## NEWS FROM THE CONSORTIA AND INSTITUTES

## AUSTRALIA

The past year has been exceptionally busy for the Australian SKA community, with major events such as the Sydney IAU General Assembly and the SKA 2003 conference presenting significant organizational challenges.

The IAU proved to be an excellent forum for exposing the SKA project to a wide audience, both astronomical and public, with displays by the International SKA Consortium, as well as the Australian and South African groups. SKA was a major theme at a very successful IAU Industry Day, attended by 140 delegates. Immediately following the Sydney IAU many locals and visitors attended SKA 2003 in Geraldton in Western Australia. This was one of the larger SKA conferences, with about 140 people registered from over 20 countries. It was a successful working meeting, with an emphasis on concept and technology assessment, and on scientific discussion necessary to prepare for the November 2003 Leiden SKA science meeting

For many visitors, a highlight of the Western Australia experience was a visit to Mileura Station, one of the candidate Australian SKA sites. The hospitality of the pastoral leaseholders, the Walsh family, was much appreciated. Another feature of the meeting was interaction with the local indigenous community, who staged an art exhibition on Aboriginal astronomy art in parallel with the SKA2003 meeting.

In SKA engineering work good progress continues to be made in key areas. The CSIRO team working on new dielectrics has almost completed a prototype 0.9 m Luneburg lens based on a patented material. Near-field antenna range tests on the new lens are expected to begin in late November. Waveguide measurements of the dielectric show loss tangents $< 1 \times 10^{-4}$, with some process variations producing even smaller losses. A prototype two-arm feed translator has also been completed (Fig.1). At the University of Sydney work is continuing on the 96-input narrowband correlator, the first part of the SKAMP upgrade. In Melbourne, the Swinburne University group has recently produced first pulsar science results from a new software-based DSP system. With Steven Tingay's appointment as Swinburne SKA project leader, an expanded program of SKA simulation work – both array configuration and system cost/performance – is also beginning.

Two new engineering science projects are relevant to international SKA prototyping. Both involve engineers undertaking PhD research in conjunction with Macquarie University and both are co-supervised by Peter Hall. Douglas Hayman will look at the characterization and metrology of dense arrays of end-fire elements, while Suzy Jackson will design a high-integrated RF system using CMOS technology.

*Fig. 1. Prototype CSIRO two-arm feed translator in use with a 0.9 m Konkur (Russian) Luneburg lens. The translator, incorporating a PC-based motion control system was designed by Swinburne engineering student Adam Deller (left), Ron Beresford (centre), Zachary Au (right) and Peter Hall (photographer). Using Ku-band feeds and a digital satellite receiver, the crew were martyrs to the simultaneous excesses of Jerry and Oprah by the time tests concluded!*

As part of an increasing emphasis on SKA infrastructure engineering, CSIRO hosted a successful one-day workshop on smart energy solutions for next-generation radio telescopes. It is likely that Australian SKA demonstrators will include examples of solutions to the remote energy supply challenge.

In September, the LOFAR International Steering Committee endorsed the conclusions of the LOFAR Site Evaluation Committee, which ranked the Western Australian candidate LOFAR site as the best site for LOFAR on scientific and technical grounds. With the increasing presence of the LOFAR project in the Australian SKA community has decided that it is appropriate to combine as many aspects of SKA and LOFAR as possible. One result is that the Australian SKA Consortium Committee (ASKACC) now oversees R&D in both projects. Furthermore, there is tighter coupling between the projects in a number of institutions, including CSIRO. The CSIRO program has been expanded to include both SKA and LOFAR activities. A decision on the weights of various SKA demonstrator options will be made in early-2004, once Australia's level of engagement in the international LOFAR project becomes clearer.

There have been a number of SKA personnel changes, principally within CSIRO. Brian Boyle has succeeded Ron Ekers as ATNF Director, while Ray Norris is now SKA/LOFAR Program Leader. Peter Hall will take up his position as international SKA Program Engineer in early 2004. Michelle Storey replaces Peter as ASKACC Executive Secretary and is the SKA/LOFAR Program Manager, and John Kot is now CSIRO's SKA/LOFAR Program Engineer. Warwick Wilson continues to lead the ATNF Engineering Development Group, which will now include SKA/LOFAR technical work.

Brian Boyle

## CANADA

### *LAR Project Update*

Much progress has been made on several fronts in the LAR project. Perhaps most significantly, construction of a prototype section of the reflector is nearing completion. The reflector is envisaged to be composed of many adjoining triangular "structure units" made from lightweight steel trusses, similar to those used widely in the construction industry. The reflector surface will be steel sheeting mounted on top of commonly used corrugated roofing steel, which in turn sits on an adjustable framework attached to the main structure (see Figure 1). This work is being done in collaboration with AMEC Dynamic Systems of Vancouver. One of the immediate conclusions from this work is a good cost estimate for the reflector surface and substructure, which is USD 130/$m^2$. AMEC believe that the cost can be further reduced – we are targeting USD 100/$m^2$.

***Figure 1:*** *the image on left shows the sheet-steel surface atop the corrugated sub-surface. The image on the right shows the steel trusses and surface-support framework.*

The LAR reflector surface has to be actuated in order to retain the parabolic shape of the reflector as the desired focus point moves around the sky. We aim to let an actuation contract before the close of 2003 to study possible actuation mechanisms that will be tested on the prototype reflector unit.

### The Tethered-aerostat system and the Confluence Point Mechanism

The initial tests of the tethered-aerostat system reported in the last newsletter were restricted to an "open-loop" system – that is, with tethers of fixed length, pre-determined for a particular altitude and zenith angle of the tether confluence point, our virtual focus. Those tests are now complete, and some results were presented at the URSI meeting in Ohio.

The next stage of the tether system development is a "closed-loop" system, in which tether lengths can be altered in real time via a control system to (a) slew the focus point around the sky to attain a particular azimuth and elevation, and (b) for fine control of the focus point to counteract any motions of the focus induced by forces acting through the tethers, or ultimately, through the confluence point mechanism (CPM). Three winches have been assembled and a preliminary control system developed. Initial tests of the three winches under feedback control using GPS positional data (see Figure 2) were very successful, and the winches are now being deployed for use with the aerostat. It is planned that three more winches will be added to provide a six-tether system.

*Figure 2****:*** *a test of the winches and control system. One winch is visible in the weather-resistant box at right (the other two are not in this picture). The "cherry-picker" truck is acting in place of the aerostat to provide support for the instrument package.*

The CPM is the mechanism situated at the focus of the reflector, and will support and steer the large feed plate required to achieve a wide field of view. In the past month, Meyer Nahon at McGill University (who is leading the dynamical research of the tethered-aerostat system), Clement Gosselin (U. Laval) and Benoit Boulet (McGill U.) have been awarded an NSERC Strategic Research Grant worth $500K to study the CPM. This includes exploring a number of possible mechanisms that will allow the full range of motions required by the feed plate, the control of this mechanism, and the overall control of the tethered-aerostat/CPM/reflector systems. This a major grant and its award to enable part of the LAR project is very encouraging for future funding opportunities.

*Figure 3: a design concept for the Confluence Point Mechanism (CPM), here shown supporting the circular feed-plate.*

### Focal Plane Array

Methods of reducing weight are being pursued to satisfy the weight constraint imposed by the airborne feed system.  Ed Reid (U. Alberta Ph.D. student) has demonstrated that Vivaldi elements can be made significantly lighter by strategically drilling holes through the antenna boards.  This is non-trivial, because holes placed in the wrong place can "suck" the surface currents into regions where there was originally no current flow, thereby changing the properties of antenna.  Using an electromagnetic simulator, various “holey” designs were explored before two test antennas were constructed, one with holes and one without.  As predicted, the electromagnetic performance was identical.  This is a big step forward in the realisation of a low-mass focal package for the LAR, especially given the very large number of feed elements required to attain the required field-of-view specifications.

***Figure 4:*** *a diagram of Vivaldi antennas with strategically placed holes that reduce weight without compromising electromagnetic performance.  The centre slot shows the current distribution of this configuration.*

We are also in the process of evaluating new, low-cost and low-noise transistors for use in integrated low-noise amplifiers. Angel Garcia (U. Alberta M.Sc. student) is assessing devices developed originally for personal wireless devices (eg., cell phones and GPS receivers), which have high performance at a low cost.  This work will be merged with the antenna work as the low-noise amplifiers are planned to be integrated directly on the Vivaldi elements.

Bruce Veidt continues to work on analysis and specification of wide-band beamforming networks required by the LAR concept. This analysis is focussed on beamformer errors and errors induced by element failures. This work has been presented at several meeting (NRAO, Charlottesville; IEEE Antennas meeting, Columbus, OH; SKA2003,Geraldton) and will soon appear in an IEEE paper.

LAR Group

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**CHINA**

**Main Reflector**

The previous design of the FAST reflector consisted of ~2000 hexagon-shaped elements whose backing structures are made of a large number of steel rods and spherical joints. In recent years, a scaled model element of the "tensegrity" backing structure for FAST (Figure1) has been constructed. In August 2003 it was evaluated by an expert board which concluded that it is a feasible solution for the FAST, reducing the total weight of the reflector by a factor of 3. This design replaces the network of steel rods by preloaded steel wires. From the experiment we learnt how to distribute and measure the tension forces in the pre-stressed structures, and how to control the energy loss.

*Fig. 1. Scaled element of FAST reflector with tensegrity back structure*.

In addition, a new realization of the FAST active reflector has been proposed and investigated intensively since 2002. Three groups, from Tongji University, Harbin Industrial University, and the joint group of Tsinghua University and the NAOC (National Astronomical Observatories, Chinese Academy of Sciences), are involved in the R&D. The proposal is to support the reflector surface by a cable network underneath, like Arecibo, instead of actuators, and deform it by adjusting the length and tension of the tie-down cables as the source is tracked. The simulations show that the errors of the fit to a paraboloid shape can easily be controlled to within 1-3 mm. If the feasibility of this new solution for the FAST reflector is finally confirmed by modeling, it will simplify the structure, shorten the project time and, therefore, reduce the total cost of the telescope considerably.

**Focal Plane Array**

In order to enlarge the FoV and the sky coverage of the FAST, we have begun a project to investigate a focal plane array at the FAST focus, adopting the AAT technology. This combined solution will enlarge the FoV of the 300m illuminated area of the FAST from ~3 arcmin to a half degree and will include at least 100 simultaneous beams within it. The phased array technology also enables us to form an asymmetric illumination pattern as the focus goes to the edge of the active reflector by dynamically weighting the Vivaldi-elements in the array. There are three groups working on the layout design of the AAT type feed, from Tsinghua University, Beijing Astronautics University, and NAOC. A very rough estimate indicates that the array would include 1300 Vivaldi antennas on a plate of diameter 2.5 m. Electromagnetic field analysis in the vicinity of the focus has been completed, and the results appear close to those of the FARADAY project.

*Fig. 2   50-meter model of feed supporting system for FAST*.

**Feed Support System**

A new 50-meter model of the feed support system (Figure 2), combined with a cable car and Stewart stabilizer, has been constructed at Tsinghua University. A high sampling rate, high precision ranging system comprised of API laser trackers has been developed to measure the position of the feed support as it moves. Tracking measurements have shown that an accuracy of about 0.4 mm for the focus plate position is achieved. According to the similarity law, a positional accuracy of 4~7 mm is predicted for focus tracking for the full FAST.

FAST Group in China 2003

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**The EUROPEAN SKA CONSORTIUM**

**Proposal for a major Design Study**

The main current development in Europe is the increasing coherence of our efforts as a result of planning a proposal for R&D funding from the European Union. The proposal deadline is 4 March 2004 and we will be seeking funds from the Framework 6 programme for a “Design Study”. We are in the process of putting together a proposal for a series of projects, covering the period mid-2004 to end-2007, to a total value of €20M. Since the EU rules stipulate that matching contributions to the value of 50% of the total cost must be obtained, €10M will be sought from national funding agencies. All member institutes of the European consortium are expected to be involved, although the major contributions to the programme are likely to come from (in alphabetical order) France, Italy, The Netherlands and the UK. Non-EU countries, in particular Australia, South Africa, Russia and possibly Canada will also be partners in the FP6 Design Study.

What are we trying to achieve? It has become clear that no single concept/technological solution will enable us to achieve all the prime science goals which ISAC and the community has identified. The basic aim of the Design Study is therefore to explore cost-effective technologies appropriate for those prime science goals which *demand* wide-field observations in the low frequency range ~0.2 to ~2 GHz. We will concentrate on: i) the development of techniques which will enable large instantaneous sky coverage to be achieved appropriate for making unique astronomical surveys; ii) on techniques for forming multiple independently-steerable fields-of-view enabling independent users to observe simultaneously with the full sensitivity of the array.

At the heart of this study is the enabling technology of phased arrays. These can be deployed either as "aperture plane" arrays – in which the incoming electric field is collected directly – or at the focus of either parabolic or cylindrical antennas in which the passive reflector provides the physical collecting area. *A principal goal of the programme is to establish the viability of "aperture plane" array technology for radio astronomy by constructing one or more demonstrators with a total area up to 1000 $m^2$ in a band centred on ~1000MHz.* Cylindrical antennas are long-established in radio astronomy but the new option of using phased arrays along their line-foci offers the promise of a major improvement in their capabilities.

The main work programmes can be summarised as follows:

- To compare and contrast at least two possible solutions (aperture plane arrays and cylindrical-parabola reflector arrays) for the wide-field SKA collector systems in the frequency range 0.2-2 GHz
- To carry out a range of science and technical simulations to establish the observational requirements for achieving the prime science goals appropriate to the chosen frequency range.
- To study the generic data transfer and signal-processing aspects of the SKA design
- To study how the user will interact with the data from SKA
- To produce an end-to-end timeline and costing for the production of the SKA to at least one specific design for the frequency range 0.2-2 GHz

The different international concepts currently being developed share many common features, particularly in terms of overall array configuration; data transport and signal processing. Hence, even if the specific concepts being explored in the FP6 Design Study are not selected as the basis for the final SKA design, a large fraction of the work in the Design Study will certainly contribute to the final end-to-end SKA design.

If this Design Study is funded we can look forward to a step change, both in our understanding of the feasibility of the large-field-of-view concepts and in the overall global coherence of SKA R&D efforts. Keep your fingers crossed!

Peter Wilkinson,
Chair ESKAC

**INDIA**

**Preloaded Parabolic Dish Antennas for the Square Kilometer Array**

In April 2003, in the Raman Research Institute campus (RRI), the mechanical engineering group was busy weaving a basket. This is a basket with 24 elastically bent stainless steel tubes with outer and intermediate circumferential rings to hold these tubes. This is a prototype of a preloaded parabolic dish antenna for SKA being built in India. The skeleton of the dish was ready in May 2003.

*Fig. 1 A 12-meter Preloaded Parabolic Dish*

Design and fabrication of a conventional parabolic dish antenna is rather complex and it is not easy to make it cost effective. Minimizing its cost would depend on selection of satisfactory antenna configuration and choice of right structural shapes. It is also important to minimize wind loads. Estimate of wind loads depends on choice of proper values of aerodynamic parameters such as co-efficients for drag and lift. In addition, satisfactory experimentation enhances the confidence of the designer and the telescope user. It is with these thoughts, a preloaded parabolic dish antenna (PPD) based on a new concept is being fabricated in India.

The main thrust of the new design of PPD, developed by the Tata Institute of Fundamental Research (NCRA-TIFR, Pune), has been the simplification of the backup structure and usage of wire mesh panels for the reflector. Preloading the structural members of the backup structure uses the principle that if a structure has initial stored strain energy, then under certain conditions it has the capacity to offer a larger stiffness for the same weight. eg.: bicycle wheel and umbrella. So, we have optimized the preloaded backup structure, to have less weight and lower cost than a conventional backup structure. The usage of wire mesh panels reduces the solidity of the dish to less than 20% of a dish with solid panels.

Fig.1 shows the complete stainless steel basket with the reflecting panels mounted on it. The value of the preload used in the dish is equivalent to 75 kg at the end of each radial member. To minimize errors in parabolic modelling due to radial facet approximation, four planar facets are employed between two radial members. Stainless steel tubes are used as backup structures for these panels. The measured rms deviation of the wire mesh panels from a parabola is around 2 mm.

The design is optimized to ensure that for any position of the telescope up to a maximum wind speed of 150 km/hour, the stresses induced in the structure does not exceed 60% of the yield strength. The total weight of the 12-meter dish is approximately 3 tonnes and the wind force at 150 km/hr wind speed is approximately 2.7 tonnes. Wind torque about the elevation axis is 3 tonne-m. These weights and torques are much lower than those of conventional dishes. Vibrations and different modes of bending of the dish play a very prominent role in the final performance of the telescope. In view of this, vibrational and modal analyses have been carried out on the dish. They indicate that the lowest resonance frequency of the dish with panels is around 2 Hz.

*Fig. 2 Compact Corrugated Horn*

Along with this activity on the dish, a host of other activities related to the control system, front-end and back-end of the receiver are under way at RRI. Top priority is assigned to test the dish in the frequency range of 4 to 8 GHz. A compact corrugated horn with a quad-ridged OMT has been designed and tested (Fig.2) for this frequency range. Discussions are under way to use HEMT amplifiers which are cooled using pulse tube coolers. Design and development of a state-of-the-art back-end with wide bandwidth is under progress.

The design of a mechanical drive system and antenna mount have been finalized and tenders issued to several contractors in India. A control system using brushless DC motors and a DSP based programmable multi-axis controller is also being configured. (Fig. 3)

*Fig. 3 DSP Based Control System*

We expect the 12 m telescope to be installed in the first half of the next year in the Gauribidanur field station, which is about 80 km away from Bangalore.

N. Udaya Shankar (RRI)
G. Swarup (NCRA-TIFR)

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**The U.S. SKA CONSORTIUM**

During 2003 the U.S. SKA Consortium met in Crystal City, Virginia, near Washington D. C. on April 24 and also in Pasadena, California, on October 3. The main discussion issues have been to prepare a technology development project to be submitted to the U.S. National Science Foundation for funding for the next five years.

During the year two new institutions joined the U.S. SKA Consortium, the University of Wisconsin and Virginia Tech. More than 60 radio astronomers and engineers are involved in various aspects of the SKA development in the US.

The technology development project has its goals to:

- Develop technology needed for advancing the Large-N/Small-D concept for the SKA, with special attention to elements on the critical path and to costs;
- Provide deliverables in technology relevant to the LNSD concept, its scientific capabilities and its costing;
- Develop necessary prototypes to advance the LNSD concept; and
- Lead to the choice of the LNSD concept as an integral part of the SKA project. This entails satisfaction of international milestones for providing documents and plans for the LNSD project as it develops.

The primary issues for the technology development program are as follows:

a) How do we address science goals in terms of technical specifications of the LNSD concept?
b) How do we achieve A/T at lowest cost?
c) How do we maximize signal bandwidth and data processing throughput?
d) Can we mitigate RFI to achieve sensitivity goals and science specifications?
e) How do we sell the SKA project and use it to promote science?
f) How does the LNSD concept fit into a hybrid design for the SKA?
g) How do we promote the best site for the LNSD concept?

Various teams with designated Leaders have been identified and these will address the above issues as well as the following comprehensive items:

- The science case for the SKA;
- Antennas, Feeds, Optics and Mount;
- Receivers design;
- Array configuration;
- Data transport;
- Signal processing, Correlator/Beamformer;
- RFI management;
- Modes of operation;

- Data management: post-processing;
- Data management: archiving, virtual observatory;
- Maintenance and operation;
- Possible upgrade plans;
- Costing;
- Education and public outreach; and
- Issues relevant to siting the SKA.

The U.S. Consortium plans to submit a comprehensive technology development proposal covering a period of five years to the U.S. National Science Foundation in December 2003. All efforts will be made to comply with the international ISSC guidelines and timetable for the development of the SKA design and siting. The U.S. SKA Consortium has agreed to the proposal by the U.S. National Astronomy and Ionosphere Center (Director, Robert Brown) to manage the Technology Development Program.

In the meantime, the U.S. SKA Consortium is continuing development work that began in mid 2002 on possible LNSD antennas, feeds and receivers. RFI mitigation techniques are also being studied, as well as data handling and data transport. We also view the Allen Telescope Array as an important prototype.

The Allen Telescope Array (ATA) is to be an array of 350 six-meter hydroformed dishes distributed within an area 700 m in diameter, at an RFI-quiet site in Hat Creek, California. It is the principal prototype for our Large-N SKA design and will serve as a test bed for many of the SKA concepts. The ATA will operate between 500 MHz and 11 GHz using a broadband dual-polarization log-periodic feed system of the type we are considering for the SKA. The angular resolution is about 75" at 1.4 GHz over the 2.5-degree field of view of the individual antennas.

Three antennas are in place at the Hat Creek site. Room temperature feeds are presently being used for tests, but by the end of 2003 each antenna will have cryogenically cooled LNAs and feeds operating over the full ATA bandwidth. By late 2004 thirty-two antennas complete with correlator will be available. The plan is to have 206 antennas constructed by the end of 2006 and reach 350 antennas within the following two years.

The U.S. SKA Consortium has invited the ISSC to meet in New Mexico early in 2005.

Yervant Terzian and Jim Cordes

The Allen Telescope feed

## OTHER NEWS

### LOFAR receives Dutch financing

The LOFAR radio telescope project aims both to explore the low frequency radio sky in preparation for SKA, and to develop an operational software multi-telescope based on the aperture array concept. Its web-site is at URL: http://www.LOFAR.org/

The project is currently a collaboration between ASTRON, M.I.T. Haystack and the Remote Sensing Division of NRL. The Australian community plans to join the effort and various groups in Europe and the USA are expressing strong interest in also doing so. Technical development started several years ago and in 2004 the project expects to move into construction. The photo below shows the Initial Test Station site in the northeastern Netherlands, at which the station level system is being prototyped and tested.

*LOFAR Initial Test Station: 100 low-band antennas and station processing*

As with most substantial international projects the phasing of construction finance and the selection of site have proven significant difficulties. In these regards the project provides salient lessons for the global SKA program.

The financial situation, however, was greatly eased when, on 28 November, 2:00pm CET, the Dutch Minister of Education, Culture and Science stepped out of the regular weekly Cabinet meeting of the Dutch government to let the project know that the Dutch contribution to LOFAR construction had been secured – €52M (US$62M). This is not enough to complete the project, but will allow the effort to move ahead in anticipation of the successful acquisition of additional funds by the other partners.

One hopes that the LOFAR experience will also provide input to the SKA program on three other fronts. First, the usefulness of multiple fields of view will be explored in practice. Second, the problems of the transport and processing of unprecedentedly large data streams will be attacked and solutions identified. And third, the facility will be operated remotely and simultaneously at full sensitivity by up to eight users at widely distributed locations. With the financing now available one would expect that around the end of 2004 SKA groups around the world will be given initial observational access via the web to the prototype system.

Harvey Butcher

ASTRON