of concept designs complete with considerable performance and cost analysis, which will feature in the next phase of the system engineering process.

CoDRs completed: aperture arrays, dish and dish arrays, signal transport, networks & timing, signal processing, monitor & control (telescope manager), and software & computing.

SKA system engineering

The SKA has all of the hallmarks of a complex project as well as fitting the ‘big science’ description. There are multiple participants, funding sources, cultures and...
many stakeholders. There are also competing technologies. This all points to the use of a formal systems engineering approach for the design, suitably tailored to fit the unique aspects of the SKA project. Systems engineering is an interdisciplinary approach to engineering, which focuses on how complex engineering projects should be designed and managed over their life cycles.

The engineering team is assessing in detail the functions that both the telescope system and the SKA Organisation will perform. This information will be used to identify the requirements which will be fed into the system engineering plan. The full set of requirements are clearly stated goals that contain the best balance of key science surveys with the additional goal of constructing a flexible radio telescope system capable of a wide range of high-sensitivity observations, and takes into account the progress to the full SKA. Clearly the science is top level and to this end the Design Reference Mission (DRM) document has now been ‘baselined’ and is being analysed to extract requirements.

There are many other sources of requirements besides the science. This process will occur not only at the organisation and system levels, but also at sub-system levels. Major sub-systems (elements in SKA parlance) will be designed by consortia of contributing organisations. The focus of work in the SKA office is to assemble a robust set of system requirements and to allocate additional requirements to the element level so that the consortia can begin their system engineering tasks. This is a major task and the SKA office has solicited assistance from experienced people in the participating organisations to carry it out expeditiously. An external review of the system engineering approach as applied to the SKA is planned for mid-late November.

The site agreement and its impact on engineering

Earlier this year the SKA Board formally decided to develop the SKA across two sites. For SKA phase one, the SKA site in South Africa will host a dish array and the SKA site in Australia will host the low frequency aperture array, as well as a smaller dish array specialised for high survey speed (the ability to cover large areas of sky in a
short time). While the science requirements, constrained by cost, will ultimately decide on the performance details of each of the telescope systems, this partitioning enables the engineering progress to accelerate. Recently an all-hands visits by the SKA office technical staff to each of the sites took place. This was extremely useful in acquainting the office with the realities of the sites on the ground. In addition, the precursor telescopes (ASKAP and MeerKAT) are currently in advanced stages of construction on the same sites. The purpose of these visits was twofold: to engender a good understanding of the impact of these telescopes on the sites and on potential SKA phase one programmes; to obtain a measure of how much of the infrastructure and other parts of the precursor telescopes might be re-usable for the SKA.

"The SKA has all of the hallmarks of a complex project as well as fitting the ‘big science’ description."

Defining work at the sub-system (element) level

The SKA telescope system has been partitioned into elements, the major telescope sub-systems (see the list of CoDR topics) plus power and infrastructure. Over the past year, the system engineering, management and technical work needed through the requirements definition phase has been organised in work breakdown structures (WBS) and statements of work (SoW) for each element. (A subsequent stage will include work from the requirements definition phase to the detailed design phase). This is quite an extensive, detailed breakdown, running to some hundreds of pages. A call for Expressions of Interest to carry out the work was sent out to known interested parties, to which there were more than 100 responses, and a formal Request for Proposals (RfP) will be released early next year. Currently the WBS/SoW is being reviewed in light of the dual site decision. In the meantime consortia are forming to respond to the RfP, which must be led by institutions from one of the participating countries. Consortia are likely to be assemblies of participating organisations, supplemented in some cases by industrial partners.

Recruitment

The SKA Office is going to be carrying out a recruitment drive in the coming weeks and months with a view to increasing the staff numbers to about 50 people. We urge interested people with relevant qualifications to consider applying for these positions, which will be posted on the SKA website and advertised in other media.

Peter Dewdney, Project Engineer.
This summer’s outreach activities started with the very wet, though well attended, Live from Jodrell Bank festival in June where the SKA featured in the Science Arena. Further afield, in August the SKA Organisation was in attendance at the large IAU General Assembly exhibition in China. In Manchester a collection of SKA images has been included in an art exhibition as part of the Manchester Science Festival - don’t worry if you can’t visit, all the images are also online. Last but not least we have been making some improvements to the SKA website, we hope you like them.

SKA plays a part at the Live from Jodrell Bank festival
The Live from Jodrell Bank festival, held in the shadow of the Lovell telescope, took place on the 23rd June at Jodrell Bank, UK. The SKA booth featured in the Science Arena, an area packed with demos and activities that offered festival goers a chance to find out more about science and engineering at Jodrell and beyond. Despite heavy rain more than 12000 turned out to see Manchester band Elbow headline the Saturday night concert. Glowing blue SKA balloons, visible in pictures of the evening, were handed out to the crowd. An evaluation survey carried out at the event to assess public perception and knowledge of the SKA received more than 600 responses. The results of the survey can be used help inform future SKA outreach.

SKA Organisation attends XXVIII IAU General Assembly
The SKA Organisation had a busy exhibition stand at the General Assembly of the International Astronomical Union (IAU) held at the end of August in Beijing, China. The SKA stand, manned by Georgina Harris and Jo Bowler representing the SKA Organisation, with the assistance of Xiang Zhang from the National Astronomical Observatory China (NAOC), saw a great deal of activity throughout the fortnight. It was a great benefit to have a native Chinese speaker providing translations and chatting with the large numbers of Chinese delegates about the SKA. The IAU GA is held every three
years and is one of the largest astronomy conferences in the world. This year the meeting, which ran from 20 – 31 August, had more than 3200 registered attendees. In addition to the exhibition, several talks were given on the SKA in sessions relating to forthcoming large-scale facilities.

**SKA brochure and factsheet**
An amended SKA brochure and factsheet was produced following the site announcement. A short print run was carried out for the IAU GA exhibition and several copies of both still remain. A large print run and distribution to international SKA partners will be carried out in the coming months. If you would like to receive printed copies of the brochure please contact the SKA office using the enquiries@skatelescope.org email address.

**SKA factsheet in Chinese**
We are pleased to add this Chinese language SKA factsheet to our existing collection of translated material. Translated by Xiang Zhang, from NAOC for the IAU GA in Beijing, the factsheet proved very useful for the Chinese delegates who visited the SKA exhibition stand.

**SKA images on show at Manchester art cafe**
A collection of SKA images has been included in an art exhibition as part of the Manchester Science Festival. Celebrating invention, ingenuity and innovation, the art on show highlights the creative side of science and engineering. The exhibition is hosted by the Nexus Art Café in Manchester’s Northern Quarter and runs until the 18th November 2012. If you’re not able to visit the
improvements to the SKA website

You may have already spotted that the SKA website is looking a little different. It is now more than a year since the new website was launched and, having listened to comments and requests from the SKA community, we have made some changes that will make the site easier to use and navigate. The improvements include a features bar at the top of the homepage that will highlight new documents or information added to the website. There is also an ‘in this section’ box on the right of each page to suggest pages that you may wish to visit. We want to keep improving the website and so if you have further suggestions or spot a missing link please let us know using the enquiries@skatelescope.org address.

SKA HQ images on Flickr

We have added some images of the new SKA Organisation headquarters to the SKA Flickr page showing the construction period and now the finished building. Check them out here.

I will soon hand over to the new Chief Communications Officer, William Garnier, who starts on the 19th November. If you are interested to find out what I am up to please visit www.johannabowler.com

Jo Bowler, interim Outreach Officer
News from around the world
In early October a meeting of the SKA Board was held in Perth, Australia. While in Western Australia, Board members and other invited guests attended the official opening of CSIRO's ASKAP telescope. ASKAP is now undergoing commissioning. In a major milestone and world first, phase closure was recently achieved on three of ASKAP’s PAF receivers. The MWA telescope, also located on Australia's SKA site, is reaching the advanced stages of its commissioning program and will be officially opened in late November. Other recent technical upgrades include the procurement of a peta-scale supercomputer for the Pawsey Centre to support SKA pathfinder science and a capability upgrade of the AUT 12-metre telescope in Warkworth, NZ, to enable greater eVLBI opportunities with Australian telescopes.

**SKA Organisation Board visits Australia**

In early October 2012, members of the SKA Organisation Board visited Australia for a two-day meeting and other SKA related events. On the evening of 6 October, a drinks reception was held in Perth’s King’s Park to welcome the Board to Australia and to acknowledge the important role the SKA project plays will play in global astronomy. The Board was welcomed by speeches from...
Federal Science Minister, Chris Evans and his Western Australian counterpart, Minister John Day. During their visit, board members visited Australia’s SKA site to witness the opening of one of Australia’s precursor survey telescopes, the Australian SKA Pathfinder (ASKAP).

**ASKAP Opening Ceremony celebrations**

Friday 5 October 2012 marked an historic day for the SKA project. Under clear blue skies, Science Minister Chris Evans officially opened CSIRO’s Australian SKA Pathfinder (ASKAP) telescope – a major SKA precursor telescope that will eventually form part of SKA Phase 1. The opening celebrated the construction of ASKAP and the establishment of the Murchison Radio-astronomy Observatory (MRO) on which ASKAP is sited. Guests on the day included SKA Organisation Board members, senior government representatives, ambassadors of SKA countries, industry representatives, neighbouring pastoralists and traditional owners of the MRO, the Wajarri Yamatji. Highlights included a ‘Welcome to Country’, traditional dancing by members of the Wajarri Yamatji, and the naming of the ASKAP antennas with traditional Wajarri names. Proceedings concluded as several antennas rotated in unison to point to Virgo A and test data began to stream in.

**MWA ready for launch**

Another SKA precursor telescope located at the MRO, the Murchison Widefield Array (MWA), is in the final stages of testing and will be officially launched at the end of November. The MWA is the only low frequency SKA precursor and an important stepping stone...
News from around the world

to the Phase 1 low frequency SKA. The MWA is well into its engineering and science commissioning program, already collecting and outputting science quality data. Recently, MWA astronomers used the telescope to image an area of the sky 20,000 times larger than the full Moon. The MWA is led by Curtin University and is a collaboration between thirteen research institutions in Australia, India, New Zealand and the US, several of which are already processing commissioning data. Data transfer tests between ICRAR and Victoria University of Wellington in New Zealand are also taking place to prepare for future astronomy surveys. The MWA will launch on Friday November 30th with events at the MRO and in the town of Geraldton to mark the occasion.

ASKAP achieves phase closure on PAF receivers
In a major milestone for ASKAP commissioning, phase closure was achieved in August on phased array feed (PAF) receivers installed on the ASKAP antennas. This was the first time ever that phase closure has been successfully demonstrated on a three PAF system. Not only is this an important step in calibration of the antennas in preparation for interferometry with ASKAP, it also demonstrates the antennas and their electronic systems function as expected. In addition, final site acceptance tests carried out on all 36 of the ASKAP antennas have confirmed the reflector accuracy at levels a factor of two better than the required ASKAP specification. Efforts are now focussed on the next commissioning milestone – BETA – an engineering test array of six PAFs and their associated electronics systems installed on ASKAP antennas at the MRO.

Supercomputer procured for Pawsey Centre
The procurement of a Cray peta-scale supercomputer to be housed at Perth’s Pawsey Supercomputing Centre was announced in July this year. By 2014, the supercomputer will have a combined performance of over 1.2 petaflops to support the data-intensive science carried out by the ASKAP and MWA telescopes. The supercomputer will be built to complement two smaller supercomputing systems which have already been established at Murdoch University and the University of Western Australia.

Upgrade of New Zealand radio telescope
Auckland University of Technology’s 12 m radio telescope in Warkworth, NZ was recently upgraded to L-band capability, giving it compatibility with the ASKAP telescope and other antennas in Australia. The upgrade will allow further very long baseline interferometry (VLBI) opportunities between the two countries. The L-band feed was designed and manufactured by InterTronic Antennas (Canada) with funding support from the NZ Ministry of Economic Development.
Steady progress is being made on composite reflectors, phased array feeds, low noise amplifiers and digital technologies for the SKA. In addition, plans for the proposal to lead the central signal processor work package in stage one of the SKA preconstruction phase are underway.

Composite Reflectors
Construction of the 15 m Dish Verification Antenna (DVA-1), being developed by National Research Council (NRC)/ Dominion Radio Astrophysical Observatory (DRAO) and the US Technology Development Program, is well underway after a successful critical design review (CDR) held in June 2012. Beam pattern analysis at 10 GHz shows a gain loss of less than 0.1 db over gravity, wind, and thermal test cases indicating that DVA-1 will operate at a very high performance level. Tony Willis has been simulating observations based on an array of DVA1 antennas configured with 1100 to 1900 MHz broadband feed designs developed by Bill Imbriale of JPL. The simulations clearly show that feeds that produce antenna radiation patterns with low asymmetry yield superior images. Fabrication
of the primary and secondary moulds is complete with delivery scheduled for October 15 2012. The pedestal, designed and fabricated by Minex Corp., is substantially complete with all large parts fabricated. The DVA-1 project is on schedule for 'first light' in the first half of 2013.

**Digital Systems**

The Office of the SKA Organisation, supported by organisations and groups around the world, is in the process of finalising the work breakdown structure (WBS) and statement of work (SOW) for the stage one SKA work packages. A request for proposals for the work packages will be issued in early 2013. NRC/DRAO, in a collaborative contract with MacDonald Dettwiler & Associates (MDA) of Vancouver BC, is proposing to lead the central signal processor (CSP) stage one work package. A plan for proposal has been generated and received a favourable response at the kick-off telecon held on September 5 and 6 2012. At that telecon a number of other potential CSP consortium leads decided to join the Canada-led consortium. Recent effort has been focused on adding detail to the SKA Office WBS/SOW so that a contractually ready proposal with precisely defined inputs, activities, relationships, and deliverables can be written. A preliminary distilled WBS has been combined with an EoI (Expression of Interest) form and a preliminary stage one execution schedule, and sent to potential consortium members.

**University of Calgary**

**LNA and ADC Development**

Researchers at the University of Calgary continue their work on a fully integrated SKA receiver and broadband low power analogue to digital converters (ADCs). The RF portion of a single IC direct-sampling receiver in 65 nm TSMC CMOS is currently undergoing testing. The tests show 70 dB of gain over the design frequency range from 0.7-1.4 GHz with input return loss of better than 8 dB. Noise measurements are being undertaken but the large gain of the circuit causes measurement difficulties that are being resolved. New 10 GS/s 4-b Flash ADCs have been fabricated in 65 nm TSMC CMOS and delivered to the University of Calgary in early September. Initial low frequency tests show that the self-calibration circuit is operational, increasing the effective number of bits (ENOB) from 2.2 to 3.9 with 5 GS/s power consumption of approximately 50 mW. Careful testing is on going to verify all aspects of ADC operation. Testing of time-based 65 nm TSMC CMOS ADCs is also on going. The time-based ADC, consisting of two stages, which are separated by cables, is operating at 5 GS/s and is operating both as an ADC and as a data transfer system. Time-domain waveforms show abnormalities at some input frequencies, which cause a reduction of the effective number of bits (ENOB) at these frequencies from about three to nearly two. The cause of the frequency dependent behaviour is thought to be due to high input signal levels. Accurate investigation of these abnormalities is underway.
**Phased Array Feeds**

Significant progress is being made on the development of the Advanced Focal Array Demonstrator (AFAD) with a prototype thick Vivaldi element developed in collaboration with Christophe Craeye and Rémi Sarkis at the Université catholique de Louvain, Belgium. The elements are self-supporting, low loss and are thick enough to house a low-noise amplifier (LNA) near the antenna feed point, reducing feed-line losses (for testing a coaxial cable connects the feed point to the output connector in the figure). Craeye et al. have performed a full-wave EM simulation of a 71-element array using this Vivaldi and the data are being used to design an LNA coupling network. These results were recently presented at the 2012 International Conference on Electromagnetics in Advanced Applications in Cape Town, SA.

Each LNA output in AFAD is connected to a receiver module which amplifies, filters, and digitises the signal. A high speed ADC directly samples at the signal frequency (of 0.7 - 1.5 GHz).

*The prototype AFAD receiver. The analogue board (left) and the controller board (right) that make up the receiver module.*
China continues to play an important role as a member of the SKA Organisation. The IAU General Assembly held in Beijing earlier this year was an opportunity to highlight not only Chinese astronomy but also the involvement of China in the SKA Project.

**SKAO exhibitors during IAU General Assembly**

The 28th International Astronomical Union General Assembly (IAU GA) was held in Beijing between 20 - 31 August 2012. Mechanical engineer Dr Georgina Harris, Outreach officer Dr Jo Bowler and Dr. Xiang Zhang from the Chinese SKA team represented the Office of the SKA Organisation with the SKA telescope conference booth for the duration of the two-week meeting.

Georgina Harris, Jo Bowler and Xiang Zhang gave visitors to the stand detailed overviews of the SKA project including scientific objectives, key technology, site selection, construction timetable and organisational management. Xiang Zhang translated the SKA factsheets into Chinese. The stand attracted considerable media attention and interviews were given to Xinhua News Agency, Chinese Science News, BBC Knowledge magazine and many other media. The meeting proved an excellent opportunity to highlight the SKA project to the international astronomy community.
Ever flown a hexacopter? Now's your chance to see one in action. Italy is working alongside partner countries on the aperture array verification programme (AAVP). One of the goals of the AAVP is to refine the electromagnetic (EM) tools and test systems necessary to design and measure low frequency aperture array antennas. The Italian team (INAF, CNR-IEIIT and Politecnico di Torino) designed and manufactured both a single sensor, which covers the whole AA-low band (70 - 450 MHz), and an innovative test system based on a flying hexacopter.

The Vivaldi antenna
A dual-polarisation metal-only Vivaldi array element has been investigated for AA-low by INAF/IRA in collaboration with CNR-IEIIT. The main design goals of the antenna are high directivity in the ±45° angular region from the zenith (required sky coverage), low reflection coefficient above 200 MHz and compact transverse size in order not to have too many grating lobes. It is composed of a matching section with circular stub and a tapered slot radiating section. The single-ended excitations (one for each polarisation) are placed at the interface between these two sections. In practice, the two feeding probes are the central conductors of 50 Ohm coax structures, so balun transformers are not required. The two polarisations are completely independent and exhibit the same behavior owing to the symmetry of the structure. For that reason, good performance in terms of (raw) cross polarisation are easily obtained on the principal planes. One antenna able to work properly without
a metallic ground plane would be a great advantage for AA-low. It would allow for cost reduction and would simplify the site preparation. For that reason, particular care has been taken to determine the effects of the soil and to understand how it should be included in the EM simulations.

Studies on antenna industrialisation, aimed to reduce costs and mechanical complexity, are ongoing.

A first low cost prototype, made in collaboration with the Italian industries Cospal Composites and Sguinzi, based on aluminum honeycomb technology, has already been manufactured. Thanks to this technology, the number of mechanical components of the antenna reduces from more than 200 to about ten. Consequently, the assembly time drops from about an hour to a few minutes. First measurements on the industrial prototype have shown no appreciable performance degradation with respect to the lab prototype. Another approach, developed in collaboration with ASTRON, is under evaluation and preliminary measurements already show good results.
The unmanned aerial vehicle (UAV) test bench

One of the main goals of the AAVP program is to prove electromagnetic performance on full-size elements, both isolated and in small array configurations (AAVS0). In the AA-low band it is quite challenging to perform effective antenna measurements. As a result of both the low operative frequency

![Hexacopter on operation.](image)

and the interaction of the antenna with the soil, with or without a metallic mesh, measurements in anechoic chambers are not possible. Moreover, astronomical tests on the field with only one or few elements are difficult and not very accurate due to lack of sensitivity, exposure to RFI and the low gain/large FOV of the antennas. As a consequence, INAF, in collaboration with the CNR-IEIIT and the Politecnico di Torino, has been studying an antenna measurement system based on a micro UAV. When in operation an RF transmitter mounted on an hexacopter, synthethises a far field source which scans the entire antenna FOV. The operator is necessary only during takeoff and landing phases. The first implementation of the UAV is based on a commercial solution, with engines and some electronic parts which have been modified. Three different positioning sensors are used by the system. The main one is the on-board GPS receiver, which has a navigation accuracy of half a metre and a real-time accuracy of one metre. This sensor is coupled to a magnetometer to improve the height accuracy to 0.1 m. The overall accuracy is then enhanced with absolute measurements using a ground-based measurement system called total station. This instrument has a nominal distance and angle accuracies of 3 mm + 1.5 ppm and one arcsec, respectively, within a one kilometre operative range. The far-field measurements are performed using a planar scanning strategy. In early July, a test field for both single and small antennas array was set up at the Medicina radio telescopes. Preliminary results of antenna pattern measurement are in good agreement with the expected ones. This measurement system seems very promising and could be very useful in order to fulfill the AAVS0 objectives.

![UAV assisted landing/take off.](image)

Check out a movie of the tests with aerial views taken by cameras mounted on the hexacopter. Watch on [YouTube](https://www.youtube.com).

![Assembling of the 3x3 Vivaldi array for UAV embedded element pattern measurement.](image)
The Netherlands, working alongside European partners, has been making significant progress in aperture array antenna development. There has also been considerable work on phased array feeds for the APERTIF prototype. ASTRON and IBM have joined forces on DOME, an exascale computing research project and as LOFAR enters its operational phase, we update you on recent developments.

**Aperture arrays (NL, UK, It., Fr.)**
The SKA aperture array program made significant progress in the completion and verification of new AA-low antennas to cover the large frequency band of 70 to 450 MHz. Two new antennas have been developed, both reported below, the SKALA log-periodic antenna and the Vivaldi. Developments on spiral antennas, the third alternative for the low band, have been stopped due to insufficient dual polarisation performance. Of both remaining antenna types small 16 element verification arrays have been constructed. Besides the antenna, design work on receivers and signal processing commenced in order to make the necessary performance improvements from LOFAR and MWA to SKA1. The last Aperture Array Verification Program (AAVP) workshop was held at ASTRON in Dwingeloo, Dec 2011. Program and proceedings can be found at: [http://www.astron.nl/aavp2011/](http://www.astron.nl/aavp2011/). A specific meeting on the aperture array calibration and calibrateability, AACal 2012, July 2012, Schiphol, was organised by the calibration and imaging working group. Reports of the considerable progress can be found at: [http://www.astron.nl/AACal2012/index.php](http://www.astron.nl/AACal2012/index.php)

"High sensitivity is crucial; it minimises the number of elements required and substantially reduces cost."

The AA-mid verification system EMBRACE, one in Westerbork and one in Nançay, continued to produce convincing results demonstrating the merits of dense aperture arrays. Issues with local RFI have been overcome by additional filtering and control and processing software written, resulting in a demonstration of a pulsar detection and HI mapping at the same time utilising the dual independent field of view capability of EMBRACE, one of the unique features of aperture arrays.

The SKA low frequency phased array operates from <70 MHz to
450 MHz. This is challenging, especially with the area of sky that must be covered ±45° or more and good polarisation purity characteristics. High sensitivity is crucial for the antenna as it minimises the number of elements required and so substantially reduces the total system cost.

INAF, in collaboration with CNR-IEIIT and Politecnico di Torino, has designed and manufactured a dual-polarisation, metal only, Vivaldi array element, which covers the whole AA-low band. See the Italy article in this newsletter for more details.

Log periodic antennas are wide bandwidth, but normally have too narrow a beam; however, careful design for the SKALA antenna developed at Cambridge University has widened the beam such that it is more sensitive over the full beamwidth than a more isotropic antenna. Work to reduce the cost and installation time is progressing well with a wire based antenna that minimises the amount of material. The SKALA design can meet SKA requirements; the next phase of development is to further optimise the ease of manufacturing and deployment of the element.

**Phased array feeds: APERTIF in Westerbork (Nl.)**

Lots of work has been put into the hardware and firmware development for APERTIF which is progressing steadily. The work has included a frontend filter to combat severe out-of-band RFI contributing to the overall system noise budget. With the completion of the final receiver hardware design we now estimate the total APERTIF system temperature to be around 70 K. Disappointing as this is, a first assessment indicates that most of the core science goals envisioned in the original APERTIF funding proposal can still be achieved. Most importantly, the APERTIF prototype has successfully demonstrated the polarimetric calibration of a phased array feed system depicted in the picture insert. The accuracy of the calibration was confirmed by the measurement of the rotation measure of the celestial source BL Lac. The measured rotation measures for an on axis beam (-204.1 rad/m²) and a 1 degree scanned beam (-204.9 rad/m²) agreed very well with the reference measurement taken with the WSRT (-205.1 rad/m²). This observation
convincingly demonstrated that the APERTIF prototype can be polarimetrically calibrated and that no major issues remain to successfully perform polarimetric measurements with APERTIF phased array feeds!

At the same time, preparations at the Westerbork Synthesis Radio Telescope (WSRT) for the installation of APERTIF are on-going. To transport the almost 200 Gbps from every dish to the correlator, new fibre-optic cables have been dug into the ground. Electromagnetically shielded cabins are procured to house the analogue and digital electronics at every dish. Once all infrastructure is in place the WSRT will be ready to receive the PAF systems.

Developments on exascale computing (Nl.)
The computational and storage demands for the SKA radio telescope are significant. Building on the experience gained with the collaboration between ASTRON and IBM on the Blue Gene based LOFAR correlator, ASTRON and IBM have now embarked on a public-private exascale computing research project aimed at solving the SKA computing challenges. This project, called DOME, investigates novel approaches to exascale computing, with a focus on energy efficient, streaming data processing, exascale storage, and nano-photonics. DOME will not only benefit the SKA, but will also make the knowledge gained available to interested third parties via a User’s Platform. The intention of the DOME project is to evolve into the global centre of excellence for transporting, processing, storing and analysing large amounts of data for minimal energy cost: the 'ASTRON & IBM Center for Exascale Technology'. A key was handed over at the second face to face meeting in Zurich (IBM ZRL) in June to Albert-Jan Boonstra who is leading the Dome operations.

Developments at JIVE (Eur.)
One of the aims of the EC-funded NEXPReS project, recently rated excellent in its second year review, is to prepare the EVN for the higher bandwidths that are becoming available. As part of the project, the first ever 4 Gbps EVN test observation was performed in June 2012, involving the telescopes at Effelsberg, Onsala and Yebes and the NORDUnet, SURFnet, RedIRIS and GÉANT research networks. Using digital base band converters and Mark5C recorders, data were simultaneously recorded at 4 Gbps at the stations and correlated in real time on the SFXC software correlator at JIVE at speeds of 1, 2 and 4 Gbps. The UniBoard project, part of RadioNet FP7, has produced a generic, high-performance computing platform for radio astronomy. At JIVE, the focus has been on the development of a VLBI correlator application. Also in June, just before the formal end of the project, the first fringes on a baseline between Jodrell Bank and Effelsberg were produced, successfully demonstrating the end-to-end functionality of the design.
Towards a green future for radio astronomy (Eur.)

Information from SKA pathfinders and precursors indicate that power will be an important part of the lifecycle cost of these large-scale radio astronomy instruments. This will be greatly amplified for the SKA itself with energy transport infrastructure, power generation for the electronics and signal processing being key factors. Thus, efficient power generation and usage are paramount for these projects. An EC proposal led by Spain, with partners from Portugal, Netherlands, Finland, Germany, Belgium and Sweden, was recently approved to investigate one innovative approach towards the use of thermal solar energy to power radio astronomy stations and study the 24/7 duty cycle of radio astronomical observations. It involves the installation, in South east Portugal, of a concentrated solar power system with storage for night operations to power EMBRACE type stations at the site. Besides bringing expertise from industry, this experiment provides experience with RFI assessments of solar power plants and related subsystems along with the RFI motivated optimisations for radio astronomy. In June, an international workshop was organised in Moura, Portugal aimed at reviewing current R&D trends, industry forecasts for solar energy options, and experiences that may be relevant to the challenges set by mega science infrastructures, in particular by the SKA. The workshop also reviewed the convergence with the Horizon 2020 EC roadmap and the integration and development of low carbon emission technologies, as part of a strategic energy technology plan (SET-Plan) adopted by the European Union. The focus was on green energy experiences such as solar photovoltaic, solar thermal, smartgrid and hybrid power mix management. Attendees of this highly interactive and informative workshop were representatives of government, industry and scientific partners from all over the world. The attendees visited the now fully operational 50 MW Moura solar voltaic power plant and the EU’s first commercial solar thermal plants in Sanlucar near Seville in Spain (see http://www.power-technology.com/projects/Seville-Solar-Tower/). The workshop presentations and other details can be found here.

LOFAR enters its operational phase (ILT)

Following a period of intense development commissioning, LOFAR will start its first operational phase in December, 2012. During the first semester, 1 December, 2012 - 31 May, 2013, functionality offered to the community includes interferometric observations for synthesis imaging, plus in/coherently added single and multiple station data (several beam-formed modes) as well as transient buffer-board read out (for example for studies of pulsars, transients, and cosmic rays). The first release of the software accompanies all offered observing modes. In view of the first call for proposals, the current characteristics of the array were determined, by analysing a series of test observations with the available software and
are reported on the LOFAR web site. For the proposal deadline of 17 Sep, 2012, 43 proposals were submitted by international groups. The 247 individual authors are affiliated to institutes from 17 countries. After review on scientific merit and technical eligibility, 90% of the designated observing and processing time, will be allocated in tandem between national LOFAR consortia and the independent Programme Committee (PC) and this will include reserved access.

Meanwhile, five new LOFAR stations in the Netherlands have been constructed during the spring and summer 2012, and will be included in the array by the end this year; the remaining two (of the 40 planned) will be constructed in 2013. Specially designed hardware enabling the connection of all 24 core stations (those within a radius of 2 km from the centre of the array) to a single distributed clock, was modified to include an improved clock distribution within the station electronics. These new boards were installed in early autumn 2012 and will allow the coherent addition of all 24 core stations, where required, from the start of operations.

In parallel with the operational phase, considerable development will continue throughout 2013, in order to reach the full potential of the International LOFAR Telescope (ILT). While the preparations for the transition to the operational phase were ongoing, the intense commissioning work has led to an increasing number of scientific results that appear in the literature. A few recent examples of the early scientific output of LOFAR are shown here.

de Gasperin et al (A&A accepted): LOFAR HBA image of Virgo A at 140 MHz. The rms noise level is $\sigma=20\mu$Jy/beam, the flux peak is $101\mu$Jy/beam and the beam size is $21\times15$ arcsec. Some deconvolution errors are visible as small holes slightly above and below the bright core.

van Weeren et al (A&A, 543, 43 (2012)): Abell 2256 61–67 MHz images in grey scale and contour form. Left: High-resolution, $22\times26$ arcsec beam image. The radio relic (source G and H) is indicated with the dashed ellipse. Contour levels are drawn at $\{1, 2, 4, \ldots\} \times 30$ mJy beam. Right: Low-resolution (beam $52\times62$ arcsec) image. Contour levels are drawn at $\{1, 2, 4, \ldots\} \times 75$ mJy beam.
The SKA site decision has triggered intensified activity in the SKA South Africa project office and has provided the incentive for a number of events, including a visit by President Jacob Zuma to the SKA site, celebrating this important milestone in the SKA project. Various scientific and engineering meetings relevant to the SKA have also been held over the past months.

**Government support for the SKA project**

President Jacob Zuma visited the SKA site on 9 October 2012 in what has been described as a turning point for science in Africa, proving that African science enjoys support at the highest level. The president touched down by helicopter at the telescope site about 100 km from Carnarvon where the seven KAT-7 telescope dishes are already operational. The newly appointed Minister of Science and Technology, Mr Derek Hanekom, as well as his predecessor who played a key role in the SKA bid, Ms Naledi Pandor, joined the President on his visit. The support of the South African government has been recognised as a key factor in the country's SKA bid.

The Minister of Science & Technology, Mrs Naledi Pandor, hosted a gala dinner in Pretoria on 17 July 2012 to celebrate the significant achievement on the path towards the SKA.

Rhodes University hosted the Minister, government officials and SKA South Africa project staff at a celebratory function in Grahamstown on 27 August 2012. Rhodes

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“I am absolutely excited to be here and see this area making such a significant contribution to global science,” President Jacob Zuma told the crowd. (Photo: Siyabulela Duda, GCIS)

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Dr Bernie Fanaroff (middle) with South Africa’s Minister of Science and Technology, Ms Naledi Pandor (right) and her predecessor Mr Mosibudi Mangena (left) at the gala dinner in Pretoria, July 2012. Minister Mangena was also an avid supporter of the SKA during his term of office, as was his predecessor, Dr Ben Ngubane, who also attended the event.

The Minister of Science & Technology, Mrs Naledi Pandor, hosted a gala dinner in Pretoria on 17 July 2012 to celebrate the significant achievement on the path towards the SKA.

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Head of Physics and Electronics at Rhodes University, Professor Makaiko Chithambo (left), congratulates Prof Justin Jonas.
alumni, staff and students have played key roles in the establishment of the SKA South Africa project.

The team that produced the African SKA site proposal were recognised for their sterling work by the National Research Foundation (NRF) on 13 September 2012. The citation for this award read: “The NRF recognises the commitment, creativity and achievements made by the SKA bid team in securing the SKA project for South Africa and the partner countries; their contribution to the advancement of human knowledge in the fields of science and technology for the benefit of South African society, and for the role they played in raising the country’s stature in the arena of international scientific research.”

Dr Fanaroff was honoured as South Africa’s Ambassador of the Year at a gala event hosted by Die Burger newspaper and the Cape Town Chamber of Commerce. Dr Fanaroff was recognised for his leading role in the participation of South Africa and African partner countries in the SKA project.

**MeerKAT milestones**

Recent major milestones in the MeerKAT project were the awarding of the dish antenna contract, the initiation of major infrastructure projects on the Karoo site, and a successful preliminary design review (PDR) for the MeerKAT L-band receiver.

Four consortia responded to the call for tenders for the MeerKAT antennas, and after a comprehensive selection process the contract was awarded to a consortium consisting of South African company Stratosat Datacom (Pty) Ltd and technology partner General Dynamics SATCOM. The contract was signed at the NRF offices on 31 July 2012. (Media release at [http://www.ska.ac.za/releases/20120809.php](http://www.ska.ac.za/releases/20120809.php))

Two civil engineering firms – Group Five and Brink & Heath – have moved onto the Karoo site and are establishing power and
data reticulation services, a road network, and operations buildings (including the buried facility that will house the electrical and electronic equipment at the central site complex).

EMSS, the company responsible for developing the MeerKAT receivers, hosted a PDR (preliminary design review) for the L-band receiver from 27 – 31 August 2012. The panel, comprising Peter Dewdney (SKA Office), Jan Geralt bij de Vaate (ASTRON), Bob Hayward (NRAO), George Nicolson and Keith Jones (both HartRAO), considered the cryogenically cooled single pixel receiver design to be both innovative and mature. EMSS will now progress the design to the critical design review (CDR) phase and construct pre-production prototypes.

Ten members of the SKA Office visited South Africa from 10 – 14 September 2012 in order to explore how phase one of the SKA might make the most effective use of the MeerKAT and its associated infrastructure. Discussions about the technical, scientific and administrative aspects of integrating MeerKAT and SKA phase one were held at the Pinelands engineering headquarters of the SKA South Africa project, and also in the Karoo during the two day excursion to inspect the infrastructure being developed on site.

The week of 2-7 September 2012 saw a very successful trio of international meetings in Cape Town that included topics relevant to the SKA: the International Conference on Electromagnetics in Advanced Applications (ICEAA ’12), the IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (IEEE APWC ’12), and the Electromagnetic Environment and Interference Symposium (EEIS ’12).
Onsala Space Observatory, representing Sweden, was formally accepted on 27 June 2012 as a member of the SKA Organisation. A number of projects are already underway in Sweden including system analysis of dish antennas and the development of wide-band, single-pixel feeds.

Sweden joins SKA Organisation
On 27 June 2012 the SKA Organisation approved Onsala Space Observatory, which is hosted by Chalmers University of Technology, as a new member.

"Our application to join the SKA has already been ratified by the Swedish Research Council and by Chalmers, and today it was accepted by the SKA Board. I’m happy to say that Sweden is now officially the SKA’s ninth member country, ready to participate fully in the design of the telescope", said John Conway, deputy director of Onsala Space Observatory represented the observatory at the board meeting in Schiphol, Netherlands, when the decision was taken.

"The SKA will be one of the 21st century’s most important pieces of scientific equipment. For astronomers it is a long-awaited step into the future and an immensely exciting challenge. It will give us new insight into the nature of our astonishing universe and how it has become a place where life could arise", says Hans Olofsson, director of Onsala Space Observatory.

For Onsala Space Observatory, founded in 1949, working with world-class radio telescopes is business as usual. Nowadays many facilities it contributes to are off-site – ALMA and APEX in Chile, for example – but the 20 metre and 25 metre telescopes at the observatory site on the beautiful Swedish west coast are valuable components of the global astronomical and geodetic VLBI networks. And since 2011, Onsala has its own station in LOFAR.
"It's great to have Sweden and Onsala Space Observatory in the SKA. Onsala Space Observatory has a long history of expertise in radio astronomy which will be a huge asset as we make the technology and engineering choices which will define how the SKA will work and what it will be able to do to transform our understanding of the universe", said John Womersley, chairman of the SKA Organisation board.

What can the SKA expect from Sweden?
A number of projects are already underway.

"Together with the Department of Signals and Systems at Chalmers, we are carrying out system analysis of dish antennas. We want to calculate how combinations of antennas, feeds and receivers work together, following the analysis through the calibration and imaging process", explained John Conway.

Sweden is also strong in receiver technology and has its own foundry for MMIC technology at Chalmers. Another related area of work involves wide-band, single-pixel feeds, capable of spanning a factor of 4 to 10 in frequency.

John Conway explained. "Wide-band feeds potentially allow very large savings if you compare to the cost of building and operating a suite of octave bandwidth receivers," he said. "They also have unique scientific advantages, especially in the key science areas of pulsar timing and astrometry, with the ultimate goal of tracing gravitational waves".

The Eleven feed is an example of this kind of instrument. Developed together by companies Omnisys, Elevenantenna, Low Noise Factory and Onsala Space Observatory with geodetic VLBI in mind, the Eleven feed has now been developed in a version which is optimised for the SKA.

"I'm happy to say that Sweden is now officially the SKA's ninth member country, ready to participate fully in the design of the telescope",

"In the next stage of SKA, we want to work with our international partners in developing and comparing different wide-band feed designs to find the best technological solution for the SKA", said John Conway.
Future meetings and events

Visit the meetings calendar page to find out what SKA-related meetings are coming up. More details