International Square Kilometre Array Newsletter
Volume 2
October 2000

This second newsletter of the International SKA project follows the 24th General Assembly of the International Astronomical Union at the University of Manchester, during which representatives of 11 countries and 24 institutes signed a Memorandum of Understanding to formally establish the International Square Kilometre Array Steering Committee (ISSC). Short articles on the MOU signing ceremony appeared in the October issue of Physics Today and November issue of Sky and Telescope. The MOU formalizes a committee that held its fourth meeting in association with the workshop, "Technical Pathways to the SKA", at Jodrell Bank in early August. At that meeting Ron Ekers from the Australia Telescope National Facility was appointed chair of the ISSC. Harvey Butcher of ASTRON in the Netherlands, and Jill Tarter from the SETI Institute in California will serve as vice-chairs, and Russ Taylor from the University of Calgary begins a term as Executive Secretary.

International SKA Steering Committee members and delegates present at the 4th ISSC meeting on August 6th at Jodrell Bank Observatory.

A brochure highlighting the scientific promise and the exciting technical challenges of the SKA was available at the Manchester IAU meeting. The brochure can be previewed as a pdf file. Copies of the brochure itself can be obtained by contacting Russ Taylor.

The Jodrell workshop was a tremendous success, thanks to the diligent planning of the Scientific Organizing Committee lead by Rick Fisher and the hard work of the staff at Jodrell Bank Observatory. Over 50 participants attended. The proceedings will be available shortly on the Web. About 2/3 of the presentations have been submitted. Please send your contributions or questions to Phil Diamond at pdiamond@jb.man.ac.uk.

Subsequent to the Jodrell workshop an ambitious plan was agreed to that we hope will lead to an international agreement by the year 2005 on both the technology decision and the site of the SKA. To launch ourselves effectively along this path the ISSC will constitute three working groups: a Science Working Group to evolve the SKA science case and provide critical input to the technical studies, an Engineering Management Team to begin to manage the process of technical convergence, and a Site Evaluation and Selection Committee. We plan to have these groups in place by the time of the next ISSC meeting at MIT in January.

The next international SKA workshop will take place at the University of California, Berkeley in July 2001. Stay tuned for details.

Following the ISSC meeting in Munich last March, our European colleagues have formed the European SKA Consortium. This consortium brings together the several SKA development efforts within Europe, under the umbrella of the European Infrastructure Cooperation Network for radio astronomy, which has been funded by the European Community's Fifth Framework Program. The initial meeting of the European SKA Consortium, held in May, included representatives from institutes in Germany, France, Italy, Poland, Spain, Sweden, the Netherlands and the UK. Harvey Butcher from ASTRON in the Netherlands and Phil Diamond from Jodrell Bank Observatory have been appointed, respectively, chair and vice-chair.

Technical studies continue to advance at the institutes represented on the ISSC. As in volume 1, the remainder of this newsletter is devoted to news on happenings in several of the SKA partner countries.

Russ Taylor, Editor
Executive Secretary, International SKA Steering Committee

News from Australia

The Australian SKA effort continues to grow and evolve, with the recent Jodrell Bank meeting providing us with opportunities to present our work, calibrate our efforts in the international context and, importantly, spot a number of possible collaborations with other groups. Like other players, we are also beginning to appreciate the implications of supporting a growing international project, including the reality of contributing funds and manpower to project direction and management.

The Australian "seed" SKA research program is approaching full strength with the recent appointment of a full-time SKA support engineer and the forthcoming appointment of an RF systems postdoc. Both positions actually commence in early 2001 and, by the end of the seed program in June 2003, we will have formally accounted for about 30 man-years effort. Plans for funding and prototype work beyond 2003 are currently being developed.

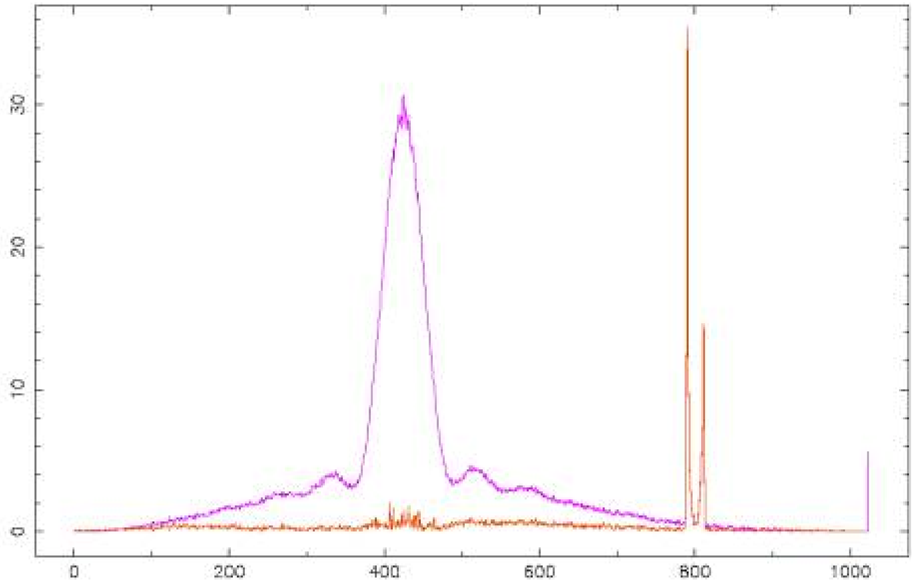
Luneburg Lenses

In the antennas area, our main work continues to be directed at evaluating the feasibility of the Luneburg Lens as an element although, in the light of discussions at Jodrell Bank, we also plan to follow through some more investigations on the cylindrical reflector doublet concentrator. Significant progress has been made in the modelling and synthesis of dielectric lenses and, very recently, we have extended the project to incorporate genetic algorithm design of electromagnetic systems comprising shell-stratified lenses and associated feeds. Of course, materials, manufacturing and cost issues are still to be resolved, and we are pursuing R&D partners who may be able to help us answer, as quickly as possible, the questions surrounding the viability of refracting concentrators for the SKA. We have also had some profitable discussions with Russian colleagues on the Luneburg Lens question and we hope to pursue the collaboration in coming months.

In addition, we anticipate defining more precisely the form of our first-round prototype due by the end of the seed program. This prototype, and the subsequent larger-scale demonstrator, could well be built in co-operation with international collaborators. For developments, check our Web site at http:// www.atnf.csiro.au/SKA

Early Results on Post Correlation Interference Mitigation

Interference mitigation (IM) continues to have a high profile, especially the post-correlation work undertaken recently by Mike Kesteven and colleagues. The picture below shows the effectiveness of some of the early work. Post-correlation IM exploits the fact that astronomers are often interested in signal statistics rather than the signal itself. The new work is attractive because it is vastly less compute-intensive than pre-correlation matched-filtering and because it can be applied, fairly easily, to existing telescopes. In Australia, we plan to explore the technique more thoroughly in coming months and, as well as using tools such as our software radio telescope to help in the design of SKA systems, we hope to have a form of IM available shortly to users of the AT Compact Array.



A post-correlation approach to interference mitigation. Data from the AT Compact Array (purple trace) are corrupted by the spread-spectrum signal from a GLONASS navigation satellite. After post-correlation processing involving the use of a template of the GLONASS signal, the satellite interference is subtracted to produce the vector-averaged residual plot (brown trace). The 1612 MHz maser lines remain unaffected. The total processing bandwidth is 8 MHz. The vertical scale is an arbitrary linear one while the horizontal scale corresponds to correlator channel number. More details are available at http://www.atnf.csiro.au/SKA/techdocs /mjk_postcorr_im.pdf

Western Australia Site Studies

Investigations into representative SKA sites continue, with quite a bit of work presented at the Jodrell Bank gathering. Workshop attendees also received a small booklet produced by the Government of Western Australia illustrating the Western Australian interest in hosting the SKA. While an SKA international site decision is some way off, and while no ranking of candidate Australian sites has yet been done, the WA expression of interest nevertheless shows that the project is receiving political attention in some quarters. Allied with the site studies work, a parallel project aimed at examining the issues involved in establishing a radio-quiet reserve is well underway.

Peter Hall, SKA Program Leader, Australia Telescope National Facility

News From Canada

The Large Adaptive Reflector: Canada Flies a Trial Balloon

In a recent positive development, the group working on the airborne platform for the LAR, led by Prof's Meyer Nahon and Inna Sharf at the University of Victoria, have been awarded funds to construct a one-third-scale multi-tethered aerostat platform at DRAO. The award comes from the Canada Foundation for Innovation. The project is also supported by the National Research Council of Canada.

Construction of this balloon facility is an important step forward since it will allow us to determine the feasibility of an airborne platform and to understand the behaviour of a fundamental aspect of the LAR. Beyond being a practical demonstration, this study will be used to validate and refine computer models developed by Nahon. Over the next 8 months we will be designing equipment - computer controlled winches, tethers, etc. Also, several different aerostat designs are under consideration. In parallel we will be bringing services to about 100 hectares of unserviced land at the DRAO site.

One of the most challenging aspects of the LAR design is the prime-focus feed array required to properly illuminate the primary and to provide a wide field of view. Bruce Viedt has shown that for a wide-band (about one octave) phased array at the prime focus of the LAR, a frequency-dependent, beam-forming network is required. Otherwise, the primary reflector will be over-illuminated at low frequencies, and under-illuminated at high frequencies. This could be done with a beam-forming version of the WIDAR technique developed for the Expanded VLA project. About 2000 feed elements are needed for each polarization. Such an array operating at 1.4 GHz would have a diameter of 9 metres and provide a 0.5 square-degree field of view. The large field of view is possible because multiple overlapping narrow beams are available from the phased array.

SKA Imaging and Computing

SKA imaging simulations are being undertaken by Tony Willis, using the deep radio sky models developed by Andrew Hopkins. Tony has begun to investigate the relationship between number of stations and dynamic range. The large filled aperture of the LAR provides a clean beam with a small field of view. Within the imaging beams of the LAR, each covering a sub-field of about 3.5 arcminutes (at 1.4 GHz), the dynamic range requirements can be met with an array of 30-50 LARs. This is because the chances of a strong source in any one beam will be much smaller than in the entire imaging field, which consists of many beams. Contrary to conventional belief, a large number of stations may not be necessary to obtain sufficient dynamic range to image at nanoJy levels. The next step in this work will be to more accurately simulate the behaviour of an array of LARs. In particular, we need to model the influence of a time-variable primary beam on the synthesized images and develop an effective procedure for image restoration under such conditions. We will also investigate more realistic array configurations than the one used for the initial simulations.

At the Jodrell Workshop, Brent Carlson discussed the size and cost of correlators for the SKA. He presented two options: first, a large-N configuration with 50 to 1000 stations composed of arrays of 5 or 10-m dishes, and second, an array composed of 30 to 60 LARs. A large-N array requires a significantly larger correlator than an SKA based on LAR elements. Even with cost and performance improvements that follow Moore's Law, a future large-N correlator could consume about 50% of the total construction budget.

Tony gave a presentation on the challenges facing us in carrying out simulations of SKA performance, and in obtaining the computing power needed for an operational instrument. His conclusion? The days of large centralized computing facilities are not over. A short article discussing the computational challenges of the SKA project has been prepared for Scientific Computing World by Jan Noordam at ASTRON in collaboration with a supporting team of SKA computer experts.

Peter Dewdney, Herzberg Institute of Astrophysics

News from China

Fast work on FAST

The Research and Development of FAST project progressed rapidly this year after getting the financial support (about 1M USD) from the Chinese Academy of Sciences and the Ministry of Science and Technology of China. The main R&D efforts focused on:

Scaled model (1:3) for element of the main reflector

> Four kinds of surface elements and three kinds actuators and supporting systems have been designed by Tongji University and the Nanjing Research Center for astronomical instruments. The manufacture of all models will be finished before September this year, and we will be checking the performance later in Shanghai.

Scaled model for the feed supporting system

> A 5-m scaled model of the cable and cabin system was completed at Xidian University. The second model (40m) will be completed early next year. A 2-m scaled model for the cable and trolley system is now complete at Tsinghua University and a new 18-m model is being manufactured. The secondary correction system (Steward platform) will be tested at the beginning of next year.

Work on the measurement and control systems is underway. The results suggest that measurement accuracy on the reflector and feed support system of about 1 mm can be achieved. Control concepts have been identified.
Finally, site surveying in Guizhou province is on-going, focusing on local climate and radio interference monitoring. No significant change in the RFI environment has been detected in comparison to surveys conducted in 1995.

Yuhai Qiu, FAST Laboratory of Beijing Astronomical Observatory

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News from the European SKA Consortium

Integrated Array Antennas Research at ASTRON

At ASTRON in Dwingeloo, research is continuing on the development of broad-band, highly integrated array antenna systems. An international review of the program was carried out in May and is being used to plan activities leading up to the decision phase of the international SKA project in 2005. The Dutch SKA array antenna development effort has focused on finalizing the design and moving to construction of the individual tiles of the Thousand Element Array (THEA). Testing and assembly of components has proceeded, and an outdoor platform made ready, to allow first observing to begin early in 2001. Readers are referred to Newsletter vol.1 for the goals and technical specifications of the THEA project.

Broad band, dual polarization array antenna designed for THEA demonstrator project.

Noteworthy interim achievements include a dual polarization antenna element design (a Vivaldi egg-crate construction by Dan Schaubert of U.Mass. working with Bart Smolders) that covers nearly a factor of 7 in frequency; a 20 Gbit/sec digital link from the array into the control building; and integration on a common substrate of antenna elements with their front-end beam forming circuitry - with LNAs and single chip vector modulators.

An efficient algorithm has been developed and demonstrated (by Willem Cazemier and Grant Hampson working together with Steve Ellingson from OSU) for adaptively suppressing (at 30 dB) side lobe response in the spatial domain while minimizing distortion of the primary beam response in a controlled fashion.
ASTRON's RF-IC team implemented several single chip LNA designs to study integration of the antenna element into first gain stage circuitry, including optimal impedance matching for minimum noise. A first wafer run for a single chip IF-mixer designed for the Allen Telescope Array was also made and the results are currently being evaluated.
And finally, a small Beowulf PC cluster has been brought into operation and the top level design of an end-to-end simulator for SKA (or LOFAR or other telescope) developed.

Data Transmission Studies at MERLIN

A bid to partially fund the connection of MERLIN using optical fibres has been made for regional funding via the North West Science Review and we await its outcome. Although this is initially for the benefit of MERLIN, much of the development will be directly applicable to SKA. A related grant is being prepared for PPARC to provide the necessary funding for the full e-MERLIN upgrade.
We still await the results of a bid to the Joint Research Equipment Initiative (JREI) to fund a digital backend capable of providing coherent de-dispersion for pulsar work as well as on-line interference mitigation.

The Low-Frequency Array: LOFAR

The LOFAR project involves the design, construction and operation of a low frequency array based on the insights gained in the SKA R&D program. It was also described in some detail in the February Newsletter.

Current partner institutes in the project are the ASTRON Institute in Dwingeloo, the M.I.T. NEROC/Haystack Observatory, and the Naval Research Laboooratory in Washington. The design of the instrument is proceeding jointly, and a planning and costing exercise has been completed preparatory to formal proposal submissions. In the Netherlands, financing for the project is being sought through a government program for pre-competitive technology development and will involve an industrial consortium formed specifically to carry out the LOFAR work. Of particular interest to the SKA project is a public-private cooperation in which LOFAR provides a platform for the development and implementation in an operational environment of multi-Tbit/sec digital network hardware and control software. In addition, studies are scheduled to begin shortly on the design of distributed networking software that will allow simultaneous access by multiple users to LOFAR's independently pointed beams over the next generation Internet.

Harvey Butcher, Chair of the European SKA Consortium
Phil Diamond, Vice-Chair

News from the Indian SKA Consortium

Within the recently formed Indian SKA Consortium, the Raman Research Institute has started construction of a 12m low cost parabolic dish based on an innovative design developed by the GMRT group of the Tata Institute of Fundamental Research. Results will be available by mid or end 2001. Parametric studies are also planned for dishes in the range of about 7.5 m to 25 m for operation in the frequency range of about 100 MHz to 10 GHz.
Govind Swarup, Tata Institute of Fundamental Research

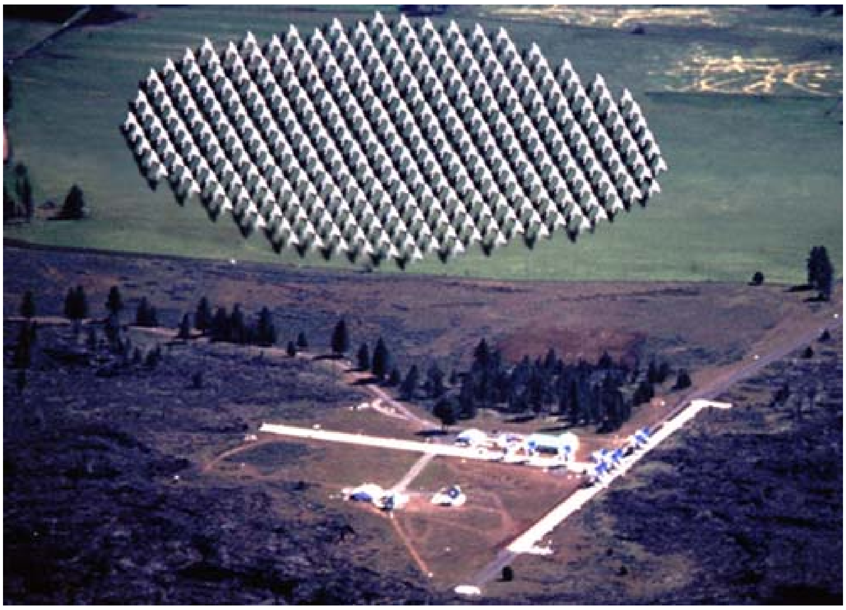
News from the US SKA Consortium

Currently the US SKA Consortium consists of MIT/Haystack, the University of California Berkeley's Radio Astronomy Lab, the SETI Institute, the National Radio Astronomy Observatory/AUI, Cal Tech, Harvard Smithsonian/CfA, Ohio State University, the University of Minnesota, Cornell University/NAIC, and the Naval Research Laboratory. The Consortium met during the US SKA Science and Technology Meeting held at Arecibo in February 2000, and again in Washington, DC in September.

The Consortium has now begun the process of trying to engage with the National Science Foundation to establish a development plan and win funding for the US contributions to the SKA over the next 5 years. By the spring of 2001 we will submit a "white paper" to the NSF outlining the necessary technical developments for arrays consisting of a large number of small parabolic antennas, plus the theoretical studies, required modeling, and simulations to be completed prior to the ISSC decision deadline of 2005. This document will explain how each of the tasks relate to one another and to the international efforts, as well as providing a timeline, a probable allocation of effort, an estimation of resource requirements, and an organizational structure to guide the activities to a successful conclusion. It is unclear whether we will choose to amalgamate all of our efforts into a single large proposal, or submit multiple proposals, each referencing the overall development plan. The Astronomy and Astrophysics Decadal Review process that completed earlier this year did recommend technical development for the SKA at $22 million. Our efforts are aimed at influencing the NSF take the next step to implement that recommendation.

MIT/Haystack members have submitted an NSF proposal for configuration studies and simulations against an existing research initiative program. This MIT/Haystack proposal would fund work to follow up on the studies they have begun on deconvolution algorithms for high dynamic range large-N imaging, analyses of redundant data to assist with SKA calibration, and correlator architecture for large-N arrays. They have also joined with the NRL LOFAR group to see how that instrument might serve as a testbed for the SKA.

UC Berkeley and the SETI Institute were successful in raising private funding to continue technology development work on a large array of small paraboloids that was previously called the 1hT, and is now called the Allen Telescope Array in honour of the generous donation of Paul Allen. Preliminary design reviews have been held for the LNA's, cryogenics, and antennas. Reviews of signal path and overall system will be completed by end of year.



Artist Impression of the Allen Telescope Array (ATA). Technologists Paul G. Allen and Nathan P. Myhrvold recently announced $12.5 million in support of the technology development for the ATA.

Cornell/NAIC is investigating the role they might play as a lead institution for a single proposal to the NSF, should the US SKA Consortium decide that is the proper way to engage with the NSF. Dr. Bao-Yan Duan from Xidian University visited Arecibo and Ithaca for two months as part of his work on the Chinese FAST project. Cornell did an excellent job of hosting a technical SKA meeting at Arecibo and getting the materials on the web very quickly. See: http://www.naic.edu/~ska/usskameeting.htm.

Ohio State University continued its work on RFI mitigation in collaboration with NFRA, NRAO and the SETI Institute. Their project Argus prototype has grown to 8 elements in a new location and is demonstrating its ability to locate and remove narrowband RFI.

Cal Tech and JPL have been very involved in developing the international timelines and planning for SKA management. Sandy Weinreb has also continued his MMIC LNA development and is conducting a study for replacement of DSN 70 m with an array of small parabolas. This study and the ATA should help firm up cost estimates for the elements.

NRAO/AUI is investigating possibility of siting LOFAR at the VLA. Rick Fisher and Richard Bradley were awarded grant from NSF to expand their RFI mitigation work in collaboration with OSU and SETI Institute. NRAO is also studying optical fibers and correlator architectures.

Harvard is trying to establish a center for excellence in software and system control, from which the SKA could benefit. University of Minnesota is beginning to study optimization of SKA for Galactic HI studies. Now that NRL is a member of the Consortium, the US can more actively participate in finding synergisms between LOFAR and SKA.

The US consortium is planning an April meeting at CfA, with a secondary agenda to advertise the SKA and capture the interests of the many young researchers in that area. Because of the need to prepare the white paper for the NSF, we will also meet in January, immediately before or after the ISSC, AAS, and URSI meetings.

Jill Tarter, Chair of the US SKA Consortium