International VLBI Service for Geodesy and Astrometry

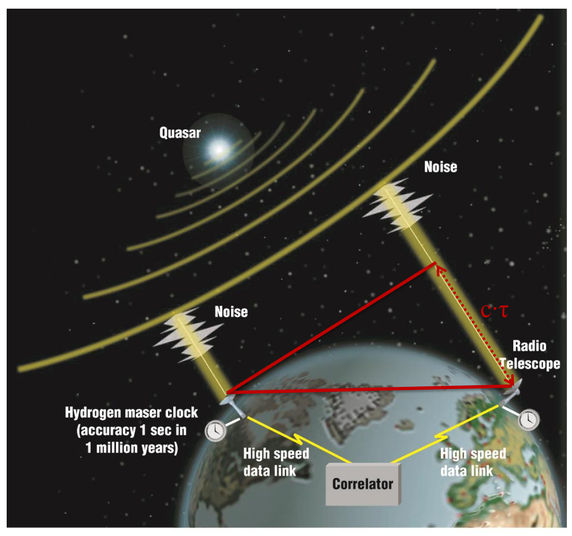
Dirk Behrend

NVI, Inc./NASA Goddard Space Flight Center, Greenbelt, MD, USA

Very Long Baseline Interferometry (VLBI)

The VLBI observable is the difference in the arrival time of a radio signal (from a quasar) at two different radio telescopes. The measured time delay, using the speed of light, can be interpreted as a distance. The distance is the component of the baseline toward the source (quasar). By observing many sources, all components of the baseline can be determined.

How does VLBI work?

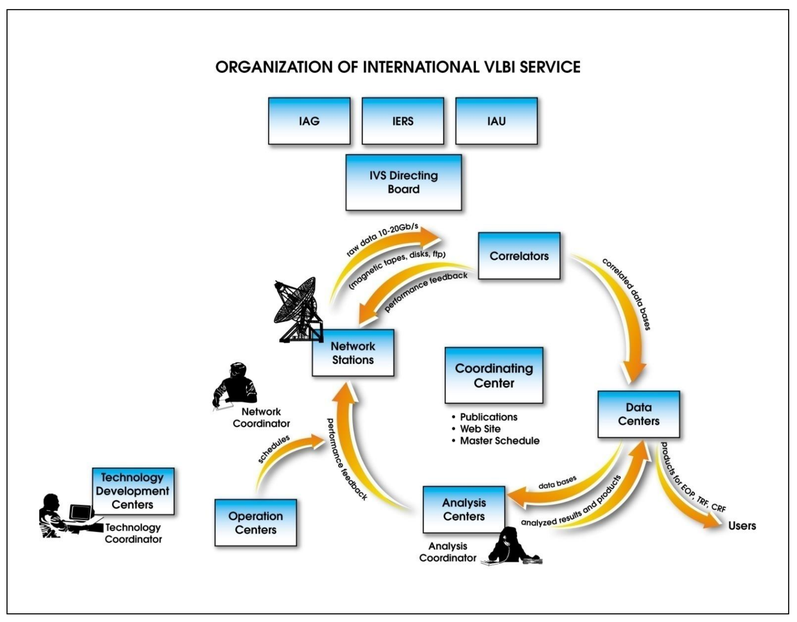


International VLBI Service (IVS)

The **International VLBI Service for Geodesy and Astrometry (IVS)** is an international collaboration of organizations which operate or support VLBI components:
- IVS inauguration was on March 1, 1999;
- 83 permanent components supported by 43 institutions in 21 countries;
- ~300 Associate Members.

IVS is a service of
- **IAG** – International Association of Geodesy
- **IAU** – International Astronomical Union
- **WDS** – ICSU's World Data System

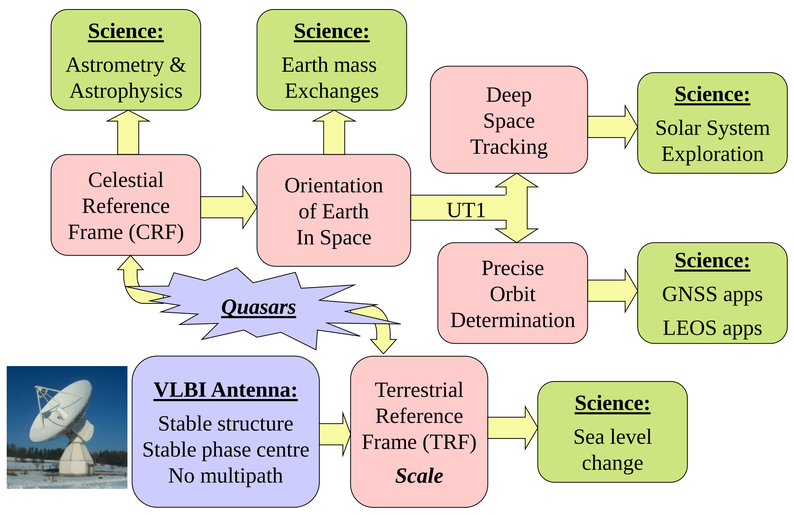
IVS goals:
- provide a service to support geodetic, geophysical, and astrometric research and operational activities;
- promote research and development in the VLBI technique;
- interact with the community of users of VLBI products and integrate VLBI into a global Earth observing system.



Main activities:
- interacts closely with the IERS, which is tasked by IAU and IUGG with maintaining the international celestial and terrestrial reference frames (ICRF and ITRF);
- coordinates VLBI observing programs;
- sets performance standards for the observing stations;
- establishes conventions for data formats and products;
- issues recommendations for analysis software;
- sets standards for analysis documentation;
- institutes appropriate product delivery methods in order to insure suitable product quality and timeliness.

All **VLBI data** and results in appropriate formats are archived in data centers **and publicly available** for research in related areas of geodesy, geophysics, and astrometry. The IVS data set extends from 1979.

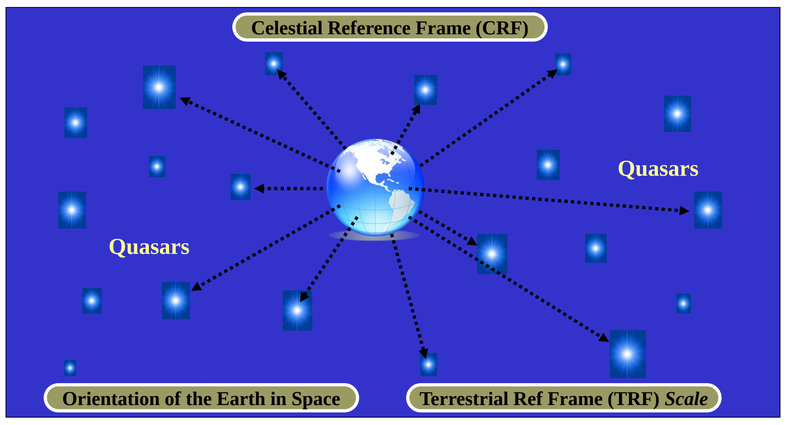
Roles of VLBI



IVS Products

Products (VLBI as unique contributor):
- Definition and realization of the International Celestial Reference Frame (ICRF);
- Monitoring of Universal Time (UT1) and length of day (LOD);
- Monitoring the coordinates of the celestial pole (nutation and precession).

Products (VLBI as significant contributor):
- All components of Earth Orientation Parameters (EOP) at regular intervals;
- Station coordinates and velocity vectors for the realization and maintenance of the International Terrestrial Reference Frame (ITRF).



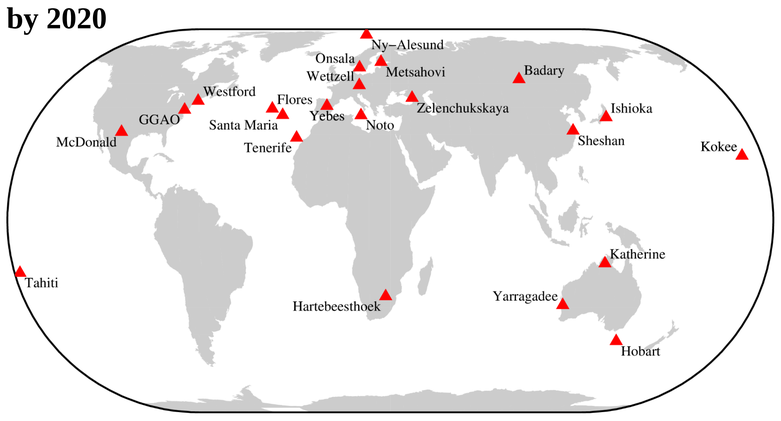
Other products:
- Tropospheric parameters (e.g., zenith wet delays);
- Ionospheric models;
- Geodynamic parameters (e.g., Love numbers in solid Earth tides models);
- Astronomical parameters (e.g., post-Newtonian parameter γ).

VLBI Global Observing System (VGOS)

Why a new system?
- aging infrastructure
- new technologies available
- new scientific requirements

VGOS goals:
- 1-mm position accuracy (based on a 24-hr session)
- continuous measurement of station position and EOP
- Turnaround time to initial products in <24 hours

Projected VGOS network by 2020



Outlook:
- VGOS is expected to perform significantly better than the legacy (S/X) system;
- VGOS will be a key technique within the Global Geodetic Observing System (GGOS);
- geographical gaps will be closed/reduced;
- IVS will expand with new components (e.g., new stations).

Training and Education

Technical Operations Workshops (TOW):
- organized every two years for four days;
- technical training of station staff in VLBI operations;
- improves stations' performance significantly.

VLBI Training Schools:
- organized every three years for one week;
- added on to major IVS meeting (e.g., General Meeting or European VLBI Meeting);
- train the next generation of researchers to understand VLBI systems and inspire them in their future careers;
- venues so far: Helsinki, Finland; Johannesburg, South Africa.

VLBI School in South Africa:
- 45 participants: 32 students and 13 professionals;
- 20 students from Africa: Ghana, Kenya, South Africa, and Zambia;
- `http://www.evga.org/2nd_vlbi_school.html`.

Strategic Planning

Governance:
- Directing Board (DB) with representatives from a broad spectrum of IVS constituent bodies (i.e., institutions, geography, component types);
- meets twice a year;
- determines policies and strategies.

IVS Retreat 2015:
- DB plus external experts;
- Penticton, BC, Canada on October 7+8, 2015;
- SWOT (strengths, weaknesses, opportunities, threats) analyses for various IVS areas;
- Summary of Retreat as basis for strategic paper: `/about/strategic/Summary_IVS_Retreat_2015.pdf`

Strategic Plan 2016–2025:
- Based on Retreat summary: `/about/strategic/Strategic%20Plan%20of%20the%20IVS%20for%20the%20Period%202016-2025_V2.2.pdf`

Challenges and Possible Remedies

- **IVS not a formal global institution, but a collaboration on a best-effort basis** ==> in addition to scientific endeavors also service character needs to be emphasized and funded
- **Aging workforce** ==> active replacement with young enthusiasts
- **Lack of awareness of existence/importance of IVS in spite of using its products** ==> external and internal PR, stronger institutional ties between IVS and outside groups
- **Value/importance of IVS products undervalued and poorly understood** ==> establish and maintain a database about users and product usage (including parameters such as frequency of use, purpose, expected latency, and so on)
- **Move from 3–4 weekly 24-hr sessions to 24/7 observing** ==> enhanced automation
- **Increased data throughput due to VGOS at correlators impacting correlation volume and data transport** ==> increase network connectivity, distributed correlation, increase number of operational correlators

Contact Information

IVS Point-of-contact to WDS:
Dirk Behrend
NVI, Inc./NASA Goddard Space Flight Center
Code 698.2
Greenbelt, MD, 20771
USA
Phone: +1-301-614-5939
E-mail: *dirk.behrend@nasa.gov*

IVS Web site (with mirror sites):
`http://ivscc.gsfc.nasa.gov`
`http://ivscc.bkg.bund.de`
`http://ivs.nict.go.jp/mirror/`