NEWSLETTER

Volume 06

June 2004
FROM THE INTERNATIONAL PROJECT OFFICE

In order to keep pace with global developments in the SKA project, the International SKA Steering Committee (ISSC) has decided that the SKA Project Newsletter should appear at 6 monthly intervals rather than annually. This then is the first Newsletter for 2004.

It has in fact been a busy six months. The five key science projects proposed at the end of 2003 by the International Science Advisory Committee (ISAC) were adopted by the ISSC in its meeting in Cape Town in January. Particular note was also made of the potential for new discoveries with the SKA as a result of its greatly increased sensitivity together with a large field of view – this has been dubbed the Exploration of the Unknown. The rationale behind the choice of the key projects can be found in Memo 44. The full science case is nearing completion under the leadership of Chris Carilli and Steve Rawlings and will be published as a book later this year. The science requirements posed by the key projects on the technical design for the telescope were assembled by Dayton Jones and published as Memo 45. These requirements form the input to the Systems Definition Document to be drawn up by the International Project Engineer together with the International Engineering Management Team (IEMT).

As part of the continuing process of international review of progress in the national or regional technical efforts, the different teams recently submitted reports to the ISPO setting out the plans and milestones for their prototypes and demonstrators. These reports are in the process of being reviewed by the IEMT, and will be instrumental in helping narrow SKA specification space as well as providing the basic data needed by the ISPO for its international coordination role. While on the subject of the specifications and costs of the SKA, the Simulations Working Group is making progress on a cost simulator to help evaluate the different designs; this will be the subject of discussion at the SKA2004 meeting in Penticton.

It has been a concern that an SKA fulfilling the current science requirements would be beyond the capabilities of any single technical design. To address this question, a “Convergence Workshop” was held during the ISSC meeting in Cape Town in order to look at potential combinations of designs as well as the common elements of the different designs. A summary of the discussion is given in Memo 48. Combinations (or hybrids) identified as worthy of further study were Small Dishes (SD) + Aperture Arrays (AA), and SD + Cylinders (CYL); the Large Adaptive Reflector was also identified as a hybrid in itself. More detailed information on these three hybrid candidates has been generated by the proponents and is under review by the IEMT prior to the Penticton meeting.

With the selection of the SKA site now two years away, the Site Evaluation and Selection Committee (SESC) is in the final stages of finalising a Request for Proposals for locating the SKA that is expected to be issued in July or August this year. Preparations are also in full swing for international calibration of the RFI testing at the different candidate sites by an ASTRON team under contract to the ISPO.

Projects like the SKA need international agreements to set out the rules of engagement for all elements of the project. The current MoU signed in 2000 to
establish the ISSC is in need of revision, in part because the project structure has grown with the creation of the ISPO 18 months ago, and in part because the financial provisions in MoU2000 are no longer adequate. A new Agreement on Collaboration in the Development of the SKA has been drafted by a small committee and will be debated in Penticton in mid-July before going to the SKA parties for signature.

At a level below the international Agreement on Collaboration we have the detailed Management Plan for the SKA. In January, the ISSC approved an ISPO proposal for a change in the management structure that recognises the need for external independent advice when the selection of site and technology is to be made as well as at times of major project reviews. Advisory panels for Science, Engineering, and Site Selection will be established by the ISSC in 2005-6. The current ISAC, IEMT and SESC will be re-convened as Working Groups (Science WG, Engineering WG, Site Evaluation WG) to reflect the fact that project-related work at the international level is becoming increasingly important, in addition to the very valuable internal advisory roles these groups have played up to now and will continue to play.

In March, the SKA Consortia in the US and Europe both submitted major funding proposals for design studies to the NSF and the European Commission respectively. Results are awaited with anticipation!

The ISPO distributes information about updates to the contents of the international website at intervals of a couple of months. If you are not on the distribution list, please contact the ISPO Secretary, Astrid Marx, at secretary@skatelescope.org. And while you are visiting the website, please admire its new layout and contents.

Richard Schilizzi
International Project Director

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**NEWS FROM THE COMMITTEES**

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**ISAC – INTERNATIONAL SCIENCE ADVISORY COMMITTEE**

The ISAC activity over the last six months has focused on two areas. By far the most prominent area has been the revision of the SKA Science case. The second major area of effort has been to finalize the level 0 science goals ('key science'). These significant milestones for the project are the result of intensive work by the committee, and many others, and all participants should take pride in the results. Communication has been frequent and thorough, through email, regular teleconferences with the working group and subcommittee chairs (plus minutes distributed to the full ISAC), and at the Science meeting in Leiden Nov. 2003.

Science case book: the SKA science case will be effectively complete by July 2004. This represents a watershed event in the project since 1998, when the original science case was published. The new book involves over 60 authors, many from outside of radio astronomy, including a number of prominent theorists. The book has about 40 chapters on topics ranging from solar system objects to the most distant galaxies, and physical processes from high energy cosmic rays to strong field GR. The publisher is New Astronomy Reviews, and all articles will be placed on the web (astroph) as well as be accessible from the SKA home page.
Key science: Bryan Gaensler chaired a subcommittee to determine the highest priority science for the SKA. After an extensive review process by the subcommittee (see SKA newsletter #5), and the full ISAC, a final list of 5 topics were selected. Establishing the key science goals was a difficult process, with significant design (and possibly political) ramifications, and Bryan carried through the process thoroughly, and most importantly, in a transparent and clearly unbiased manner. We applaud his efforts, and that of the subcommittee. The final report includes a flow-down of the telescope requirements set by the key science goals, and has been published as SKA memo 44. These goals have been summarized in a new SKA flier designed by the public outreach committee.

The key projects chosen were:

* Strong field tests of gravity using pulsars
* Probing the dark ages (cosmic reionization and the first luminous objects)
* The origin and evolution of cosmic magnetism
* The cradle of life (terrestrial planet formation and astrobiology)
* The evolution of galaxies and large scale structure

Chris Carilli
Chair ISAC

IEMT – INTERNATIONAL ENGINEERING MANAGEMENT TEAM

Since the last Newsletter report, the IEMT has had one face-to-face meeting in Cape Town, together with much e-mail discussion on key SKA issues, including plans for SKA 2004 and criteria for evaluating technology demonstrator submissions.

The Cape Town meeting was very productive with the Committee examining the progress of SKA concept development, reviewing the first-round hybrid submissions and participating in the ensuing general debate, and formulating general plans for SKA 2004. In the area of concept development the IEMT re-iterated its view that prototyping and demonstration should be the basis of SKA technology selection. It identified both advances and deficiencies in this area. Advances include the funding of LOFAR, the construction of an Indian PPD prototype, new Chinese prototyping, and progress within the ATA. The Committee was concerned though that technical developments within the critical Aperture Array concept have slowed; this trend will hopefully be reversed if the European SKADS FP6 proposal is successful.

A major up-coming task for the Committee involves the review of SKA technology demonstrator plans. Assessment criteria for the reviews have now been finalized and reviewers allocated for the various papers. Papers are due by April 30 and draft reviews will be available by July 2004. Still on reviews, the IEMT has also suggested inclusions for next-round hybrid concept submissions. The request for more detailed information has now been circulated by the Director to authors; round-2 submissions will be reported on by the IEMT and its working groups prior to SKA 2004. In general terms the IEMT expects that the demonstrator plans, and related concept and science discussions, to be useful in narrowing the still unrealistic SKA specifications.

In Cape Town the IEMT considered the place of new proposals such as the cylinder-based HYFAR, noting that pathfinder science instruments do not automatically constitute good SKA technology demonstrators. The Committee further discussed,
for the first time in any detail, aspects of SKA computing and software engineering. Tim Cornwell advanced the view that this area can be split into three parts:

(i) computer systems and engineering, encompassing the design of all station antennas, and central computing systems;
(ii) data management; and
(iii) calibration and processing, encompassing both imaging and non-imaging modes.

The first category can be, and will eventually need to be, out-sourced. The main SKA effort at present can sensibly continue to be in (iii). Tim has undertaken to present a discussion paper on these themes at SKA 2004.

The IEMT endorsed continuing efforts at SKA system definition and related cost/performance simulation estimators being developed in conjunction with the International Simulation Working Group. In the area of outreach, the Committee put forward a proposal to publish an international engineering outreach leaflet, similar to the general SKA leaflet now available. The engineering version will be invaluable when interacting with industry and it is scheduled to be available by the end of 2004.

In line with its Geraldton discussion last year, the IEMT has now finalized plans for a short “retreat” to be held in Penticton prior to SKA 2004. This gathering will include IEMT members, working group chairs and other invited participants. The retreat will run from 13-15 July, with the first day being devoted to discussions of demonstrators and hybrids. The following days will include discussions on SKA system definition and costing models, together with a look at software engineering issues and risk management.

The IEMT meeting in Cape Town also considered the site characterization process proposed by the SESC and it endorsed a model involving independent RFI testing by the ASTRON group. The Committee also expressed the view that on-site amplitude and phase stability measurement are necessary for adequate assessment of tropospheric conditions at candidate SKA sites.

Finally, another organizational task for the Committee over coming months involves initial and final reviews of engineering and related papers destined for the up-coming special issue of Experimental Astronomy. This edition will contain technical contributions presented at SKA 2004 and it is expected to be published in Quarter 1, 2005. Completed papers should be submitted by 18 July, the start date of SKA 2004. See the conference web site at http://www.drao-ofr.hia-iha.nrc-cnrc.gc.ca/ska2004/ for further details.

Peter Hall
Chair IEMT

SESC – SITE EVALUATION AND SELECTION COMMITTEE

In the fall of 2003, the SESC reviewed the four SKA Siting Proposals from Australia, China, South Africa and the United States of America, and prepared detailed new questions to be answered by the proposing countries in December 2003. The SESC then met in Cape Town in January 2004. After reviewing all the responses, it recommended that the ISSC accept these proposals as potential locations for the SKA.
The SESC also recommended to the ISSC to initiate independent RFI measurements at the appropriate potential SKA locations indicated by the proposals. The ISSC in its January 2004 meeting did indeed accept these recommendations and has begun the process of RFI testing with a contract to ASTRON. Peter Hall, the Project Engineer from the International SKA Project Office is coordinating this effort. ASTRON will provide appropriate transportable RFI testing equipment and plans to monitor the RFI climate for periods of about a month per site (at one site per proposal specified by the proposing country). It will also provide calibrations to the RFI tests being performed by each country, analyze the data and prepare the results for the ISSC by the end of 2005. The SESC is also investigating available data on ionospheric activity, water content and tropospheric stability for the proposed sites.

While in Cape Town, all the members of the SESC participated in a flyby visit to potential SKA sites in South Africa. In the summer of 2003, the SESC members participated in a similar visit to a possible site in Western Australia.

In the August of 2003, the ISSC extended the initial SKA siting proposal dateline for Argentina and Brazil to the end of March 2004. Indeed, Argentina and Brazil have now submitted separate proposals to host the SKA. These are currently being reviewed by the SESC. The SKA Committee in Argentina is headed by Dr. E. Marcelo Arnal and they have identified three possible sites. The highest, called CASLEO (San Juan), is at 2550 meters at longitude 69 degrees 18 minutes West, and latitude 31 degrees 29 minutes South. Argentina proposes to locate the distant array stations in Brazil. The first figure shows a view of the Pampa de la Ciénaga del Medio possible SKA site in Argentina.

The Brazilian effort, headed by Dr. Jacques Lepine, suggest three possible locations for the SKA, all in the eastern part of Brazil, a few hundred kilometers from Brasília, at an altitude of about 900 meters. One of the three sites, called Teresina de Goiás, is at longitude 47 degrees 5 minutes West and latitude 13 degrees 35 minutes South. The second figure shows a view of the area.

The SESC is preparing the final Request for Proposals document that will be reviewed by the ISSC in July 2004. The RFP will be issued shortly after that time, with final proposals due a year later. It is also anticipated that the RFI tests, mentioned above, would also be completed by the end of 2005. The ISSC has indicated that a site ranking or selection is possible by early 2006.

Yervant Terzian
Chair, SESC
SSWG – SKA SIMULATIONS WORKING GROUP

Quite a bit has been happening on the simulations front since the last SKA newsletter.

Recently an SKA design study proposal was submitted to the European Union Framework Programme 6 by a consortium of European organisations, with non-European partners. This proposal is aimed at supporting European efforts in SKA research and development and includes a substantial component dedicated to SKA simulations. It is hoped that this programme will boost the effort of the SSWG in the lead-up to the SKA site and technology decisions in the next few years. Both technical simulations (led by Mike Garrett) and science simulations (led by Steve Rawlings) are covered in the FP6 proposal. Enquiries on the detailed content of the simulations component of the proposal can be directed to Mike or Steve.

It is hoped that the European simulation studies supported under this programme will be able to make use of existing simulation software such as AIPS++ or the MIT/Haystack simulation software. A collaboration between the SKA groups at MIT/Haystack and the Swinburne University of Technology was initiated at the
Geraldton SKA meeting last year. This collaboration is mainly aimed at making the MIT/Haystack simulator available for SKA simulations. Ramesh Bhat from MIT/Haystack was able to visit Swinburne in February to work with Richard Ogley, to install the simulator package on Swinburne's supercomputer. After initial testing of the code, Richard has been looking at a number of areas where development of the code needs to take place in order to be able to customise the simulator for SKA work. At the same time, Richard has been looking at developing a web-based user interface for remote users, and has been working closely with a small number of external users on specific simulations e.g. EoR simulations.

After shaking down the code we hope to be able to make the LOFAR simulation software widely available to the SKA community before the middle of the year. Swinburne will provide user support to the SKA community and the collaboration between MIT/Haystack and Swinburne will continue to develop the code for SKA use.

Work continues on AIPS++ simulations and Maxim Voronkov was able to visit Swinburne in May to start evaluating the two packages side-by-side.

Another of the suggested projects to come out of the Geraldton meeting of last August has also been developing nicely over the last 6 months, the production of software that will allow various SKA concept options to be costed. This has been a collaboration between the IEMT and the SSWG. Shinji Horiuchi has taken up the project in conjunction with the SKA Project Engineer, Peter Hall, and a small team of others, mainly at the ATNF. The team have come up with a general framework in which SKA cost calculations can be undertaken and Shinji has started to implement this framework in software. A number of meetings have taken place over the last few months, in the lead-up to the IEMT retreat in Penticton in July. The cost calculator work will be a significant focus for the retreat. For those of you going to the retreat we look forward to your input on the cost calculator. More information will be made available prior to the meeting via the IEMT.

After the IEMT retreat in Penticton, the annual international SKA workshop will be held, also in Penticton. At this meeting the SSWG will take the opportunity to get together and present updates from the various groups around the world. A small number of invited and contributed presentations on simulations will be made during the SSWG breakout session in the morning of Thursday July 22.

Lastly, on the meetings front, in January the ISSC met in Cape Town, South Africa. An SSWG report was presented to the ISSC outlining the progress in the area of SKA simulations.

Steven Tingay
Chair SSWG

OUTREACH COMMITTEE

In the first half of this year, the outreach committee was mainly concerned with a restructuring of the SKA webpages. The result can be visited at www.skatelescope.org and a picture of the front page is shown here. We relied heavily on the skills of Stephanie Voegele from ASTRON who made the basic design concepts. Many people from around the globe contributed to the contents to make it interesting for lay people as well as professional astronomers - thanks to all of you.
who contributed. Also in the future we are dependent on community contributions. This is particularly true for graphics, presentations, and animations that are related to the SKA or just radio astronomy in general. Please send us any material you may find suitable without us always having to ask you!

New homepage of the SKA website

Page 1 of the Key Science Projects insert for the SKA brochure

It is clear that such a webpage needs to be maintained and expanded. As a consequence the committee feels that a dedicated professional is needed to keep up with this work and public outreach in the future.

In the long term the SKA project needs to achieve a broader popularization of radio astronomy in general through a range of activities. This includes producing high-quality graphics and visualizations of radio astronomy concepts and results, popular science articles, or even entire science & art exhibitions with accompanying material.

Within the scientific community, radio astronomers and SKA representatives have to be present and visible. The “Berlin” meeting as well as the Geraldton SKA meeting last year were certainly big successes as far as public outreach is concerned. This needs to be continued. For that reason we are right now working together with the organizers of the next SKA meeting in Canada to pass on that experience.

To further strengthen our impact within the astronomical community, the ISAC has come up with five basic themes the SKA will address and which can capture scientist’s imagination. The Outreach Committee, together with the respective science working group chairs, has condensed this further into a 2 page flyer that can be inserted into the standard SKA brochure. Please make use of this opportunity - the SKA has an extremely interesting science case! Copies may be requested from the SKA project office and it can also be found at [http://www.skatelescope.org/PDF/flyerska.pdf](http://www.skatelescope.org/PDF/flyerska.pdf). More material is expected to follow later this year.

Heino Falcke
Chair Outreach Committee
CAPE TOWN

**Cape Town ISSC, IEMT and SESC meetings – January 2004**

Cape Town was the venue for the 11th gathering of the International SKA Steering Committee during January 2004. A number of associated technical meetings preceded the ISSC meeting and a total of about 40 international delegates found their way to the southern tip of Africa for the week.

All of the SKA delegates lodged at the Courtyard Hotel, which has a good view of Devil’s Peak and is situated near to the historic headquarters of the South African Astronomical Observatory (SAAO). The various meetings and functions were held at various venues around greater Cape Town.

Formal proceedings began on Sunday evening (11 January) with the ISSC executive meeting in the board room at the hotel. Monday morning was set aside for IEMT and SESC meetings at SAAO. On Monday afternoon the SKA community and local South African academics, engineers and industry were given a chance to get to know each other at a technology workshop hosted on the University of Cape Town campus.

Monday evening saw the first of the social events: a cocktail party after the Industry Workshop, and a traditional "braai" (barbeque) hosted by Dr Khotso Mokhele (CEO of the National Research Foundation) on the SAAO grounds. Besides the food, guests were entertained by an energetic group of dancers accompanied by African drums.

Tuesday was set aside for a Technical Convergence Workshop where the various consortia were challenged to investigate ways in which their chosen antenna concepts could be hybridized with other concepts to achieve the full performance expected of the SKA. This meeting was held at the National Botanical Gardens on the slopes of Table Mountain.

After the Convergence meeting delegates and spouses were bussed down the Cape Peninsular to visit the penguin colony at The Boulders. A restaurant with a view of the Boulders beach and False Bay provided us with a fish dinner.

Wednesday was dedicated to exploring the Northern Cape province which is host to SALT and the prospective SKA sites proposed by the South African SKA steering committee. We were bussed to Cape Town airport early in the morning where we were loaded into 4 light aircraft, and our adventure began. The first leg of our journey traversed the “Namaqualand” site and we landed in Upington to refuel and stretch our legs. Despite some fluffy clouds we were afforded good views of the proposed core site area. From Upington we flew toward Sutherland, traversing the Karoo site. Again, we dodged broken clouds to get a good view of the landscape below.
The bleak and bare airstrip at Sutherland was uncharacteristically busy when we arrived around midday. Ambulances, a fire engine, police vehicles, minibus taxies and their occupants provided a rather incongruous reception party. After meeting with mayors from towns in the district we were loaded in the waiting minibus taxies and led by the police vehicles, we formed a cavalcade that headed for the village of Sutherland, some kilometers away.

When we entered Sutherland we were greeted by hundreds of schoolchildren who lined the streets and waved SKA and South African flags as we drove past. Despite being on vacation these children donned their school uniforms to be part of this reception party. The minibuses delivered us to the village church hall where we were hosted by the Premier of the Northern Cape, Mr Manne Dipico. The hall was decorated with bunting, flowers and splendid table settings. Lunch was cooked by the local farmer’s wives and served by local schoolchildren. While eating we were entertained by choirs and a San ("Bushman") dance group.

After lunch the project engineer for SALT, Kobus Meiring, gave a presentation on the design and construction of SALT. This presentation was followed by a site visit to SALT, which is located on an escarpment above Sutherland, together with all of the SAAO telescopes. Kobus’ young team of engineers showed small groups all of the major subsystems of this massive optical instrument which is nearing completion.

The final leg of our journey was the flight from Sutherland back to Cape Town. Most of us were too exhausted to contemplate any arduous social engagement that evening, so most chose to have supper at the hotel.

The ISSC meeting filled both the Thursday and Friday, and was held at the Botanical Gardens. The banquet was held on the Thursday evening at the highly acclaimed Buitenverwagting restaurant, which is located on a small wine estate within Cape Town city limits. The dinner was sponsored by Telkom, the South African telecommunications operator, and was attended by the then Minister for Science & Technology (Dr Ben Ngubane), the Director General for Science & Technology (Dr Rob Adam), Dr Khotso Mokhele and various federal and local government representatives.

The week’s activities ended with a boat trip to Robben Island on the Friday night. This infamous island prison was “home” to many South Africans during the apartheid era, the most famous “resident” being Nelson Mandela. We were given a tour of the austere prison buildings, and shown Mandela’s cell. After the tour we had a late dinner at the prison governor’s house where we toasted Jill Tarter and the absent Jack Welch on their respective birthdays – a fitting end to a busy week.
Dancers at Monday’s “braai” in Cape Town (photo courtesy of Bob Preston)

Pictures of some of the highlights can be found at:
http://jansky.ru.ac.za/~phjj/SKA/Newsletter/

Justin Jonas  
Chair LOC

BERLIN

Symposium on "Exploring the Cosmic Frontier: Astrophysical Instruments for the 21st Century", Berlin, Germany, 18-21 May, 2004

The Berlin symposium was dedicated to discussing major scientific themes of the coming decades, in connection with major future astrophysical facilities. The meeting, organized and sponsored by the Max-Planck-Institut für Radioastronomie, ESO, ESA, RadioNet, and Opticon, has brought together over 170 scientists from all branches of astrophysics. The stage for discussions at the meeting was set by detailed reviews of scientific and technical capabilities of forthcoming instruments in the radio, millimeter, sub-millimeter, far and near IR, optical, UV, high-energy and gravitational wave astrophysics. These reviews were followed by presentations of scientific prospects in five widely defined areas of research, all of which among the primary science drivers for the SKA. The main focus of these presentations was set on advances that future instruments should bring to studies in fundamental physics, cosmology, early Universe, galaxy and star formation and evolution, nuclear activity in galaxies, black hole physics, and search and detection of extra solar planets.
The scientific sessions of the meeting were concluded by discussions within four working groups which were aimed at identifying priorities and critical issues in astrophysical research and charting the ways to synergies and cooperation between various future facilities. The outcome of the working group discussions was described in four summaries presented on the last day of the symposium. These summaries will be included into the proceedings of the symposium, alongside with all of the talks and poster presentations made during the meeting. The proceedings will be published by Springer Verlag as part of the ESO Astrophysical Symposia Series.

All of the proceedings contributions will be made available at the conference website. At present, the conference website features copies of a large fraction of the PowerPoint presentations made at the meeting. The website can be found at: http://www.mifr-bonn.mpg.de/berlin04/

Andrei Lobanov
Anton Zensus

PENTICTON

SKA 2004 Conference: Lakeside Resort Convention Centre, Penticton, British Columbia, Canada July 18th – 22nd

Preparations for the International SKA2004 conference are now into their closing stages. This is looking to be the largest SKA-related meeting to date, with 147 delegates from all parts of the world, and an exciting programme of both invited talks and a large number of poster presentations.

Conference Summary:

Day 1  Concept and demonstrator/pathfinder reports
Day 2  Science day, including invited talks
Day 3  Engineering session with invited speakers in the morning
       Tour of SKA-related work at DRAO in the afternoon
Day 4  Breakout meetings for SKA working groups in the morning
       Convergence workshop in the afternoon

In addition to the three days of plenary sessions, and the final day of break-out meetings and convergence workshop, there will be several peripheral activities. A welcoming reception at the Art Gallery of the Okanagan will start things off on Sunday July 18th, and we are hosting a public lecture by Jill Tarter of the SETI Institute on Tuesday evening. The conference dinner is scheduled for Wednesday evening following the DRAO tour. The dinner will be held at the Red Rooster Winery overlooking scenic Okanagan Lake (see picture).

Immediately prior to SKA2004 is a three-day Radio Frequency Interference workshop (July 16-18th) at DRAO, a joint event with IUCAF. For more information see www.drao.nrc.ca/rfi2004, as well as a three-day retreat for the IEMT, also being hosted by DRAO.

We anticipate that all will enjoy their visit to the sunny Okanagan Valley, one of Canada’s most popular summer destinations, famous for its hot, dry weather, sandy beaches, and its wine industry. More information can be found at www.penticton.ca.
We strongly encourage you to examine the detailed programme at the SKA2004 web site ([www.drao.nrc.ca/ska2004](http://www.drao.nrc.ca/ska2004)), and if you haven't yet registered and/or booked accommodation, you'd best attend to it! Please forward payment information by fax at (250) 493-7767.

See you in Penticton.

The SKA2004 LOC

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**Guayang**

*Information on the ISSC-13 meeting in China*

The 13th ISSC meeting in China is to be held in Guiyang, capital city of Guizhou province. Guizhou is the potential SKA site proposed to the ISSC by the Chinese SKA Group and where the FAST will be built as a National Megascience project.

The dates for the meetings: 16-20 March 2005.
Hotel cost: 75 (single bed room), 90 (double bed room) and 120 EURO (suite) per night with breakfast included.
Internet access: available in each hotel room and the meeting rooms free of charge.
Registration: 17:00 - 20:00 on March 16.
Reception drinks and snacks: 18:00 - 20:00 on March 16.
Meeting webpage: [http://www.bao.ac.cn/LT](http://www.bao.ac.cn/LT) (available September 1, 2004 ?)

We propose the following rough agenda (a detailed schedule will appear on the meeting web page and be modified anytime before the meeting)
The ISSC Executive Committee will meet in the evening of March 16. On March 17, an SESC meeting is to be arranged in the morning, with the afternoon being available for local and ISSC-related meetings. It will also be possible for participants to tour around this (under developed) city. March 18 is reserved for (more than) half a day visit to one of the best FAST/SKA sites, and (less than) half a day for sightseeing at the Huangguo Shu waterfall. (A different trip will be arranged for those who have already visited the waterfall.) There will be evening entertainment with local minority people, and a dinner at Huangguo Shu park. The last 2 days are scheduled for the half yearly ISSC meeting, with a welcome Banquet hosted by the Provincial governor (and/or National Science Minister to be confirmed) on one of the evenings.

Programs for spouses can be arranged through a travel agency. Tour after the meeting could be arranged within or outside the province, depending on participant requirements, but would be better known in advance. We will come up with a suggested list for tours on the web at http://www.bao.ac.cn/LT.

National Astronomical Observatories, Chinese Academy of Sciences
FAST Group, China

NEWS FROM THE CONSORTIA AND INSTITUTES

AUSTRALIA

The various groups around Australia involved in SKA research and development have continued to make good progress, and links are increasingly being made between groups. A few highlights for the last few months are described below.

Supercomputing Simulations and Baseband Processing

A major achievement of the recent work by the SKA Supercomputer Simulations and Baseband Processing project at the Swinburne University of Technology was the organization of two international VLBI experiments that used disk-based recording systems and software correlation of the data to demonstrate the basic elements required for real-time VLBI.

The experiments took place in April and the antennas participating were the Australia Telescope Compact Array, Mopra, Parkes, Tidbinbilla, Hobart, and Ceduna (in Australia), and Hartebeesthoek (in South Africa), Pie Town (USA) and Kashima (Japan). Three different types of disk-based recording systems were used in the experiments, PCEVN, MkV, and K5. Software was written to electronically transport some of the data in near-real-time and software correlation was used to verify fringes between 4 antennas in Australia. The data from all telescopes is currently being collected at Swinburne University and will be correlated on the supercomputer there. These initial observations pave the way for real-time VLBI using the gigabit data links that are planned for the ATNF in the near future.

Luneburg Lens Project

The Luneburg lens development program has proceeded with antenna range and radiometric testing of a prototype lens manufactured by CSIRO materials scientists.
and delivered to ATNF in late 2003. The tests confirm the earlier cavity-based measurements of loss tangent well below the target loss tangent of $10^{-4}$. Overall, the Luneburg lens program has been very successful in its development of innovative materials and manufacturing technology, and it has now reached the major review milestone identified in the original project plan. A review has been carried out externally by a sub-committee of the Australian SKA Consortium, that has determined that Australia should not continue to carry the Luneburg lens forward as a candidate SKA concept antenna technology at the moment. Commercial applications for the technology are currently being explored.

Doug Hayman working on the Luneburg lens tests, lifting the lens for testing into the radiation shield.

Site Studies

ATNF continues to be actively involved in SKA site studies, and is currently exploring opportunities to develop a demonstrator array at the remote candidate SKA site in Western Australia. A project plan for development of a low-frequency radio astronomy demonstrator array is being developed in collaboration with international and national partners, including the SKAMP cylindrical reflector telescope project based at the University of Sydney. In addition, a long–term radio-frequency monitoring program will be implemented towards the end of 2004, in order to obtain data on background levels of radio-frequency radiation at Australian candidate sites. Ron Beresford has designed a suite of equipment to enable sensitive background radio-frequency levels to be measured at several Australian sites, and will soon be putting the equipment together prior to setting off once more into the Australian outback in search of elusive radio waves.

Signal Processing

Another area of active ATNF research is the construction of a broadband backend for the Australia Telescope Compact Array. The major recent achievement towards this goal has been the installation of the proof-of-concept digital filter bank at the Mopra radio telescope. Current best performance of this system is 256 MHz bandwidth with 1024 frequency channels. The plan is to increase this to 600 MHz with 1024 channels by July 2004. Work is well underway on the design of a prototype 2GHz filter bank printed circuit board.

Australian SKA Consortium.
Canadian LAR project update.

Over the past six months, work on the LAR concept has been going full-speed ahead on a number of fronts – the reflector structure and actuation design, focal plane and focus mechanism work and the aerostat control system.

The Reflector and Actuation system.

The proto-type section of the LAR reflector surface has now been completed by AMEC Dynamic Systems in Vancouver. The triangular structure unit is 20-m on each side. Two 10-m reflector panels have also been assembled and attached to the structure unit (see photo).

To keep the LAR reflector pointed at the desired focus as the focal point moves across the sky, the surface needs to be actuated – with a maximum throw of around 8 m at the outside edge of the proposed 200-m reflector. Various actuation mechanisms have been investigated over the past year. We have now settled on a
The actuated linkage design for the LAR. The top view is the fully extended actuator, and lower image is the fully lowered position.

linkage systems that offers a 4:1 mechanical advantage throughout the complete throw. We have let a contract to AMEC to build three of this type of actuator for testing on the completed structure unit, with a maximum throw of 6m. The hydraulic system for this prototype is being supplied by Bosch-Rexroth Canada.

We are planning on assembling the actuated structure unit at DRAO, prior to the SKA2004 meeting. Currently the on-site civil works are nearing completion, and the fabrication of the linkages and hydraulic system is underway.

The Feed Control Mechanism

A new design of feed control mechanism is being developed at the Laval University Robotics Laboratory under the direction of Prof. Clement Gosselin. Taking advantage of the fact that the load is always below the support structure the group has come up with novel inverted Stewart Platform type mechanism in which the legs are flexible cables. To ensure the cables are adequately tensioned at all times the addition of an active centre leg is being investigated. Using tensioned cables allows the weight of the mechanism will be kept to a minimum while the dexterity is maximized. Current work is focusing on the kinematics of the mechanism with dynamic studies to follow.
Focal Plane Array

We are continuing to make progress on the development of focal-plane arrays for the LAR. A "test bed" has been designed by Ed Reid and will soon be fabricated. This is a unique Vivaldi array because of its modularity, allowing experimentation, such as the substitution of old element designs with new, without requiring the entire array to be replaced. This will be a fairly large array---342 elements---and will permit us to examine the properties of not only elements near the edge, but also elements at the centre, which should be close approximations to elements within an infinite array. This array will function from below 2 GHz up to 6 GHz.

A critical parameter for an LAR focal-plane array is its weight. Dean Chalmers and Bruce Veidt have begun to look at radical modifications to Vivaldi array design as a way to achieve major weight reductions. They are looking at several ideas. First is to consider a structurally-integrated design where the Vivaldi antennas do not simply have an electrical use but are part of the structural framework supporting the feed. The other idea is to replace printed circuitboard construction with thin metal structures. For example, three-dimensional variants of Vivaldi elements could be fabricated in a way similar to how soft-drink cans are made. Like egg shells, these new antenna structures may be fragile (because of their thin shell) if forces are applied in the wrong way, but can be very strong if forces are distributed correctly.

Aerostat Control System

Flight testing of the tethered aerostat system continues. With the recent addition of a GPS receiver and tilt sensors on the aerostat validation of the mathematical model has been improved significantly. Currently the flight crew is busy moving the computer controlled winches out to their field positions so that closed loop flight testing can begin over the Summer months.

The LAR group
CHINA

FAST progress from new SKA groups at the first half year 2004

During the last period, there are developments to report in three main areas: the SKA site survey, the radio frequency interference (RFI) test observation which follows the “RFI Measurement Protocol for Candidate SKA Sites” (hereafter RFI protocol) set by the SESC’s RFI working group, and the FAST cable support demonstrator.

Site survey

FAST, a large, light weight and innovative version of the Arecibo telescope, would be built as a demonstrator of Chinese SKA concept KARST in the karst land, province of Guizhou in China’s southwest. During 1994—1997, the search for suitable karst depressions, which have the ideal shape for supporting FAST’s huge spherical reflector, had concentrated on two karst-rich regions in the province, Puding and Pingtang counties. In late 2002, a new site survey group was set up in the Guizhou University of Technology, and it has extended the search to cover the entire province. Some 90 candidate depressions have recently been located, each of 500 m or more in diameter, even up to about 1000 m in the extreme few cases. Their physical parameters have been recorded and simulated in a digital terrain model (DTM) with adequate resolution (10000:1 mapping). Subsequently, 81 candidates were visited, mainly depending on traffic accessibility, and photographs have been made for comparison with the DTM. An example is shown in the two figures, where the first panel shows the DTM image and the second the photo.
RFI test:

In November 2003, a new RFI survey group was established within the monitoring center of the Guizhou Radio Regulatory Bureau GRRB, in order to carry out, for a period of at least one year, RFI monitoring at candidate sites according to the RFI protocol. In the middle of December 2003, an RFI test at one of the best candidate sites, Dawodang, was performed for 8 days, it was only on mode 1 of the RFI protocol to check if there is any difficulty for a year long measurement. The result was that the SESC’s RFI protocol can be followed with the equipment from the GRRB, and a complete RFI measurement, including both modes 1 and 2, would take about 2 weeks. The test observation has been summarized in the table, and some results are shown in the figure, where the frequency is along the x-axis in units of MHz, the power is along the y-axis in dBWm²Hz⁻¹; horizontal polarization is shown in red, and vertical polarization in blue.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Longtide: 106° 51’ 20.02” E; Latitude: 25° 38’ 59.55” N; Altitude: 1002.3 m</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Antennas</td>
<td>Below 1 GHz: HLI03A2 Log Periodic Antenna (R&amp;S); Above 1 GHz: Parabolic antenna (Diameter=0.8 meter)</td>
</tr>
<tr>
<td>Antenna height</td>
<td>4 m</td>
</tr>
<tr>
<td>Low noise amplifier</td>
<td>0.7 - 1 GHz: gain 25 dB, NF 3.0; 1 - 30 GHz: gain 40 dB, NF 2.5</td>
</tr>
<tr>
<td>Spectrum analyzer</td>
<td>FSP30 Spectrum Analyzer (R&amp;S)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency Range (MHz)</th>
<th>Resolution Bandwidth (kHz)</th>
<th>Antenna Gain (dBi)</th>
<th>Mean Noise Level (dBW m² Hz⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-300</td>
<td>3</td>
<td>6.5</td>
<td>-173.82</td>
</tr>
<tr>
<td>300-960</td>
<td>30</td>
<td>6.5</td>
<td>-189.63</td>
</tr>
<tr>
<td>960-1400</td>
<td>1000</td>
<td>6.5 or 17.4 (&gt;125 MHz)</td>
<td>-199.61</td>
</tr>
<tr>
<td>1400-3000</td>
<td>30</td>
<td>~ 20.9</td>
<td>-223.06</td>
</tr>
<tr>
<td>3000-22000</td>
<td>1000</td>
<td>~ 33.8</td>
<td>-228.76</td>
</tr>
</tbody>
</table>

*Location, RFI instruments and parameters for testing observations made at Dawodang in December 2003*
RFI testing results, recorded at Dawodang depressions in Dec. 2003

The RFI monitoring at Dawodang site will be performed once every 3 months, roughly in May, August, November and early 2005 by this regional RFI monitoring group of the GRRB. It should be noted that the last measurement will be accommodated with the visit of the international RFI calibration group from ASTRON. The May session has been completed, but the parabolic antenna used for higher frequency bands is too time consuming, and has been replaced by a horn ETS 3115 which is working in the frequency range of 1 — 18 GHz.

FAST cable support demonstrator

To test the FAST innovative technology, scale models have been built for some of the major subsystems. A 10% (50 m diameter) scale model of the towers, cable support and feed cabin was built and operated last year at Tsinghua University in Beijing in order to test the cable-car driven concept in practice. The initial tests proved to be very successful, see early report in last newsletter. Some of the major components are being re-built at the radio observatory at Miyun of the NAOC after the contract, between the NAOC and Tsinghua University, ended in Feb. 2004, to carry out further testing and to be part of the FAST cable support demonstrator. Four new, taller (21 m instead of 15) towers are erected, to support the cables and cabin. The present situation is shown in the photograph on the following page. In addition, a cable-supported mesh reflector is under extensive study by a new engineering group at the Harbin Institute of Technology (HIT), which was set up in late 2003. A simulation of the design has been successfully completed recently. The plan is to start building a scale model of cable-mesh reflector at Miyun later this year. Because of the limited space at the observatory, the FAST cable support demonstrator, which includes a cable-car feed support system, a cable-mesh reflector (and a L-band receiver), will not extend beyond 30 m which is not as big as the previous plan of 50 m.
The “SKADS” Design Study Proposal

The European SKA Design Study (SKADS) was submitted to the EC on March 4 for consideration for funding under its Framework 6 Programme (FP6). The SKADS proposal is multi-faceted and principally involves:

- a range of scientific simulations to explore the impact of the principal science drivers on the final SKA design
- a range of technical simulations to explore the impact of various technical choices on the final SKA design
- an end-to-end study of the SKA signal path from collection to the delivery of data to the user.
- specific hardware deliverables to explore different multi-beam collection and signal-processing concepts
  - a ~500 m² aperture phased array EMBRACE (Electronic Multi-Beam Radio Astronomy ConcEp) intended to demonstrate multiple, independent beam-forming capabilities; in addition several smaller copies may be constructed in the UK and France to demonstrate long baseline data transfer and high resolution image formation capabilities
  - beam-forming hardware and software employed on the cylindrical antennas of the “Northern Cross” in Italy

SKADS is also acting as a partial “cohering mechanism” for international SKA technology development. The following non-EU countries will be active participants in SKADS, largely funded from national sources but with some travel funds shared with European partners.
Australia: via the Australian SKA Consortium, in particular a combination of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), via its Australia Telescope National Facility (ATNF), and the University of Sydney and other Australian Universities.

Canada: via the Canadian SKA Consortium.

Russia: via the Astro-Space Centre Moscow; Puschino Observatory.

South Africa: via the South African SKA Consortium. South African participation in SKA R&D is being supported at the highest levels of government.

In total the SKADS work programme produced a request for €38M, with less than half being sought from EC funds and the rest from national sources. This is a large R&D programme and funding it to this level will be hard.

**SKADS Status**

The competition for European funding is intense. SKADS was one of 121 proposals received by Commission for this particular FP6 Call (Design Studies and Construction of New Projects) and the total of the funding requests was almost a factor six over-subscribed compared with the €70M budget. As for the previous FP6 “Integrated Infrastructures Initiatives” round—which resulted in the funding of “RadioNet”—European astronomers put in two large proposals (essentially to support SKA and an optical ELT) as well as several smaller ones. The SKADS proposal has now been assessed and it received an excellent rating of 4.5 out of 5, with highly favourable comments from the assessors. Given the pressure on the Design Study budget we are now anxiously awaiting the decision on funding, which should be made in the second half of June. We have been informed that the ceiling for EC funding of any Design Study will be €10M.

Should SKADS be successful then EC contract negotiations should begin relatively rapidly but based on what the EC tells us, and on past experience, any new EC money would not flow until Q2 2005. In the meantime all SKADS partners will actively be seeking national matching funds to boost the total to more than double what the EC may offer.

Peter Wilkinson
Chairman ESKAC

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**INDIA**

**Interaction between Industries and Radio Astronomers in India:**

Interaction between academia and industry is very important for the success of projects of SKA's magnitude. Since we are keen to explore a model for this interaction for the GMRT upgrades, a one-day workshop was held on 19 June 2004 at the GMRT observatory in Khodad, near Pune. The workshop, organised by NCRA, Pune and RRI, Bangalore, highlighted the opportunities for research and development in hardware and software technologies that are becoming available with the various developments in radio astronomy. About 20 participants from 10 organisations representing software industry and R & D were exposed to the current trends in radio astronomy, including GMRT upgrades and developments in SKA, LOFAR, etc. The workshop will be the starting point for future interaction to identify
possible areas of interaction between the radio astronomy community and the Indian industry.

Preloaded Parabolic Dish project update:

After the completion of the fabrication of the preloaded parabolic dish (PPD), the focus has now moved on to its mount fabrication. Several meetings were held to review the design of the mount. The mount has been designed for survival, up to wind speeds of 150 km/hr. A contract has been awarded for the fabrication of the mount and its erection at the Gauribidanur field station located at about 80 km north of Bangalore. Since the time allotted to carry out this work is 6 months, the dish with its mount and the receiver system are expected to be in place by the end of this year.

Our studies indicated that a mount with a screw actuator for the elevation drive does not offer any cost advantage. In view of this, we have gone in for a conventional alt-azimuth mount with a slew ring bearing for the azimuth drive and a sector gear for the elevation drive. The left hand figure shows the model of the mount with the dish. The dish with its mount and the mechanical drive system is expected to cost $500/m$^2$. This is the cost for one-off fabrication and is expected to come down substantially for mass production.

Momentum has picked up in the lab to ensure that the whole electronics will be ready in time for the dish with its mount. On the control system front, a test setup with an electrical load simulating the actual inertial load of a dish has been designed and used to evaluate the tracking and backtorquing capabilities of the PMAC based control system. This system shows satisfactory performance. After successfully adapting the commercially available off the shelf controller for telescope control, we are now investigating a suitable architecture to employ this for controlling a cluster of sixteen to thirty-five antennas. To improve the robustness of the control system, an alternate control path with a Linux based PC is also under development.

The design and development of a 4-8 GHz front-end receiver that can handle one polarization is complete. A Wideband Ridge Horn has been designed to operate in the frequency band from 600 MHz to 1600 MHz. The novelty in the design has been the use of ridges having sine square profile, which has enabled us to obtain symmetrical E and H plane patterns and a broadband performance. The right hand figure shows the ridge horn on its test bench. Design and development of a cryogenic system based on pulse-cooled cryocoolers to cool the front-end electronics at the prime focus of the dish has been initiated.

N. Udaya Shankar (RRI); A. Pramesh Rao (NCRA-TIFR)
SOUTH AFRICA

News from the South African SKA Steering Committee

After hosting the January ISSC gatherings in Cape Town in January, the South African SKA Steering Committee got back to the more technical tasks at hand. Our SKA activities are divided into two themes: preparation of our site proposal and development of an SKA science and technology pathfinder.

Our work continues to be given financial and moral support by the government. We received a two-year grant of R30 million (about US$3.7 million) from the Innovation Fund (via the Department of Science & Technology) and a further commitment of financial support from the Department of Trade and Industry. In his address to the newly elected parliament on 21st May president Thabo Mbeki made reference to our SKA activities:

“...In this context we must mention that the construction at Sutherland, the Northern Cape, of the largest optical, infrared telescope in the southern hemisphere will be completed in December. A formal bid has been submitted for us to host the largest radio telescope ever built, the so-called Square Kilometre Array Radio Telescope. Namibia is host to the most powerful gamma ray (HESS) telescope in the world, which has now been commissioned. I mention all these to indicate the development of our region as a Global Hub for Astronomy and Space Science and Technology. This underlines the need for us to devote more resources to the development of science and technology.”

The funding has allowed us to purchase the equipment necessary to conduct the intensive RFI studies required in the site RFP currently being drafted and to start the realization of our SKA Research and Technology Collaboration Centre (RTCC). The RTCC will coordinate our SKA activities within South Africa and forge links with the various other SKA consortia. We have recently enlisted the services of two people to increase our human capacity in our project work. Ms Anita Loots, who has broad experience in innovation management, will drive our RTCC activities as project engineer. Ms Kim de Boer will assist Dr Bernie Fanaroff in overall project management.

After discussions and consultations with SKA role-players during the Berlin meeting we have decided to pursue a science and technology pathfinder to be located in South Africa. We are considering a hybrid design with a compact array of 25 12-metre traditional dish reflectors fitted with L-band focal plane phased arrays. Principle science drivers for this project are pulsar timing and astrometry, cluster HI surveys, L-band VLBI and galactic OH source monitoring. We are actively seeking international partnerships to realize this project.

SA SKA Steering Committee
USA

US SKA Consortium News:


The full membership now stands as follows:

- University of California at Berkeley
- California Institute of Technology and the Jet Propulsion Laboratory
- Cornell University and the National Astronomy and Ionosphere Center
- Harvard University and the Smithsonian Center for Astrophysics
- University of Illinois
- Massachusetts Institute of Technology and the Haystack Observatory
- National Radio Astronomy Observatory
- University of New Mexico
- Naval Research Laboratory
- The SETI Institute
- University of Minnesota
- University of Wisconsin
- Virginia Institute of Technology

Technology Development Project Submitted to the US National Science Foundation

In early March 2004, the Consortium completed a major proposal for a SKA Technology Development Project that was submitted to the US National Science Foundation for funding for a five year period. The Consortium signed a Memorandum of Understanding with The National Astronomy and Ionosphere Center to manage the Technology Development Program and Professor James Cordes of Cornell University has been appointed as the Project Director for this program. The review of the proposal will take place over the next few months and any funding that results from it will commence late FY 2004 or early 2005.

During the course of the last year significant activities have taken place for SKA development of the LNSD concept, for the Allen Telescope Array and for JPL's Deep Space Network project, which we describe here.

Developments for the US SKA’s LNSD Concept Under Current NSF/ATI Funding

Concept for a 12m Antenna with a 2m Low-frequency Skirt and Low-Frequency Feed: The top figure on the next page shows the concept as developed by S. Weinreb and colleagues. The low-frequency skirt provides more wavelengths across the antenna and thus better performance. A prime-focus feed flips in front of the subreflector as needed. Further work will compare the price/performance of this symmetric antenna design against asymmetric designs.
Visualization of a 12m dish with 2m low frequency skirt

Further specifications for SKA 12m/16m Versatile Antenna:

- 12m solid diameter with 2m mesh extension to 16m diameter
- Mesh is 10x10mm with 0.56mm diameter SS wire. Has <5% transmission for F < 1.5 GHz.
- 16m is $4\lambda$ at 75 MHz. Will be efficient low frequency antenna at prime focus.
- 16m F/D = 0.375 with 67° edge angle has very low ground pickup with wideband feed. Very low noise for a 0.5 to 1.5 GHz
- Shaped reflector and subreflector provides high A/T for secondary focus operation 1.2 to 34 GHz
- 0.1 to 1.5 GHz feed can flip to provide 60° FOV with collecting area equivalent to a 250m dish at 100MHz for 4500 elements.

The Allen Telescope Array Project

The ATA project has finished installing the next 30 antenna foundations (which includes the SKA test antenna site) and has completed trenching for the ATA-32 (see figure). Testing continues on the three existing antennas and work is underway to complete the cryogenic feeds. Parts are on order for the ATA-32 antenna structures and we expect them to be fully emplaced this fall. We are finalizing production versions of all other cards in our signal path and developing code for the digital hardware and we expect end-to-end tests this fall.
DSN Array Progress Report

- The DSN array development project is now part of a plan for the future DSN which includes uplinks, arrays, and operations.
- Major milestones
  - By end of FY05, complete 3 x 6 m array and select 12m antenna.
  - By end of FY07, complete 12 x 12 m prototype array.
  - By FY12, complete 400 x 12 m arrays at 3 longitudes.
- Three 6m hydroformed reflectors delivered by Andersen; pedestals under construction by JPL.
- Bids for single 12m complete 32 GHz antenna due in mid May; includes detailed cost estimates for 12 and 100.

Hydroformed Aluminum Antennas

Hydroforming is a process of using a fluid or gas at very high pressure to force aluminum sheet to conform to a mold. The result is a stiff, accurate, and low cost reflector.

JPL has performed a structural analysis of 5m and 8m hydroformed reflectors manufactured by www.anderseninc.com and has found that the wind and gravitational distortions would allow operation at frequencies as high as 100 GHz.

<table>
<thead>
<tr>
<th>Example</th>
<th>Antenna Diameter</th>
<th>Cost per Antenna</th>
<th>Cost per m²</th>
<th>Cost per km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>New 70m DSN antenna</td>
<td>70m</td>
<td>$100M</td>
<td>$40.8K</td>
<td>$40.8B</td>
</tr>
<tr>
<td>25m VLBA antenna</td>
<td>25m</td>
<td>$3M</td>
<td>$9.6K</td>
<td>$9.6B</td>
</tr>
<tr>
<td>6m ATA antenna</td>
<td>6m</td>
<td>$30K</td>
<td>$1.7K</td>
<td>$1.7B</td>
</tr>
<tr>
<td>Target SKA cost</td>
<td>10m</td>
<td>$30K</td>
<td>$600</td>
<td>$0.6B</td>
</tr>
<tr>
<td>Hydroformed DBSTV antenna</td>
<td>4m</td>
<td>$2.8K</td>
<td>$350</td>
<td>$0.35B</td>
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<tr>
<td>Aluminum, 3mm thick sheet</td>
<td>Any</td>
<td>NA</td>
<td>$30</td>
<td>$.03B</td>
</tr>
</tbody>
</table>
Hydroformed Reflectors – Pros and Cons

**PROS**
- One-piece rigid shell provides high stiffness and can be supported by very simple backup structure.
- Accuracy is not dependent upon skilled labor.
- Low-labor hours – on the order of 100 hours per reflector.
- Proven no-risk, low cost, material – aluminum, $30/m²
- ATA will provide experience with 350 1/2 size units

**CONS**
- Unproven for the 12m size and the 40GHz accuracy
- Non-recurring costs for 12m tooling and factory - $5M to $15M
- Difficult to ship one-piece 12m reflector
- Not adjustable after manufacture

Yervant Terzian and James Cordes
US SKA Consortium