IVS Newsletter
Issue 25, December 2009

Thirty-four VLBI Antennas Observe Largest Astrometry Session Ever

– Dirk Behrend, NVI, Inc./NASA GSFC

On 18/19 November 2009, thirty-four VLBI antennas observed the largest astrometry session ever scheduled. The previous record was 23 stations in a single session. As an activity for the International Year of Astronomy 2009 (IYA2009; also see IVS Newsletter Issue #24), the IVS organized this truly supersized session, and, if it had not been for station troubles at Fortaleza and Svetloe, it would have been even bigger.

Recognizing the special needs of this session, the IVS Directing Board established a special Task Force consisting of Patrick Charlot (chair), Dirk Behrend (co-chair), Axel Nothnagel, Hayo Hase, and Oleg Titov. The Task Force discussed the scientific and outreach goals of the session and eventually decided to strengthen the ICRF2 by observing as many ICRF2 defining sources as possible in one single session and providing the arc lengths between all sources without relying on source overlaps. The session was accompanied by press releases through the IYA2009 (IAU), IVS, and other organizations and open doors at the participating stations. It resulted in news coverage in regional and national media.

(above) Snapshot of the dynamic Web page at Bordeaux Observatory taken during the observation of the IYA09 session; (below) 35-station network scheduled for observing the IYA09 session. Svetloe had to cancel their commitment on short notice due to station problems.

The Bordeaux group created a dynamic Web page which allowed interested people to watch the progress of the session via the Internet in real time. The page provided information about the current scan: it showed the subnet of stations observing the current source as well as a map of the source taken from one of several map repositories. We owe Arnaud Collioud a big thank you for assembling this page.

The logistical organization and practical aspects of the IYA09 session posed several challenges. First we needed to assure that there were sufficient correlator resources to actually correlate the session. Haystack Observatory agreed to do the correlation and was freed from correlating other IVS sessions until spring 2010. It was anticipated that it would take about 20 passes to correlate. With the long tie-up of recording media in the session, the strain on the geodetic media pool had to be evaluated, in particular so, as also the VLBA stations had to be provided out of the geodetic media pool. Ultimately the media resources could be scraped together, but their size limitation dictated the use of a lower sensitivity observing mode than we had hoped for.

The scheduling software sked had to be changed from a station limit of 32 to 64. A good number of schedules were generated before a satisfactory schedule could be identified. As a major goal of the IYA09 session was to observe as many ICRF2 defining sources as possible, special emphasis was put on the southern sky that was covered by only a few antennas. The lower sensitivity of the available southern hemisphere antennas made this a difficult task, which turned out to be only partially solvable. In the end we chose a schedule that observed 243 out of the 295 ICRF2 defining sources.

Once Haystack Observatory has completed correlating the IYA09 session, Goddard will analyze the session using Calc/Solve. Currently this analysis software has a hard limit of 32 stations. It will take a fair amount of work to increase this limit. The IYA09 session is the most ambitious VLBI session scheduled to date. It has posed, and continues to pose, challenges to all aspects of data analysis and data flow. It is a useful precursor to VLBI2010 data.

http://ivscc.gsfc.nasa.gov/program/iya09/.

Editorial Note: ICRF2 – Our New Celestial Reference Frame

The Second Realization of the International Celestial Reference Frame (ICRF2) will become the Fundamental Astrometric Reference Frame on 01 January 2010. The ICRF2 Resolution was adopted unanimously at the IAU General Assembly on August 13, 2009 in Rio de Janeiro, Brazil. This is thanks to the successful work of the joint IERS/IVS Working Group on the ICRF2. We would like to extend congratulations to the group and thank them for their hard work over the past three years. This is really a big step forward.

The ICRF2 has several improvements as compared to the original ICRF. It utilized fourteen years of additional observations and took advantage of numerous advances in observing, analysis, and modeling techniques. The ICRF2 source list contains five times more sources (3,414) than the ICRF. Its noise floor of 40 micorarcsec is 5−6 times lower and its axis stability with about 10 microarcsec is twice as good as the ICRF.

Please peruse the accompanying public science article, which was written by a science writer at Goddard Space Flight Center based on an interview with Chopo Ma who was the lead of the IERS/IVS Working Group. The original article was published online at `http://www.nasa.gov/centers/goddard/news/topstory/2009/icrf2.html` and has the graphics in full color.

New Celestial Map Gives Directions for GPS

– Bill Steigerwald, NASA Goddard Space Flight Center

Many of us have been rescued from unfamiliar territory by directions from a Global Positioning System (GPS) navigator. GPS satellites send signals to a receiver in your GPS navigator, which calculates your position based on the location of the satellites and your distance from them. The distance is determined by how long it took the signals from various satellites to reach your receiver.

The system works well, and millions rely on it every day, but what tells the GPS satellites where they are in the first place?

"For GPS to work, the orbital position, or ephemeris, of the satellites has to be known very precisely," said Dr. Chopo Ma of NASA's Goddard Space Flight Center in Greenbelt, Md. "In order to know where the satellites are, you have to know the orientation of the Earth very precisely."

This is not as obvious as simply looking at the Earth – space is not conveniently marked with lines to determine our planet's position. Even worse, "everything is always moving," says Ma. Earth wobbles as it rotates due to the gravitational pull (tides) from the moon and the sun. Even apparently minor things like shifts in air and ocean currents and motions in Earth's molten core all influence our planet's orientation.

Just as you can use landmarks to find your place in a strange city, astronomers use landmarks in space to position the Earth. Stars seem the obvious candidate, and they were used throughout history to navigate on Earth. "However, for the extremely precise measurements needed for things like GPS, stars won't work, because they are moving too," says Ma.

What is needed are objects so remote that their motion is not detectable. Only a couple classes of objects fit the bill, because they also need to be bright enough to be seen over incredible distances. Things like quasars, which are typically brighter than a billion suns, can be used. Many scientists believe these objects are powered by giant black holes feeding on nearby gas. Gas trapped in the black hole's powerful gravity is compressed and heated to millions of degrees, giving off intense light and/or radio energy.

Most quasars lurk in the outer reaches of the cosmos, over a billion light years away, and are therefore distant enough to appear stationary to us. For comparison, a light year, the distance light travels in a year, is almost six trillion miles. Our entire galaxy, consisting of hundreds of billions of stars, is about 100,000 light years across.

A collection of remote quasars, whose positions in the sky are precisely known, forms a map of celestial landmarks in which to orient the Earth. The first such map, called the International Celestial Reference Frame (ICRF), was completed in 1995. It was made over four years using painstaking analysis of observations on the positions of about 600 objects.

Ma led a three-year effort to update and improve the precision of the ICRF map by scientists affiliated with the International Very Long Baseline Interferometry Service for Geodesy and Astrometry (IVS) and the International Astronomical Union (IAU). Called ICRF2, it uses observations of approximately 3,000 quasars. It was officially recognized as the fundamental reference system for astronomy by the IAU in August, 2009.

Making such a map is not easy. Despite the brilliance of quasars, their extreme distance makes them too faint to be located accurately with a conventional telescope that uses optical light (the light that we can see). Instead, a special network of radio telescopes is used, called a Very Long Baseline Interferometer (VLBI).

The larger the telescope, the better its ability to see fine detail, called spatial resolution. A VLBI network coordinates its observations to get the resolving power of a telescope as large as the network. VLBI networks have spanned continents and even entire hemispheres of the globe, giving the resolving power of a telescope

A radio telescope at the Kokee Park Geophysical Observatory, NASA's VLBI station in Hawaii, one of the most active sites in the global geodetic/astrometric VLBI network. Credit: US Navy / PMRF thousands of miles in diameter. For ICRF2, the analysis of the VLBI observations reduced uncertainties in position to angles as small as 40 microarcseconds, about the thickness of a 0.7 millimeter mechanical pencil lead in Los Angeles when viewed from Washington. This minimum uncertainty is about five times better than the ICRF, according to Ma.

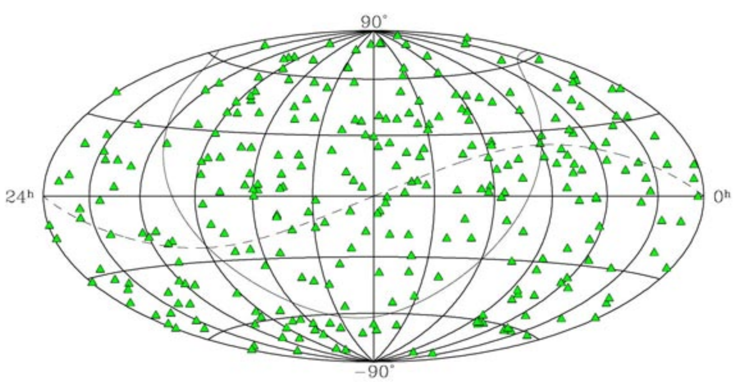
These networks are arranged on a yearly basis as individual radio telescope stations commit time to make coordinated observations. Managing all these coordinated observations is a major effort by the IVS, according to Ma.

Additionally, the exquisite precision of VLBI networks makes them sensitive to many kinds of disturbances, called noise. Differences in atmospheric pressure and humidity caused by weather systems, flexing of the Earth's crust due to tides, and shifting of antenna locations from plate tectonics and earthquakes all affect VLBI measurements. "A significant challenge was modeling all these disturbances in computers to take them into account and reduce the noise, or uncertainty, in our position observations," said Ma.

Another major source of noise is related to changes in the structure of the quasars themselves, which can be seen because of the extraordinary resolution of the VLBI networks, according to Ma.

The ICRF maps are not only useful for navigation on Earth; they also help us find our way in space—the ICRF grid and some of the objects themselves are used to assist spacecraft navigation for interplanetary missions, according to Ma.

Despite its usefulness for things like GPS, the primary application for the ICRF maps is astronomy. Researchers use the ICRF maps as driving directions for telescopes. Objects are referenced with coordinates derived from the ICRF so that astronomers know where to find them in the sky.



A sky map of the 295 defining sources of ICRF2. The dashed line represents the ecliptic and the solid line is the galactic plane. Credit: Dave Boboltz (USNO).

Also, the optical light visible to our eyes is only a small part of the electromagnetic radiation produced by celestial objects, which ranges from less-energetic, low-frequency radiation, like radio and microwaves, through optical light to highly energetic, high-frequency radiation like X-rays and gamma-rays.

Astronomers use special detectors to make images of objects producing radiation our eyes can't see. Even so, since things in space can have extremely different temperatures, objects that generate radiation in one frequency band, say optical, do not necessarily produce radiation in another, perhaps radio. The main scientific use of the ICRF maps is a precise grid for combining observations of objects taken using different frequencies and accurately locating them relative to each other in the sky.

This is an artist's concept of a quasar (bright area with rays) embedded in the center of a galaxy. Credit: NASA/JPL-Caltech/T. Pyle (SSC).

Astronomers also use the frame as a backdrop to record the motion of celestial objects closer to us. Tracing how stars and other objects move provides clues to their origin and evolution.

The next update to the ICRF may be done in space. The European Space Agency plans to launch a satellite called Gaia in 2012 that will observe about a half-million quasars. Gaia uses an optical telescope, but because it is above the atmosphere, the satellite will be able to clearly see these faint objects and precisely locate them in the sky. The mission will use quasars that are optically bright, many of which are too dim in radio to be useful for the VLBI networks. The project expects to have enough observations by 2018 to 2020 to produce the next-generation ICRF.

ICRF2 involved researchers from Australia, Austria, China, France, Germany, Italy, Russia, Ukraine, and the United States; and was funded by organizations from these countries, including NASA. The analysis efforts are coordinated by the IVS. The IAU officially adopts the ICRF maps and recommends their occasional updates.

The most original of authors are not so because they advance what is new, but more because they know how to say something, as if it had never been said before.

- Johann Wolfgang von Goethe

TIGO and O'Higgins Considerably Improve the TANAMI AGN Monitoring Program

– Roopesh Ojha (USNO), Matthias Kadler (University of Erlangen-Nuremberg), Christian Plötz, Hayo Hase (both BKG), and the TANAMI Team

The launch of the Fermi Gamma Ray Space Observatory (e.g., N. Gehrels and P. Michelson, Astroparticle Physics, Vol. 11, pp. 277-282, 1999) in June 2008 has ushered in an exciting era in the study of the physics of Active Galactic Nuclei (AGN). In combination with other space and ground based facilities at other wavelengths, we have the unprecedented opportunity to observe AGN across the electromagnetic spectrum almost simultaneously. VLBI observations are an essential part of such studies as they are the only way to spatially resolve the sub-parsec level emission regions where the high-energy radiation is believed to originate. VLBI observations are also the only way to directly measure the relativistic motion in AGN jets allowing us to calculate intrinsic jet parameters such as jet speed, Doppler factor, and opening and inclination angles.

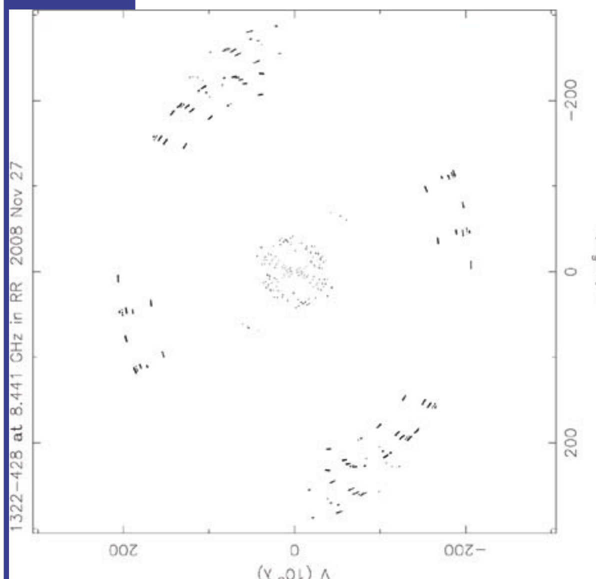


Figure 1: uv-coverage for an observation of radio galaxy Centaurus A on 28 November 2008 using the LBA, TIGO, and O'Higgins.

The TANAMI (Tracking AGN with Austral Milliarcsecond Interferometry; homepage at `http://pulsar.sternwarte.uni-erlangen.de/tanami/`) program provides parsec scale monitoring of extragalactic gamma-ray sources of the Southern Sky (e.g., R. Ojha, M. Kadler, S. Tingay, J. Lovell, and the TANAMI and GLAST/LAT AGN teams, AIP Conference Proceedings, Vol. 1053, pp. 395-401, 2008). These bi-monthly observations are made at two frequencies: 8.4 and 22 GHz. Observations began in November 2007 using the Australian Long Baseline Array (LBA). The LBA normally consists of telescopes at Parkes, Narrabri, Mopra (all in New South Wales), Hobart (Tasmania), Ceduna (South Australia), and Hartebeesthoek (South Africa; currently not operational). Telescopes of NASA's Deep Space Network at Tidbinbilla (Australian Capital Territory) participate when available. Two of these antennas, Hobart and Hartebeesthoek, are also IVS Network Stations.

The LBA is a unique facility for VLBI imaging of Southern-Hemisphere sources. However, as an ad-hoc array, its uv-coverage has limitations, constraining the fidelity of the resulting images. TANAMI was granted access to two additional telescopes, TIGO and O'Higgins, through a successful IVS proposal, which was motivated by our desire to improve the uv-coverage provided by the LBA.

The German Antarctic Receiving Station at O'Higgins is a 9-m dish located on the Antarctic Peninsula in Antarctica. TIGO (Transportable Integrated Geodetic Observatory) is a 6-m dish located in Concepción, Chile. Both these telescopes are operated by the Bundesamt für Kartographie und Geodäsie (BKG) in Germany. Observations with these two telescopes commenced in November 2008 and their participation dramatically improved our uv-coverage as is evident from Figure 1, which shows the uv-coverage for an observation of Centaurus A on 28 November 2008. The uv-plane is a representation of how well the interferometer is able to map the target. It takes into account the location and orientation of each baseline and how both change during the course of the observations. In Figure 1 the inner dots are the baselines provided by the Australian antennas, while all of the outer dots are contributed by baselines to TIGO and O'Higgins. The powerful impact of including TIGO and O'Higgins is immediately obvious. So, how well does this improved uv-coverage translate into improved images?

Figures 2 and 3 show images of the radio galaxy Centaurus A without and with these two additional IVS telescopes, respectively. The map resolution increases about four times when including TIGO and O'Higgins. Centaurus A is the closest radio galaxy (3.4 Mpc away) and its bright jet and faint counterjet are observable with this array at sub-parsec resolutions. In fact, this image is one of the highest resolution images of an AGN jet ever made!

Because of the high flux density of sources in the TANAMI program and given the large antenna diameters at the Australian end of the long baselines, the baseline sensitivity to the two relatively small new stations is not a limitation. Analysis of these spectacular images is in progress and can be expected to bear rich scientific fruit. This success has led to the desire to include O'Higgins more frequently in the TANAMI observation program, which is for logistical reasons not yet possible. [Note from the editor: O'Higgins observes in the southern summer when VLBI personnel man the station.]

In conclusion, the participation of TIGO and O'Higgins has resulted in a spectacular improvement in the quality of images and consequently the quality of science that the TANAMI program is producing. We look forward

NEWS...

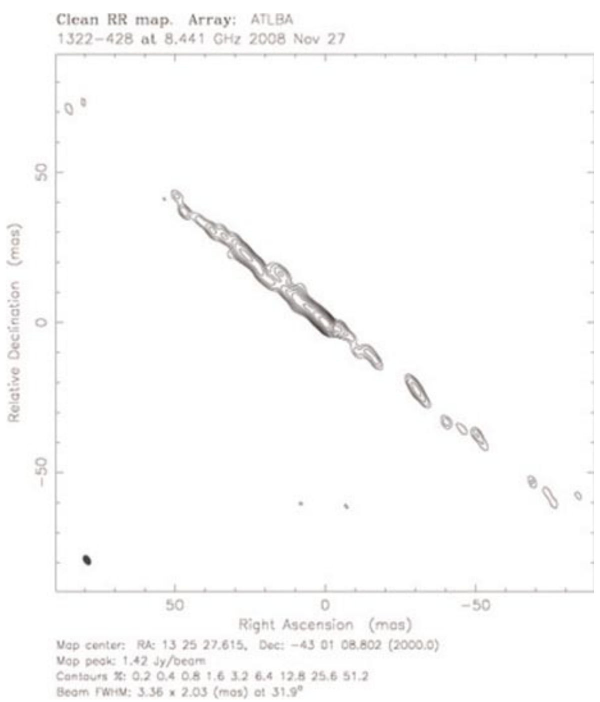


Figure 2: Image of radio galaxy Centaurus A derived from LBA data only.

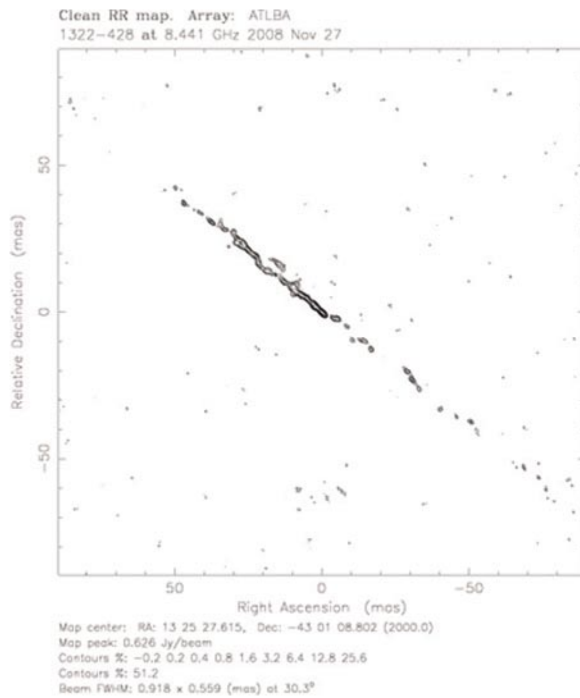


Figure 3: Image of radio galaxy Centaurus A derived from LBA, TIGO, and O'Higgins data.

to continued observations with these two telescopes for the lifetime of the TANAMI program.

Acknowledgements: The Long Baseline Array is part of the Australia Telescope which is funded by the Commonwealth of Australia for operation as a National Facility managed by CSIRO.

Upcoming Meetings...

6th IVS General Meeting
Hobart, TAS, Australia
Feb. 7-14, 2010

EGU General Assembly 2010
Vienna, Austria
May 2-7, 2010

Meeting of the Americas (AGU)
Foz do Iguassu, Brazil
Aug. 8-13, 2010

Journées 2010
Paris, France
Sep. 20-22, 2010

IAG Comm 1 Symposium "Reference Frames for Applications in Geosciences (REFAG2010)",
venue tbd
Oct. 4-8, 2010

GGOS Workshop "Observing and Understanding Earth Rotation",
Shanghai, China
Oct. 25-28, 2010

AGU Fall Meeting
San Francisco, USA
Dec. 13-17, 2010

http://ivscc.gsfc.nasa.gov/meetings

The IVS Newsletter is published three times annually, in April, August, and December. Contributed articles, pictures, cartoons, and feedback are welcome at any time.

Please send contributions to
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The editors reserve the right to edit contributions. The deadline for contributions is one month before the publication date.

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http://ivscc.gsfc.nasa.gov/.

IVS Directing Board Meets in Buenos Aires

– Dirk Behrend, NVI, Inc./NASA GSFC

On August 29, 2009 the 22nd Directing Board meeting was held in the capital of Argentina in connection with the International Association of Geodesy (IAG) Scientific Assembly, which was held in the following week. Since there is no IVS component in Argentina and thus no local host, we were glad to get assistance for the "local organization" from Claudio Brunini of the National University of La Plata (UNLP), one of the most renowned universities in Argentina. The city of La Plata is located about 60 km southeast of Buenos Aires. We would like to thank Claudio for his invaluable support.

(above) The participants at the IVS Directing Board meeting in Buenos Aires; (below) Sign announcing the IVS Directing Board meeting.

The meeting took place in the El Conquistador hotel in a conference room in the tenth floor of the building. It was a nice location, setting a 'good air' for a successful meeting. Further, a billboard in the hotel lobby made it apparent that in order to increase the appeal of the IVS in Latin America, a renaming of its governing body would be in order. John Gipson and Leonid Gurvits were included remotely via Skype for the duration of their reports on Working Group 4 and Working Group 5, respectively.

The chair of the Task Force for the IYA09 session, Patrick Charlot, reported on the plan to observe as many ICRF2 defining sources as possible, have a dynamic Web site at Bordeaux Observatory and a central Web site at the IVS, and to prepare a press release and handout material for the stations. The plans were fully approved by the Board. The IYA09 session can serve as a kickoff session for monitoring the ICRF2. Dirk Behrend was tasked to check the options for including the VLBA in the session. [Following a successful Target of Opportunity proposal and assurance of media provision, the VLBA became part of the IYA09 efforts.]

The Analysis Coordinator's office prepared and submitted the official IVS contribution to the ITRF2008. The submission consisted of session-wise datum-free normal equations of 4,539 daily VLBI sessions from 1979.7 to 2009.0 with data from 115 VLBI sites. The combination was based on individual contributions from seven IVS Analysis Centers. The Analysis Coordinator's office will prepare a paper for Journal of Geodesy about the VLBI terrestrial reference frame contribution to ITRF2008. It is planned that the BKG/DGFI Combination Center will commence official combination work on October 1, 2009.

The Editor-in-Chief of Journal of Geodesy (JoG) agreed on having a special issue on "CONT08", provided a preliminary call for papers yields enough interest. If the precall warrants a sufficient number of submissions, a full call can be issued. The special issue will be limited to one physical issue of JoG (about 100 pages, 7–9 papers). The Board suggested that Axel Nothnagel, Urs Hugentobler, and David Salstein be the guest editors for this special issue. All three agreed to take on this task. We would like to thank them for taking on this extra burden.

The Board nominated Rüdiger Haas to be the IVS representative to the IERS Working Group on Co-location. Dirk Behrend was approved as IVS representative to the GGOS Working Group on Data and Information Systems (WG DIS). For the GGOS Unified Analysis Workshop in San Francisco in December 2009, the Board nominated five IVS delegates: Johannes Böhm, Robert Heinkelmann, Dan MacMillan, Axel Nothnagel, and Thomas Hobiger. A small investigative group was created to look into VLBI–DORIS interferences. The suggested members of this group were Ed Himwich, Bill Petrachenko, Brian Corey, and Sergey Smolentsev. They will work with the Analysis Coordinator of the International DORIS Service (IDS), Frank Lemoine, on the interference issue. Finally, a Task Force on Auxiliary Data with Arthur Niell as chair was suggested. Additional members of this task force would be Ed Himwich, Axel Nothnagel, Dirk Behrend, and John Gipson.

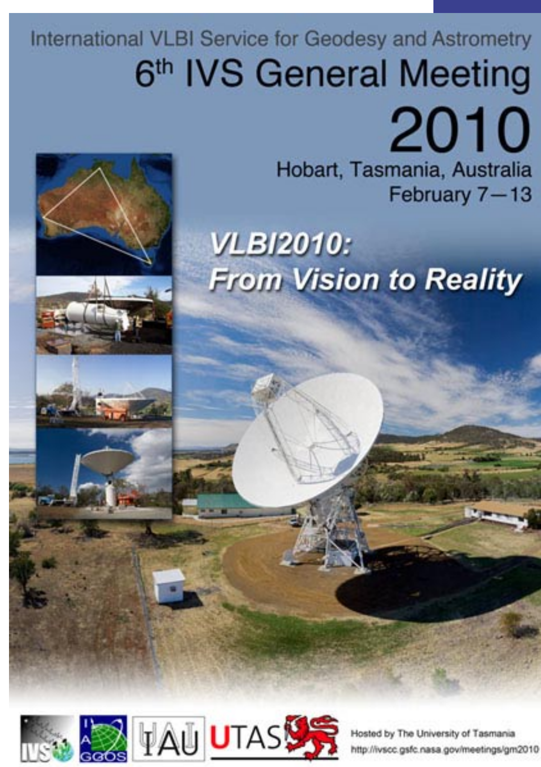
Following the meeting proper, the Board had a common dinner at a typical "parrilla" (grill) recommended by Claudio. For the non-vegetarians, a good Argentine steak was, of course, a must. Beyond the good meat, Buenos Aires has a lot more to offer. I personally was impressed by the bookstore El Ateneo Grand Splendid, which was originally built as a theater in 1919 and converted into a bookstore in 2000. It was always advisable to be aware of your surroundings. A tell-tale sign was the strap provided in restaurants and cafes with which to secure your bag or purse to the chair you were seated on.

The next Board meeting will be held in conjunction with the IVS General Meeting in Hobart, Tasmania, Australia in February 2010.

(top left) Security strap provided in many restaurants and cafes; (top right) The bookstore El Ateneo Grand Splendid in Buenos Aires; (right) Argentine steak.

Preparations for the General Meeting in Hobart in Full Swing

– Dirk Behrend, NVI, Inc./NASA GSFC



On February 7, 2010 the 6th IVS General Meeting (GM2010) will commence with an icebreaker reception at Hobart's waterfront. It will be the start of a very busy week with three days of General Meeting proper and a day each of Joint VLBI2010 Developers and Analysis meeting, Directing Board meeting, and mini-TOW workshop. A special highlight will be the dedication ceremony of the AuScope 12-meter radio telescope, which is planned for the Tuesday afternoon coinciding with the planned station visit. Some 200 guests are expected to witness the "unveiling" of the telescope by the Governor of Tasmania, His Excellency The Honorable Peter Underwood.

The official functions will be the icing on the cake of the GM2010, which by itself boasts an excellent scientific program under the theme "VLBI2010: From Vision to Reality". The vision of the VLBI2010 system is gradually being realized. The unprecedented new capabilities of 1-mm positional accuracy and station velocities of 0.1 mm/yr, continuous observational time series for station positions and Earth orientation parameters, and fast turnaround time from observation to geodetic and astrometric result will foster new science and applications.

We expect around 100 participants from some 20 countries to give about 60 oral and 50 poster presentations. Seven of those 100 participants are recipients of travel grants: we were lucky to obtain five IAG Travel Grants and two FAGS Travel Grants. The support from the IAG and FAGS is very much appreciated. The program is arranged into five sessions covering the various aspects of VLBI from data capturing and correlation, to analysis, to technology development.

The meeting is hosted by the University of Tasmania, School of Mathematics and Physics at the Sandy Bay campus. The local organizers have currently all hands full with attending to the various logistical aspects of the meeting. I would like to thank the LOC, in particular Karen Bradford, Jim Lovell, and John Dickey, for their hard work. I look forward to a successful GM2010 in Hobart.

More information can be found on the meeting Web page at the URL `http://ivscc.gsfc.nasa.gov/meetings/gm2010/`.

News...

GGOS Intergovernmental Committee (GIC) in the Planning Stage

– Dirk Behrend, NVI, Inc./NASA GSFC

On November 2–3, 2009 representatives from roughly twenty stakeholder organizations followed a call of the Bundesamt für Kartographie und Geodäsie (BKG) to participate in a “meeting on the development of a GGOS intergovernmental committee” at BKG headquarters in Frankfurt am Main, Germany. A possible GGOS Intergovernmental Committee (GIC) could play a very important role in the support of securing sustainable funding for geodetic observation infrastructure.

An important outcome of the meeting was the common “Declaration of the Frankfurt GGOS Meeting”, which recommends the creation of a GIC and invites all governmental agencies and organizations responsible for geodetic products and services to participate in the creation of the GIC. The GIC should be tasked with supporting GGOS in attaining its goals by appropriate intergovernmental agreement that facilitates planning, securing, and maintaining geodetic infrastructure and operation of the services based on the needs of science and society; and by representation and promotion of GGOS to international entities that require intergovernmental representation.

Another outcome of the meeting was the recommendation to recognize IAG services and products as GGOS services and products, and to coordinate the development of ‘GGOS themes’ addressing societal needs and requirements such as ‘natural hazards’ or ‘global sea level change’.

A planning group was established to propose the membership and initial structure of the GIC. This planning group will lay down the basic concept for a GIC in a “White Paper”. A first draft is planned to be available by the GGOS Retreat to be held in early February 2010 in Miami, Florida. It goes without saying that the IVS will benefit from the commitments expressed by a GIC in the long-term upkeep of the IVS observing program and the required infrastructure to support it.

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