Square Kilometre Array Newsletter

Feature article

Scanning the Skies for Life:
Where it began, where else it exists and what it all means.
Maureen Arges Nadin

One of the most mysterious and compelling facts that I learned when I first delved into amateur astronomy is that the starlight we see in our earthly skies left its source star hundreds or even thousands of years in the past. It is both overwhelming and humbling to consider what we might learn if we had the capacity to look back to the beginnings of our Universe. Read on

Engineering update

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Science update

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Other activities involving the SWG have been varied and include the first public release of the Design Reference Mission, participation in the PrepSKA Work Package 2 annual meeting... Read on

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Project news

Engineering update

Sparse aperture array antennas. Image available from the SKA website.

Science update

Strong field tests of gravity using pulsars and black holes. Credit: Michael Kramer and SuW.

Site characterisation

The RFI station in the Western Australian Outback at Boolardy.
News from the consortia and institutes

USA
Progress reports on SKA development work in the USA, for this issue of the newsletter, come from the MWA, the LWA, the US TDP and the ATA.
Read on

Korea
The International Center for Astrophysics at the Korea Astronomy and Space Science Institute hosted an SKA workshop on August 20th in Daejeon, Korea.

More than fifty scientists and engineers participated in the workshop and expressed their interest in the SKA project. Several speakers reviewed the status of the SKA project and various activities are now underway in the Korean astronomy community.
Read on

Canada
PrepSKA WP2 research work in Canada continues its focus on composite reflectors, focal plane, phased-array feeds and digital systems at NRC-HIA.

Research on low-noise amplifiers (LNAs), analogue-to-digital converters (ADCs), and multi-dimensional signal processing continues at the Universities of Calgary and Victoria, while cyber-infrastructure development is ongoing among a network of institutes in Canada and the US.
Read on

Outreach update
Thank you to everyone who provided feedback on the new look SKA newsletter. We have taken all your comments and suggestions into account and I hope that the changes we have made will make viewing the newsletter easier for those of you who experienced problems.

This edition we report on a range of new outreach resources including a new mini-conference stand, an SKA postcard, new images and the launch of the Square Kilometre Array Facebook page.
Read on

Future meetings and events
Visit the meetings calendar page on the international SKA website to find out what SKA-related meetings are coming up.
More details

Industry participation
During the past three months, industry engagement and participation activities have concentrated on support of WP5 PrepSKA tasks, investigating power storage options and industry interactions.
Read on

SKA promotional postcard available for download from the SKA website.
Reports on SKA progress in Europe in this edition feature aperture array development, high bandwidth, long distance, links achieved with the e-EVN as well as the continued roll-out of LOFAR.

Read on

Following an extensive engineering design process, the baseline design concept for the South African MeerKAT SKA precursor telescope has been decided.

This process consisted of an in-depth design study that investigated implementation options and tradeoffs for all key subsystems, and culminated in a Concept Design Review...

Read on

At ISKAF 2010, the Au–NZ delegation outlined how maximising the discovery potential of the SKA would also bring the greatest international benefits ‘beyond astronomy’ such as technology developments, green energy innovations, opportunity for industry and attracting young people to careers in science.

Other recent highlights of the Au-NZ SKA programme include an announcement of a CSIRO-ASTRON collaboration on Phased Array Feeds (PAFs) and funding for development of renewable energy solutions...

Read on

Cygnus A at 240 MHz with LOFAR. Credit: John McKean LOFAR/ASTRON.

The new design of the dishes of South Africa’s MeerKAT telescope.

Members of the A-NZ delegation at the anzSKA booth during the ISKAF 2010.

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**Subscription information**

We are keen to continue improving the SKA newsletter.

Please send comments and suggestions to Jo Bowler, Outreach Officer.

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+44 (0) 161 275 4130.

To add or remove names from our mailing list, please email:

enquiries@skatelescope.org
As rapid progress is made in the characterisation of the proposed SKA sites, considerable thought is also going into planning the next phase of SKA development.

Progress continues to be made in the characterisation of the sites ahead of the site selection decision that will be made in early 2012. Measurements of the levels of Radio Frequency Interference (RFI) at the proposed locations for the core of the SKA, in Western Australia and Northern Cape Province, were completed last month. Similar measurements are planned at four remote sites, and will be carried out as soon as the exact locations of the sites have been determined. Array configurations have now been generated for the SKA in Australia, and are under development in South Africa, taking the constraints of geography and risk of electro-magnetic interference (EMI) into account. The configurations will be refined once the relative weights of the site selection criteria affecting the configurations have been agreed by the SKA Siting Group (SSG). The SSG has begun work, with its first task being the development of a roadmap of activities required over the remaining 16 months to site selection. Next in line for the SSG will be the definition of “science” and “non-science” selection criteria and their relative weights.

A great deal of thought is currently going into the scope of the next phase of SKA development - the Pre-Construction Phase from 2013-2015. At its meeting last June, the Agencies SKA Group (ASG) commissioned a Project Execution Plan (PEP) for this phase in which the design work to be done and resources required are outlined. The PEP is being prepared by a 15 person team from around the world and will be presented to the SKA Science and Engineering Committee (SSEC) and the ASG at their meetings in late October. Funding for the final year of the Preparatory Phase (2012) is also required and will be a subject of discussion at those same meetings.

Technology development specifically for the SKA will be the main theme of the PrepSKA WP2 meeting that will be held in Oxford, UK on 27-30 October. Over 100 people have registered for the meeting, and much lively discussion is anticipated. I hope to see many of you there.

Richard Schilizzi - Director
One of the most mysterious and compelling facts that I learned when I first delved into amateur astronomy is that the starlight that we see in our earthly skies left its source star hundreds or even thousands of years in the past. The light that we are seeing has actually travelled through time. It is both overwhelming and humbling to consider what we might learn if we had the capacity to look back to the beginnings of our Universe - about the cosmos, the billions of galaxies and other worlds that spin silently across vast distances, and more importantly, our place in that Universe.

What if we had a telescope large and powerful enough to look back in time and space to the moment right after the Big Bang when stars and galaxies were just emerging from the legendary primordial soup and bringing the first glimmers of light to an evolving universe? The SKA will be such a telescope and it will experience first light or, perhaps more accurately, first signal, as early as 2019. And when it does, it will bring us to the threshold of not only a brand new chapter in the understanding of the Universe but quite possibly a lot closer to the ultimate soul searching question that has been asked by every human being that has walked the terra firma of this planet – “why are we here?”.

With the SKA, the largest telescope in the world, we will be able to look further out into the Universe than ever before and we will do it together, not as nations divided but as a human community united in a common goal to discover our cosmic roots.

The possibility of cosmic revelations that could literally rock our world is brought to us courtesy of the field of radio astronomy. In the case of the SKA, multiple linked radio telescopes will utilise aperture synthesis to digitally mix or synthesise the signals from separate antennas. When the SKA project is complete, the numbers of antennas will be in the thousands and the largest antenna separation will be more than 3000 km.

For most of us, the SKA science case contains very powerful concepts, usually confined to the realms of science fiction movies and books. The search for extra terrestrial life, dark energy and alternate dimensions are heady abstractions and although we might be able to imagine their existence, are we able to absorb the ramifications of such a discovery in terms of our own existence? The SKA will take us into new frontiers in more ways than just the hard science.

The revolution in astronomy brought about by the SKA will potentially trigger a similar revolution in the ideologies of areas such as philosophy, spirituality and religion. For the first time in our human history, there just might be answers to those really big
questions. Who are we, how did we get here and what is our purpose?

As I wrestled with the concept of how it is all interconnected, I was fortunate to be able to speak with Russ Taylor, Professor of Physics and Astrophysics at the University of Calgary, and gain his perspective on the ultimate intersection of science and philosophy.

"By charting a complete history of time, we will hope to understand whether the rise of life was encoded in the event that created the Universe," he explained. "Is the world as we know it logically necessary as the result of the initial conditions of the Big Bang or was it an accident?"

In other words, was life necessary? Or as a philosopher pondering the same question from a more metaphysical perspective might ask - not so much whether life was necessary but, if it wasn’t accidental in scientific terms, does it have a larger purpose or indeed does it have any purpose at all? Are we merely a random event?

Such lofty questions bring a tone of existentialism to a debate that might originate in the halls of the Astronomy Department but will not end there. The potential revelations of the SKA will have a major impact on countless ideologies that have given rise to many of the world’s major religions and philosophical bodies of work.

The SKA could also provide us with long sought after answers about the existence of other intelligent life. Let us ponder the possibility of the SKA detecting signals from a star with a family of exo-planets. If we were to realise that not only is there life on a planet other than Earth, but that it is sentient, intelligent life, capable of producing technology, then this would be a discovery that could both comfort and terrify us. For most of us, I would speculate, it would be something in-between but there is not a single soul that would be unaffected.

The science that the SKA reveals will also bring us on a human journey that could challenge everything we have come to believe about ourselves and the nature of our existence. As Norwegian writer and poet, Rolf Jacobsen reflects “If we go out far enough, we are only at the beginning of ourselves”. With the SKA, we will become time travellers and like all intrepid pioneers, we must be prepared for what we find. In looking back and reaching an understanding of how our Universe and our planet was born, we may also come to know why. And that revelation could potentially shake the foundations of many of our core belief systems. Are we ready?

Four hundred years ago, Galileo Galilei challenged the beliefs of his time and his own conscience when his improvements to the telescope transformed it from a terrestrial spy glass to a device for viewing the heavens. The revelations that came to him through that telescope defied the current heliocentric view of the Universe and put Galileo, a devout Catholic, at odds with his Church and ultimately, his own spiritual beliefs.

When the SKA brings us to those shores of self discovery, some will undoubtedly experience a similar conflict. As we grow closer to the launch of what promises to be one of the most exciting and dramatic undertakings of the 21st century, there is indeed much to think about.

Maureen Arges Nadin is a freelance writer and columnist. This is an abridged version of her article that was awarded second place in an RASC (Royal Astronomical Society of Canada) sponsored competition, Canada and the Stars, for the International Year of Astronomy in 2009.
The next phase of SKA development is the focus of ongoing work to prepare the Project Execution Plan proposal for funders. The SPDO is working with the global SKA collaboration on the proposal that will outline requirements for the SKA Pre-Construction Phase.

The plan will cover the post-PrepSKA period until construction of Phase 1 of the SKA (SKA1) commences. Although the plan covers all areas of SKA development, engineering forms the backbone of pre-construction activities. A key component of the proposal will be a long term plan that puts current work, the Pre-Construction Phase, the SKA1 Construction Phase and the development of Phase 2 of the SKA (SKA2) into perspective. An important element of this plan is determining how to carry out the construction of SKA1, while designing for extensibility to SKA2. SKA2 is likely to utilise developing technologies that must be at a high level of readiness at the time of construction.

SKA System Work
Work is underway to address the recommendations proposed by the panel of the System Concept Design Review (CoDR) that was held in February 2010. The formal system requirements are also being obtained and documented following a model that has been demonstrated in the signal processing area. These two main components will form the basis for a Delta System CoDR that is scheduled to be held in early 2011.

Signal Processing
A strong emphasis on obtaining requirements for non-visibility processing is starting to yield results. The methods being used to obtain, document and track requirements will set a pattern throughout the entire project. There are now drafts of a technology-watch document, a high-level signal processing description for correlators and non-visibility processing, and a document on beam forming for phased array feeds. Two SKA Memos have also been produced on potential correlator design, and two further Memos have been published on transient processing. The SKA Memo series can be viewed at the following link: http://www.skatelescope.org/pages/page_memos.htm

Computing and Software
The annual Calibration and Imaging Meeting (CALIM) was hosted by ASTRON in late August. Much of the work going on in this area is centred on algorithms and computing methods for calibration of wide-field images in which the instrumental parameters depend on field position. Work is also continuing on more elaborate forms of self-calibration, such as deriving antenna pointing parameters from the science data, themselves. The SPDO and partners are continuing to develop a clear understanding of the size and complexity of the computing requirements for SKA1.

Costing
An SKA costing strategy is now being produced. The strategy outlines the methods and principles by which costs for the SKA will be obtained.
Receptors
Cost estimation for sparse aperture arrays is underway with LOFAR data being used as a basis for estimation.

Structural design work is continuing in the TDP/Canadian dish design collaboration.

Optics design investigations in the TDP and MeerKAT projects are providing insights into the beam performance of potential antenna designs.

Industry
The UK Electronics Knowledge Transfer Network held a meeting in London to highlight the importance of the SKA to UK industry and to provide an update on progress to interested parties from industry. There were presentations from representatives of the UK Science and Technology Facilities Council (STFC), UK-based SKA partners, the SPDO, and industry.

Peter Dewdney - SKA International Project Engineer
**Science Update**

The Science Working Group (SWG) welcomes two new members, who are poised to take on important roles. In addition, the SWG has been involved in the design of SKA Phase 1 and is likely to play an important part in the assessment of the configuration of the telescope. Other activities involving the SWG have been varied and include the first public release of the Design Reference Mission, participation in the PrepSKA Work Package 2 annual meeting, participation in the IAU General Assembly and supporting the Astro2010 process.

The SWG welcomes new members. Dr Minh Huynh, recruited earlier this year, will now join the SWG in the role of Deputy International Project Scientist. Minh will work alongside Joe Lazio, the International SKA Project Scientist, and will be based at ICRAR in Australia but spend extended periods at the SPDO in the UK. Minh has experience with several international telescopes, including NASA’s Spitzer Space Telescope and CSIRO’s Australia Telescope Compact Array, and has been a leading member of international teams working on projects such as the Planck mission. A second addition to the SWG is Dr Lisa Harvey-Smith who has recently accepted the position of Australian SKA Project Scientist.

SKA Phase 1

With the release of a concept description for Phase 1, the SWG has begun to consider both the science implications of the Phase 1 description and the science requirements. Both the SKA Science Case and the Design Reference Mission for the low- and middle-frequency components of the SKA are relevant to the SKA Phase 2. The concept for the SKA Phase 1 includes a definition of its key science, namely observations of the Epoch of Reionisation and pulsar timing. Both are key components of the larger SKA Science Case, and particularly the SKA Key Science Projects. The technical design work for SKA Phase 1 is ongoing, and as part of that the SWG has extracted the relevant portions of the SKA Phase 2 Design Reference Mission to help guide the Phase 1 design process. Tiger teams are also being established from within the SWG, and the broader community, to help provide advice about specific aspects of the Phase 1 design.

SKA Configuration

The quality of the images that the SKA will produce, and ultimately its scientific performance, will be determined in no small part by the distribution of antennas that comprise it, also known as the ‘array configuration’. The Configurations Task Force has been working over the past year and a half to develop a set of array configurations. The SWG has provided intermittent advice during this process. However, the next stage of the process is scientific validation, or verifying that potential configurations on the candidate sites produce acceptable scientific images. The SWG will have a role in assessing the scientific performance of proposed configurations.
**New Worlds, New Horizons**
The U.S. Decadal Survey, Astro2010, released its assessment of astronomical priorities for the 2010 - 2020 decade. SWG members had contributed a large number of white papers as input to the process.

The prepublication report noted a discrepancy between the SKA schedule and the time when a significant US contribution could be made, but stated "unqualified enthusiasm for the science that this facility (the SKA) could deliver and recognition that it represents the long-term future of radio astronomy". The prepublication report also recommends that approximately every five years the international science community should come together in a forum to share scientific directions and strategic plans, and to look for opportunities for further collaboration and cooperation, especially on large projects like the SKA. This will provide the opportunity for mid-course corrections in US astronomy priorities.

*Joe Lazio, Project Scientist*
Site Characterisation

Data collection at both candidate sites has progressed well since the publication of the previous newsletter, with a number of activities running in parallel at the two sites. Information from both of the sites is required to inform engineers about the conditions under which their designs must work but also, and more importantly at this stage, to inform the site selection process that will take place in early 2012.

Radio Frequency Interference (RFI)
The measurement stations that will investigate the radio interference environment have now been deployed in the core regions of the candidate sites in both Australia and South Africa. This was an important milestone and it took hard work by teams in both countries to get the hardware designed, built and tested.

At the South African site, near the seven KAT telescopes in the Karoo, measures were taken during RFI measurements to minimise the amount of interference generated by the presence of humans and installations. This meant keeping the number of people down to the absolute minimum and also shutting down other electronic equipment at the site, including the KAT telescopes and PAPER.

Deployment of RFI measurement station in the Karoo, South Africa.

In Australia, the RFI measurement station was positioned near the first ASKAP dish in the Outback at Boolardy. This site will be bustling with activity once a new batch of precursor antennas appear at the site, but during the RFI measurement campaign all was quiet and man-made interference was avoided wherever possible.
At both sites the campaign was started with a set of test measurements, progressing into the agreed schedule of RFI measurements in two polarisations and four prime directions along the horizon. There were mishaps at both sites that caused brief delays, but no major flaws in the performance of the sets were encountered.

The high sensitivity measurements have now been completed and initial analysis of measurements looks good. What now remains to be done is to carry out measurements at four remote station locations in both South Africa and Australia. More work is also required on the data processing and reporting software which will be carried out at ASTRON in the Netherlands. Once these final tasks are complete, the concluding reports will be delivered.

Array configuration
A highlight in the process of designing configurations for the SKA was the visit of the Configurations Task Force (CTF) to Australia to work with the Australian team.

Designing the SKA configurations combines the scientific requirements with the practical limitations within areas that masks have indicated are suitable for antenna placement. Masks, as explained in the July 2010 newsletter, reflect the limitations that the terrain, the topology and Electromagnetic Interference (EMI) impact have on placement opportunities for the antennas.

The configuration, including the locations of remote stations, was successfully completed. It is however, likely to undergo fine-tuning to achieve optimum performance, infrastructure cost and EMI risk. The design will therefore be revisited once the relative weighting factors for these aspects have been established.

The first phase in the design of the South African configuration is scheduled to take place at the end of September 2010 when the CTF will visit the South African team to carry out the joint design effort.

The start of the South African configuration design has been given the go ahead after the SKA Science and Engineering Committee (SSEC) and the ASG took the decision to treat EMI buffer zones around the positions of farmsteads not as no-go areas but as potentially viable locations with increasing EMI risk the closer an antenna is placed to such a farmstead. A figure of merit for the EMI risk is being developed, and will provide quantitative information for the site evaluation.

Troposphere
The construction of the two tropospheric phase interferometer systems is progressing at JPL. It is expected that the systems will be ready for shipment and deployment at the two candidate sites in November 2010. The two sites, together with the SPDO, are working towards a rapid installation and validation so that recording of data can start as soon as possible.

Rob Millenaar, SPDO Site Engineer
Industry Engagement

During the past three months, industry engagement and participation activities have concentrated on support of WP5 PrepSKA tasks, investigating power storage options and industry interactions.

Work Package 5 (WP5)
The procurement model analysis is mostly complete, and the draft options and risks report is partly complete. It has been decided to combine the inventory of national policies and SWOT analysis into a single document that will mature into a fully developed report integrating the research, findings, and recommendations. An interim version of this combined report is now available on the WP5 Wiki, and will be further discussed during a proposed procurement workshop planned for late October in the UK (concurrent with the WP2 meeting). Following feedback from this workshop, the document will be further refined, and independently reviewed by a suitable expert consultant, prior to moving on to a white paper on options for SKA procurement for the Plenary Funding Agencies Group.

The global capability assessment (scouting) method and process which is now in advanced draft form was discussed at the September WP5 telecon, and is expected to be rolled out during 2010/2011 across the SKA consortia regions.

Other activities
- Research across large science facilities around the globe continues to inform the industry engagement effort and strategy. The SPDO has released an Industry Engagement Strategy document which is available for download from the SKA website.

- Phil Crosby (Manager, Industry Participation Strategy) provides ongoing support to the Power Investigation Task Force (PITF) meetings, in terms of linking industry capability and developments to the group. An investigation into Vanadium Redox Batteries (VRB) shows these to be of significant interest to the SKA power challenge and the leading supplier will address the PITF in Oxford in October.

- The SPDO continues to meet and talk to industry players regarding the project requirements. Phil Crosby and Kobus Cloete (Project Manager) visited BAE Systems radar testing facility on the Isle of Wight to discuss strategic involvement. A Knowledge Transfer Network (KTN) event was held in London on 16th September, and Phil Crosby will address applications of astronomy-led technologies at the Royal
Observatory, Edinburgh, UK on 14th October.

- Three further SoMI's (Statements of Mutual Interest) are under negotiation with global vendors.

Kobus Cloete (third from left) and Phil Crosby (third from right) visit BAE Systems radar antenna testing facility.

Phil Crosby,
Manager - Industry Participation Strategy,
SPDO
Thank you to everyone who provided feedback on the new-look SKA newsletter. We have taken all your comments and suggestions into account and I hope that the changes we have made will make viewing the newsletter easier for those of you who experienced problems.

This issue we report on a range of new outreach resources including a new mini-conference stand, an SKA postcard, new images and the launch of the Square Kilometre Array Facebook page.

The Outreach Committee is pleased to announce the launch of the Square Kilometre Array Facebook page. Search 'Square Kilometre Array Facebook' or click the link below to access SKA photos, videos, news, information and discussions. You can view the page without a Facebook account but you do need to sign in if you want to contribute.


New images
New images showing the proposed configurations of SKA stations across Southern Africa and Australia – New Zealand have been created and are now available from the image library on the SKA website: http://www.skatelescope.org/pages/journ_hri_mages.htm

Proposed SKA configuration images.

Non-astronomy benefits of the Square Kilometre Array (SKA) radio telescope
The SPDO has published a report on the non-astronomy benefits of the SKA. The document classifies the major benefits of SKA development in four key areas: Information and communication technology (ICT), renewable energy, global science-industry-government linkages and human capital development. The document can be downloaded from the SKA website: http://www.skatelescope.org/PDF/100922_SPDO.Summary_COST.strategic.workshop.into.non-science.benefits.of.SKA.pdf
SKA postcard
Developed by RadioNET, this new postcard featuring the SKA antennas and central core region is available for general use. The postcard can be downloaded from the website: www.skatelescope.org/outreach/100929_SK_A_postcard.pdf

Mini conference stand
A new mini conference stand has been created to complement the existing large stand. The three-sided stand features images of the Australian and South African proposed core sites as well as the three antenna types. If you would like to see the SKA display stands at a conference in your area in 2011, let us know and we will try to fit it into our 2011 conference schedule.

SKA brochure and flyer
We have just carried out a short print run and a small number of the SKA brochures and flyers are now available from the SPDO. These will last until early 2011 when a full revision and large scale print run is scheduled.

Get Involved!
If you have an idea for an outreach activity or would like advice on how to go about SKA outreach in your region, contact your local Outreach Committee member (www.skatelescope.org/pages/page_pubout.htm) or contact Jo Bowler bowler@skatelescope.org +44 (0) 161 275 4130.
For this issue of the newsletter, progress reports on SKA development work in the USA come from the MWA, the LWA, the US TDP and the ATA.

Early results from the Murchison Widefield Array: high dynamic range solar imaging
Solar observations were carried out with the 32 tile (32T) MWA prototype during the March 2010 site visit. Several interesting features were seen in the data. Notably, multiple weak transient features were observed, most of them too weak to be detected and reported elsewhere. These data allowed the production of low radio frequency solar images with unprecedented dynamic range, over a wide band, with high spectral and temporal resolution. Although based on the observations from established solar facilities, the sun was characterised to be radio quiet, the 32T data reveal it to exhibit highly dynamic behavior at low levels. The following figures give some details of one such dataset, observed on 27th March 2010, around 04:30 UT.

Image A. Amplitudes of the visibilities as a function of frequency (X axis) and time (Y axis) measured on one of the longer 32T baselines (~150m) for the X polarisation. These data span ~10 min with 1 s resolution and a frequency range from 171 to 202 MHz with 40 kHz resolution. A bright feature covering the entire frequency band is seen at ~04:30 UT and was not reported by any radioheliograph. Large numbers of much weaker narrow-band features are also clearly seen.
A cut across the time axis of Image A centered at 191.1 MHz and averaged over 0.8 MHz; the top panel shows the self-calibrated amplitude in arbitrary units and the bottom panel the phase in degrees.

A montage of total intensity images of the Sun showing the time evolution of the most prominent feature seen in Image A. The absolute flux scale is uncalibrated, but relative changes in the peak flux by a factor of ~8.5 are seen. A total of 25 s of data is shown, starting from 04:29:52 UT. Each frame corresponds to an integration of 1 s in time and 0.8 MHz in frequency, centred at 191.1 MHz. The time and spectral extent of the data presented here are marked approximately on Image A with a red rectangle. The dynamic range of these images is about 2500, and the rather large changes in the emission morphology at very short time scales are clearly evident.

Based on this early analysis, the promise of these data and the MWA is clear. These are some of the highest dynamic range radio images of the Sun ever obtained at these frequencies, and the spatial dynamics and evolution of weak (by conventional standards), short-lived features is clearly seen. The ubiquitous narrow band features in these data imply a non-thermal emission mechanism, most likely plasma radiation from relativistic electrons accelerated by magnetic reconnection. The MWA is opening a new observational regime where we can now examine the radio Sun in unprecedented detail.

D. Oberoi and L. D. Matthews

Long Wavelength Array

In August, JPL delivered the first element of the digital backend, the Transient Buffer (Wideband) (TBW). This captures the full LWA band in a 60 ms time slice. Using a selection of 19 antennas within the LWA-1 station, plus an outrigger 300 m to the east, we can use the TBW to support development of all-sky imaging capability.

The images below show the results (using self-calibration) for a mere 10 TBW captures (600 ms total), for five selections from the full band, together with the (u, v) coverage. We anticipate installation of the Transient Buffer (Narrowband) next month, at which point we will be able to test real-time imaging with a 100 kHz bandwidth using the Prototype All-Sky Imager being developed jointly with NRL and LANL.

Meanwhile, we are completing procurement and installation of the remaining parts of the digital system, with initial operating capability and science observations using 256 antennas expected early next year.

Further details can be found on the LWA web pages at http://lwa.unm.edu
LWA results: Ten TBW captures (600 ms total), for five selections from the full band and the (u, v) coverage.

U.S. TDP Report
The U.S. NSF funded Technology Development Project has proceeded in its two main work areas, (1) Antennas and (2) Calibration and Processing. The overall focus continues to be on the planning and development for an SKA prototype antenna, known as Dish Verification Antenna 1 (DVA-1). The project is a partnership led by the TDP working with the Dominion Radio Astronomy Observatory, the National Radio Astronomy Observatory, and the SKA Program Development Office.

Technically, DVA-1 has the following features:
- Offset Gregorian optics
- 15 m aperture
- Optics and mechanical design that strives for high performance with wideband single-pixel feed antennas, octave feed antennas, and a phased-array feed. The mechanical design will meet pointing and stability specifications while also minimizing weight and cost.
- Installation on the EVLA site for testing, which will comprise single dish tests (A/T, pointing performance, thermal stability)
- The goal is to deliver and outfit the antenna in the first half of 2012 and finish the first round of tests by the end of 2012.
In addition, work by the Calibration and Processing group includes development of high dynamic range imaging requirements that pertain to the dish design.

**The Allen Telescope Array**
The primary activity of the Allen Telescope Array (ATA) is observations for the key science surveys. This quarter has seen publication of results from two major surveys, the ATA Twenty Centimeter Survey (ATATS) and the Pi GHz Sky Survey (PiGSS). ATATS explores new transient parameter space in terms of large area; PiGSS provides repeated coverage of a 10 square degree field.

![10 square degree field imaged by the Allen Telescope Array as part of PiGSS.](image-url)
SKA-Korea Workshop 2010
The International Center for Astrophysics at the Korea Astronomy and Space Science Institute hosted a workshop on 20th August 2010 in Daejeon, Korea.

More than fifty scientists and engineers participated in the workshop and expressed their interest in the SKA project. Several speakers reviewed the status of the SKA project and various activities are now underway in the Korean astronomy community.

Further details about the presentations at the workshop can be found at the following link: http://minho.kasi.re.kr/SKA-Korea201008/

Delegates at the recent SKA-Korea workshop in Daejeon, Korea.
Canada

PrepSKA WP2 research work in Canada continues its focus on composite reflectors, focal plane, phased-array feeds and digital systems at NRC-HIA. Research on low-noise amplifiers (LNAs), analogue-to-digital converters (ADCs), and multi-dimensional signal processing continues at the Universities of Calgary and Victoria, while cyber-infrastructure development is ongoing among a network of institutes in Canada and the US.

The dish verification antenna
The CART group at NRC-HIA and the US TDP are collaborating closely on the design of a 15 m offset Gregorian radio telescope, part of the Dish Verification Programme of PrepSKA. This has led to rapid advancement in the design of the primary reflector, backing and feed support structures. The image below shows the gravitational deflections of the design at 15 degrees elevation. Using finite element analysis (FEA) optimisation, a peak deflection of <4 mm and a secondary displacement of <2 mm have been achieved. The primary and secondary reflectors, the feed-legs and the secondary support shell are composite materials whereas the backing structure and the weldments between the secondary support shell and feed legs are steel.

Advanced focal array demonstrator (AFAD)
Work at NRC-HIA continues on a high sensitivity, SKA-capable phased array feed (PAF). The input band is 0.7 - 1.5 GHz, with initial processing bandwidth of 500 MHz. A number of ideas and innovations are being examined to minimise noise, such as mounting the LNAs close to the feed point, eliminating dielectrics, and increasing the surface area of the Vivaldi slotline. These ideas are implemented using a "3D Tapered Slot Antenna" (essentially a thick Vivaldi). Development of this potentially novel array element is in collaboration with l'Université Catholique de Louvain (Craeye and Sarkis) and the University of Calgary (Belostotski and Haslett). The AFAD work is an integral part of PAFSKA R&D program for PrepSKA, being led by CSIRO.

Devices
The devices group at the Institute of Space Imaging Science at the University of Calgary have been advancing their research on high-performance LNAs and ADCs, currently focusing on 65 nm CMOS using a variety of processes. Measurements of the latest amplifiers are underway using a new noise source calibration technique that has been verified and calibrated against the cryogenic noise source of the Caltech group.
Digital Systems
NRC-HIA is the lead institute for PrepSKA WP2.5.1. A memo describing a straw-man concept SKA correlator has recently been published http://www.skatelescope.org/PDF/memos/127_Memo_Carlson.pdf. In addition, key technologies required to make this architecture feasible are being investigated with cost and power being of foremost concern.

The Universities of Calgary and Victoria continue to investigate 3D space-time filters and their application to broad band PAF and dense aperture array signals. It has been shown that these filters can attenuate significantly off-dish, i.e. not reflected signals, and importantly, also LNA noise. A journal paper has been published on the proposed methods. The methods also have application to pulsar processing for which a journal manuscript is currently under review. The comparative performance of 3D finite impulse response (FIR) and 3D infinite impulse response (IIR) filters for radio frequency interference (RFI) mitigation is being investigated with respect to their computational complexity and show promise for mitigating over-the-horizon RFI on broadband dense aperture arrays.

CyberSKA – The world is the SKA
The tremendous imaging power of the SKA will create massive data sets that contain information about the origin, structure and evolution of our Universe. Processing and mining these data sets will require coordinated effort among globally distributed research institutions who will design and execute major survey programmes; bringing a global pool of resources to the SKA data challenge. Radio astronomy observing programmes that foreshadow the scale and power of the SKA are currently under way with the world's most powerful instruments. The Arecibo L-band Feed array system has enabled large-scale imaging and pulsar surveys with the world's largest radio astronomy collecting area, and the Expanded Very Large Array, including the Canadian WIDAR correlator, has greatly increased the imaging power of the world's most powerful radio array. These new capacities create new opportunities for science that is underpinned by unprecedented data flows and volumes in both imaging and time-domain radio astronomy. The CyberSKA project is a multi-institution and industry partnership to create cyber infrastructure for collaborative execution of large, data-intensive science programmes in radio astronomy on the pathway to the Square Kilometre Array.

The cyber infrastructure for data management, access, services and applications is distributed over the partner nodes in Canada and the US using cloud and Web 2.0 technologies and accessed though the CyberSKA portal at www.cyberska.org. The portal is built upon an open source social networking platform and blends social networking tools with e-research. Close to 80 researchers and developers are currently members of the portal. The cyber infrastructure is under active development with new releases occurring approximately monthly. Version 1.0.1 of the portal was released on 27 September 2010.

Canadian funding for the CyberSKA project is provided as part of the CANARIE Network Enabled Platforms programme.
Europe

Reports on SKA progress in Europe this edition feature aperture array development, high bandwidth, long distance, links achieved with the e-EVN and the continued roll-out of LOFAR.

Aperture Array Verification Programme (AAVP)
Progress in the development of aperture arrays as elements of SKA-low and SKA-mid over this year included:

- In August, the final report of the successful Marie Curie-SKADS programme was sent to Brussels.
- The final SKADS report will soon be complete. Note that all material and books remain available from www.skads-eu.org
- Most of the funding required for AAVP is now in place. While the Portuguese proposal stalled momentarily, swift progress is still possible. Some delay also occurred as a result of AAVP absorbing the recent SKA Phase 1 vision that emphasises AA-low.
- The dense aperture array demonstrators still require technical work to be done but testing campaigns are in progress with Embrace at the Westerbork and the Nançay sites. It is expected that there will be exciting new results to report in the next edition of the SKA Newsletter.
- A new calibration approach to regular aperture arrays was presented by Parisa Noorishad at the recent CALIM workshop in Dwingeloo. The approach uses the intrinsic redundancy in these arrays demonstrated on a LOFAR HBA tile. In principle, it shows promise for intra- and inter- tile calibration as well as for diagnostics.
- On 8-10 December 2010 an AAVP workshop will be held at the Cavendish Laboratory in Cambridge, UK. Topics for discussion will include detailed science and technical plans for aperture arrays in Phase 1 and Phase 2 of the SKA. Emphasis will be on the achievable requirements for AA-lo for SKA Phase 1 and the evolution of AA-mid. Oral presentations and posters are requested. See: www.mrao.cam.ac.uk/projects/aavp/index.html
- AAVP is planning its next Board meeting in connection with the Cambridge workshop. A CoDR in collaboration with the SPDO is also planned for January 2011.

More information on AAVP is available from the AAVP office secretaty@ska-aavp.eu.

e-EVN demonstrates high-bandwidth links to SKA regions
In August, the European VLBI Network (EVN) celebrated the spectacular return of the 26 m Hartebeesthoek radio telescope to operations, following a major bearing failure in 2008. The successful e-VLBI fringe test was marked by a robust 896 Mbps data rate from South Africa to Europe - the highest rate yet from Hartebeesthoek. Additionally, over the past two months the new 12 m
Warkworth VLBI telescope in New Zealand has participated in several planetary mission monitoring campaigns coordinated by JIVE. The data was delivered to Europe through a fibre link, also at a rate of several hundred Mbps. Both cases highlight the e-EVN’s ability to operate with partners in two primary geographical zones of the SKA deployment. This also paves the way for future interaction of the e-EVN as an SKA Pathfinder with two other major SKA Precursors: South Africa’s MeerKAT and anzSKA’s ASKAP.

LOFAR
Roll-out of LOFAR is progressing well. It was recently decided to build four extra core stations leading to a total of 48 LOFAR stations. Eight of these are international stations placed across Europe and three have already been handed over to their host institution.

Recent development of the LOFAR imaging pipeline has focused on processing snapshot observations which will be used for an initial shallow survey of the northern sky to populate the calibration database. A motivated group of commissioners continue to participate in “Busy Weeks” which target specific commissioning issues, producing images such as the one below.

Increased automation of the LOFAR observing process and pulsar pipeline has allowed easier scheduling and analysis of hundreds of short pulsar observations over the summer of 2010. This has led to the successful detection of over 100 known pulsars with the LOFAR high-band antennas, forming what is likely to be the best available collection of low frequency pulsar profiles to date.

(Credit: John McKean LOFAR/ASTRON)
Innovative new design for SA’s MeerKAT

Following an extensive engineering design process, the baseline design concept for the South African MeerKAT precursor telescope has been decided. This design process consisted of an in-depth design study that investigated implementation options and tradeoffs for all key subsystems, and culminated in a Concept Design Review (CoDR) undertaken by an independent panel of international experts. The recommendations of the CoDR panel have informed the baseline concept, and the most visible design decision is that the MeerKAT will consist of 64 Gregorian offset dishes, each with an effective diameter of 13.5 m. An offset dish configuration has been chosen because its unblocked aperture provides uncompromised optical performance and sensitivity, excellent imaging quality, and good rejection of unwanted radio frequency interference (RFI) from satellites and terrestrial transmitters. The offset optical configuration also facilitates the installation of multiple receiver systems in the primary and secondary focal areas, and is the reference design for the mid-band SKA concept.

“This is the most innovative option of the design solutions that we considered, but it will allow the MeerKAT to operate at a sensitivity of over 220 m²/K” explains Anita Loots, Associate Director of the SKA Africa Project.

With all seven dishes of the MeerKAT precursor array (known as KAT-7) now in place, the construction of MeerKAT itself is the next big step for the SKA Africa team.

“We will start by building a qualification (prototype) dish of the new design, on site in the Karoo,” Loots adds.

This first dish will be located near the KAT-7 array, which will allow extensive testing of the performance of the new design against the existing array. This work will inform the international SKA Dish Verification Programme (DVP), an important component of the PrepSKA study and the international SKA pre-construction phase.

“The completed KAT-7 array is an important engineering test-bed for technologies and systems for MeerKAT, but it will also be used to do science. We have already received several requests from radio astronomers around the globe who want to use it as a science instrument.” explains Professor Justin Jonas, SKA Africa’s Associate Director for Science and Engineering.

The commissioning of KAT-7 is led by Dr Debra Shepherd, currently on secondment to SKA Africa from the National Radio Astronomy Observatory in the USA. It is expected that KAT-7 will be ready to do science early in 2011, while MeerKAT should be operational by 2015.

The MeerKAT sub-systems employ a number of novel technologies which are in the mainstream of SKA development. The MeerKAT design process will provide important deliverables for the SKA project, as expected from the precursor instruments.
In addition to the pioneering use of composite materials for the dish reflector surfaces and structural components (KAT-7 is the world’s first radio telescope with dishes made of fibre glass), design challenges include the development of very wide band waveguide feeds and receivers, low-cost cryogenic systems for cooling the receivers, direct digital sampling systems, high speed digital signal processing systems, algorithms for astronomy data processing, high performance computing platforms that match the algorithms, and very fast data transport networks.

Looking forward to MeerKAT science
Towards the end of 2009, the SKA Africa project invited the international astronomy community to submit proposals for science with MeerKAT. Twenty one proposals for large science projects were submitted by multi-national teams, including about 500 proposals from international astronomers and 58 proposals from astronomers based in Africa. The proposals cover large and deep surveys of neutral hydrogen, the continuum sky, pulsars and molecular lines. A recommendation on the prioritisation of these proposals was made in September 2010 by the Time Allocation Committee (TAC) comprised of South African and international astronomers. All of the proposals are linked to SKA science topics, and the science goals include pulsar timing and tests of general relativity, the evolution of galaxies and the nature of cosmic magnetic fields.

The new design of the dishes of South Africa’s MeerKAT telescope is in line with the dish design likely to be used in the SKA mid-band.
MeerKAT Milestones

- 20 July 2009 – First antenna for KAT-7, an engineering test bed for the Karoo Array Telescope (MeerKAT), installed on site in the Karoo.

- 3 December 2009 – Interference fringes seen between two of the dishes which have been constructed on the MeerKAT site.

- 10 February 2010 – All seven KAT-7 dishes in place, but not yet fully operational.

- 15 March 2010 – More than 500 proposals for MeerKAT science received in response to a request for proposals to the scientific community.

- 30 March 2010 – South Africa’s Minister for Science and Technology and the Premier of the Northern Cape visit KAT-7 in the Karoo. Seven dishes installed, with four dishes operational.

- 10 May 2010 - Four KAT-7 antennas linked together as an integrated system to produce the MeerKAT’s first interferometric image of an astronomical object. Press release and images at http://www.ska.ac.za/releases/20100510.php

- 5 – 8 July 2010 – MeerKAT Concept Design Review Panel meets in Cape Town to review the options presented by the technical team in order to define MeerKAT. The outcome of this meeting was very positive, with the panel validating recommendations from the team.

- 14 September 2010 – Conclusion of a month-long radio frequency interference testing campaign at South Africa’s proposed Karoo site.

- 20-22 September 2010 – MeerKAT Time Allocation Committee meeting to rank the large survey proposals.

- 20 October 2010 – first “cold” receiver (i.e. receiver with low noise amplifier and ortho-mode transducer that are cryogenically cooled) scheduled to be installed in the Karoo on one of the KAT-7 dishes.

To view the latest edition of the SKA Africa newsletter click here: http://www.ska.ac.za/newsletter
At ISKAF 2010, the Au–NZ delegation outlined how maximising the discovery potential of the SKA would also bring the greatest international benefits 'beyond astronomy' such as technology developments, green energy innovations, opportunity for industry and attracting young people to careers in science. Other recent highlights of the Au-NZ SKA programme include an announcement of a CSIRO-ASTRON collaboration on Phased Array Feeds (PAFs), funding for development of renewable energy solutions, a centre of excellence for all-sky astrophysics, and various industry and public engagement events.

Australia and New Zealand, a Case for Science: Report from ISKAF 2010
At the annual International SKA Forum (ISKAF) in the Netherlands, the Au–NZ delegation was led by Australia’s Minister for Innovation, Industry, Science and Research Senator the Hon Kim Carr and New Zealand’s Minister of Research, Science and Technology the Hon Dr Wayne Mapp.

Senator Carr’s keynote address and a presentation from CSIRO SKA Director and Chair of ANZSCC (Australia New Zealand SKA Coordination Committee), Dr Brian Boyle, clearly outlined the scientific merit of Au–NZ’s case for siting the SKA, also highlighting how the best non-science benefits are dependent on the SKA achieving its ‘Maximum Discovery’ potential.

The Au–NZ delegation also hosted a booth, which had its own ‘radio quiet zone’, an inflatable area where guests could watch a DVD outlining Au–NZ’s site advantages.

For more information see http://www.ska.gov.au/news/Pages/100615-SenatortheHonKimCarrMinisterCarraddressesinternationalSKAmeetingintheNetherlands.aspx

Members of the Au-NZ delegation at the anzSKA booth during the ISKAF 2010. From left: Professor Peter Quinn (Director of ICRAR – International Centre for Radio Astronomy Research), John Humphreys (Chair of ASKAIC – Australasian SKA Industry Consortium), Professor Lyn Beazley AO (Chief Scientist of Western Australia), Senator the Hon Kim Carr (Minister for Innovation, Industry, Science and Research), and Professor Steven Tingay (ICRAR, Curtin University).
Credit: Pete Wheeler, ICRAR

CSIRO-ASTRON to collaborate on the development of phased array feeds
During ISKAF 2010, CSIRO and ASTRON agreed to cooperate on the development and testing of phased array feed (PAF)
technology. The collaboration merges world-leading expertise from ASTRON and CSIRO to develop PAFs for future radio telescopes and achieve the wide field of view capability that would fully exploit the science potential of the SKA.

For more information see http://minister.innovation.gov.au/Carr/Pages/AUSTRALIAANDTHENETHERLANDSWORKINGTOGETHERONSKA.aspx

Representatives from CSIRO, ASTRON and SPDO celebrate the signing of the Collaborative Agreement at ISKAF 2010. From left: Professor Richard Schilizzi (SPDO), Dr Brian Boyle (CSIRO), Dr David DeBoer (CSIRO), Wim van Cappellen (ASTRON), Dr Carole Jackson (CSIRO), Dr Mark Verheijen (ASTRON), Dr Tom Oosterloo (ASTRON), and Professor Mike Garrett (ASTRON).
Credit: Hans Hordijk

Renewable energy solutions to support the SKA

With AUD$ 47.3 million funding from the sustainability round of the Australian government's Education Investment Fund (EIF), CSIRO will develop full-scale, clean energy technology to support the Au–NZ bid to host the SKA. The 'Sustainable energy for the SKA' project will develop clean energy technologies on two fronts.

The first is to power and provide demand-side management technology for the Murchison Radio-astronomy Observatory (MRO, Au–NZ’s core candidate site for the SKA), and the second is the nation's largest direct heat geothermal demonstrator to cool the Pawsey High Performance Computing Centre for SKA Science (ASKAP's support computing facility) based in Perth.


ASKAP survey science project teams meet

ASKAP Survey Science Teams met in early June to discuss processing data from all 36 ASKAP antennas using the Pawsey Centre’s full planned computing capacity, and producing value added products using data from the archives. Following this was a visit to the MRO where the group saw the first antenna in action and the newly-laid foundations for antennas 2 – 6.

ARC centre of excellence to build research capacity in wide-field astronomy

The Australian Research Council (ARC) recently announced funding for a new centre of excellence for all-sky astrophysics (CAASTRO). CAASTRO's mission will be to lead scientific discoveries made with future wide-field facilities such as the SKA and solve fundamental data processing problems that can be applied to communications, medical imaging and remote sensing. The Centre is a collaboration between national and international research partners.

For more information see http://www.ska.gov.au/news/Pages/100716-ARCanouncesfundingforCAASTRO.aspx

CSIRO delivers new SKAMP Digital System

A major milestone was reached for the Square Kilometre Array Molonglo Prototype (SKAMP) project with the delivery of its new digital correlator. SKAMP, recently designated an official SKA Pathfinder project, represents a transformation of the Molonglo Observatory Synthesis Telescope (MOST) with increased bandwidth, sensitivity, field of view and added spectral line capabilities.

The installation of the new correlator will also greatly improve the calibration of astronomical data and lead to a significantly improved image quality. CSIRO officially
handed-over the completed digital system to the SKAMP team on 10th September at the University of Sydney.

For more information on SKAMP, see http://www.physics.usyd.edu.au/ioa/Main/SKAMP

![The completed SKAMP correlator board. Credit: CSIRO.](image)

**POSSUM lead investigator awarded top Australian fellowship**

Professor Bryan Gaensler is one of 15 researchers to have been awarded a 2010 Australian Laureate Fellowship by the ARC. Professor Gaensler will contribute his grant to enhance the POSSUM collaboration; the new instrumentation and techniques required for the experiments will test the technology needed for wide-field polarimetry with the SKA.


**NAIDOC week celebrated at Geraldton**

At a CSIRO-hosted event celebrating NAIDOC week in August, ASKAP’s Aboriginal Liaison Officer Robin Boddington informed gathered guests that the first ASKAP antenna had been given a Wajarri name – *Diggidumble* – meaning ‘table top hill’, and that CSIRO will continue to draw inspiration from Wajarri names for key infrastructure at the MRO.

NAIDOC is a week of national activities held around Australia each July to commemorate the history, culture and achievements of Indigenous Australians.