JPL VLBI Analysis Center IVS Annual Report for 2002

Chris Jacobs

Abstract

This report describes the activities of the JPL VLBI analysis center for the year 2002. The highlight for the year was the creation of the first sub-milliarcsecond global celestial reference frames at K-band (24 GHz) and Q-band (43 GHz). Our group also continues to do celestial reference frame, earth orientation and spacecraft navigation work at S (2.3 GHz) and X-bands (8.4 GHz).

1. General Information

The Jet Propulsion Laboratory (JPL) analysis center is located in Pasadena, California. Like the rest of JPL, it is operated by the California Institute of Technology under contract to NASA. JPL has had a VLBI analysis group since about 1970. Our work is focussed on supporting spacecraft navigation. This includes several components:

1. Radio Reference Frame (RRF) is an effort which provides the infrastructure to support spacecraft navigation and Earth orientation measurements with particular emphasis on celestial reference frame work.
2. Time and Earth Motion Precision Observations (TEMPO) measures Earth orientation parameters based on single baseline bi–monthly measurements. These VLBI measurements are then combined with daily GPS measurements as well as other sources of Earth orientation information. The combined product is used to provide Earth orientation for spacecraft navigation use.
3. Delta differenced One–Way Range (ΔDOR) is a differential VLBI technique which measures the angle between a spacecraft and an angularly nearby extragalactic radio source. This technique thus compliments the radial information from spacecraft doppler and range measurements by providing plane-of-sky information for the spacecraft trajectory.

2. Technical Capabilities

The JPL analysis center acquires its own data and supplements it with data from other centers. The data we acquire is taken using NASA's Deep Space Network (DSN).

1. Antennas: Most of our work uses 34m antennas located near Goldstone California, Madrid Spain, and Tidbinbilla Australia. These include the following Deep Space Stations (DSS): the 'High Efficiency' subnet comprised of DSS 15, DSS 45, and DSS 65 (see fig. 1) which has been the most often used set of antennas for VLBI. More recently, we have been using the DSN's beam waveguide antennas: DSS 13, DSS 24, DSS 25, DSS 34, and DSS 54. Less frequent use is made of the DSN's 70m network (DSS 14, DSS 43, DSS 63). Typical system temperatures are 35K. Antenna efficiencies are typically well above 50% at X-band.
2. Data acquisition: The DSN sites have standard MkIV VLBI data acquisition systems. In addition we have a JPL unique system called the VLBI Science Recorder (VSR) which has digital "video converters" and record directly to hard disk. The data is later transferred via network to JPL for correlation processing.

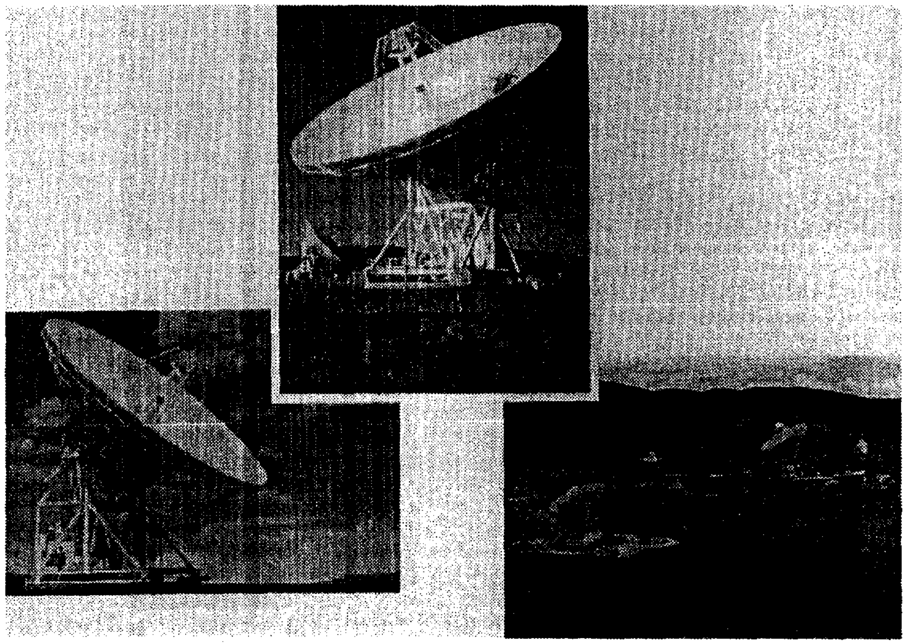

Figure 1. This figure shows the three high-efficiency antennas in the subnet: Goldstone is in the center; Robledo, Spain is in the lower left; and Tidbinbilla, Australia is in the lower right. These antennas were designed to have an optimum efficiency at X-band (8.4 GHz), which was to become the standard downlink frequency for solar-system exploration. An important secondary objective was to have a reasonable efficiency at Ka-band (32 GHz) thereby allowing for possible future use at the next highest band allocated for deep space communications. The subnet was completed in 1986 in time for the Voyager encounter with Uranus.

3. Correlators: The JPL BlockII VLBI correlator handles the TEMPO and RRF correlations of MkIIIa format tapes. The ΔDOR data from the VSR systems are correlated using the SOFTC software correlator running on UNIX or VMS workstations.
4. Solution types: We run several different types of solutions. For ΔDOR spacecraft tracking we make narrow field ($\approx 10°$) differential solutions. The TEMPO solutions typically have a highly constrained terrestrial (TRF) and celestial frame (CRF) as a foundation for estimating Earth orientation parameters. The RRF solves for a full TRF and CRF which is later used by TEMPO and ΔDOR. Experimental CRF work this year has focussed on modelling source structure.

3. Staff

Our staff are listed below with a brief indication of areas of concentration within the VLBI effort at JPL. Note that not all of the staff listed work on VLBI exclusively as our group is involved in a number of projects in addition to our VLBI work.

- Jim Border: ΔDOR
- Sid Dains: Field support of VLBI experiments at Goldstone.

- Chris Jacobs: RRF and ΔDOR
- Gabor Lanyi: ΔDOR, WVR, and RRF
- Steve Lowe: Software correlator, fringe fitting software
- Walid Majid: ΔDOR
- Sumita Nandi: ΔDOR
- Chuck Naudet: WVR, MkIV support, and RRF
- Jean Patterson: ΔDOR
- Ojars Sovers: RRF. Maintains MODEST analysis code.
- Alan Steppe: TEMPO
- L.D. Zhang: RRF

4. Current Status and Activities

This year's highlight was the extension of the high accuracy Celestial Reference Frame to higher frequencies. JPL led a collaboration with Goddard Space Flight center, the U.S. Naval Observatory, National Radio Astronomical Observatory, and the Bordeaux Observatory to extend the ICRF to K-band (24 GHz) and Q-band (43 GHz). Figure 2 gives an overview of the K-band results.

A-WVR: Another highlight was the deployment of the advanced Water Vapor Radiometer (A-WVR) in support of the Cassini gravitational wave experiment. This device calibrates the water vapor induced delay. Using this device, stabilities of roughly a few parts in 10^{15} have been achieved over time scales of 2,000 to 10,000 seconds.

5. Future Plans

We are also in the planning stage for developing a Ka-band (32 GHz) realization of the ICRF. All this work is motivated by the anticipation that spacecraft navigation will require a 32 GHz reference frame within a few years.

Mark 5 recorders: In 2003 we plan to acquire a few Mark 5 hard disk recording systems for test purposes. We hope to integrate these recorders into the Deep Space Network over the next few years as we move away from tape based recording.

6. Acknowledgements

The research described in this paper was in part performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

References

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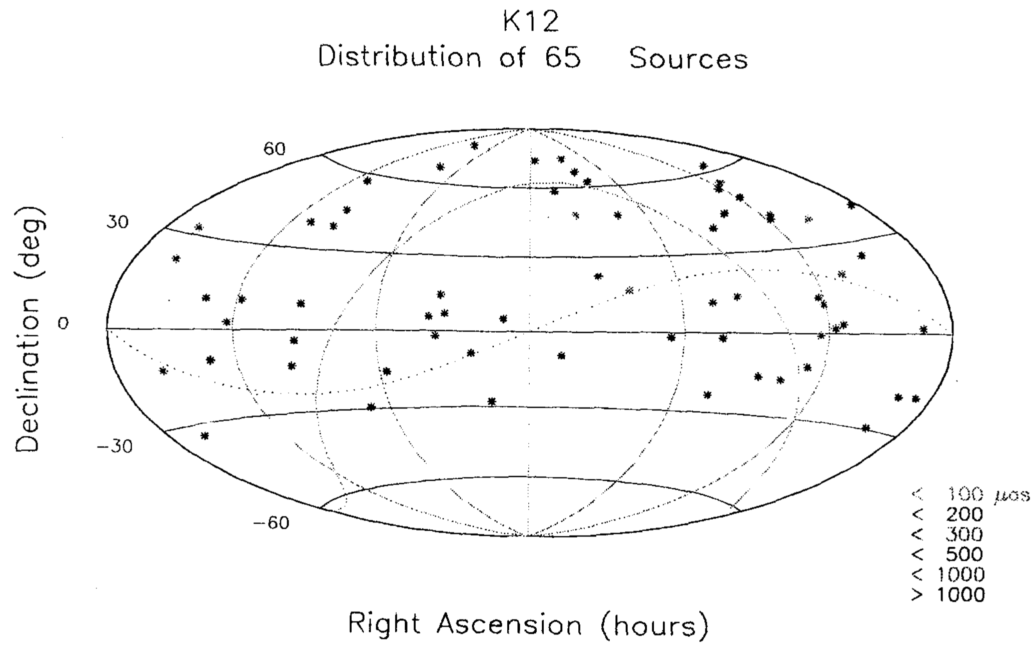

Figure 2. Celestial Reference Frame at K-band (24 GHz). There are 65 sources spread over the sky North of −30 deg declination. The label K12 indicates that the frame is based on data from the 1st and 2nd experiments of an ongoing program of observations. The color coding indicates the formal declination precision as detailed in the legend. Note the highest precision is toward the north with precision lessening towards the south by as much as a factor of ≈two. This is a result of using the VLBA which is a northern array. The dashed blue line indicates the ecliptic plane. The yellow line indicates the galactic plane

astrometric results, AAS meeting 201, session 76.10, Seattle, WA, 8 January 2003. Bulletin of the AAS, vol. 34, no. 4, session 76.10,
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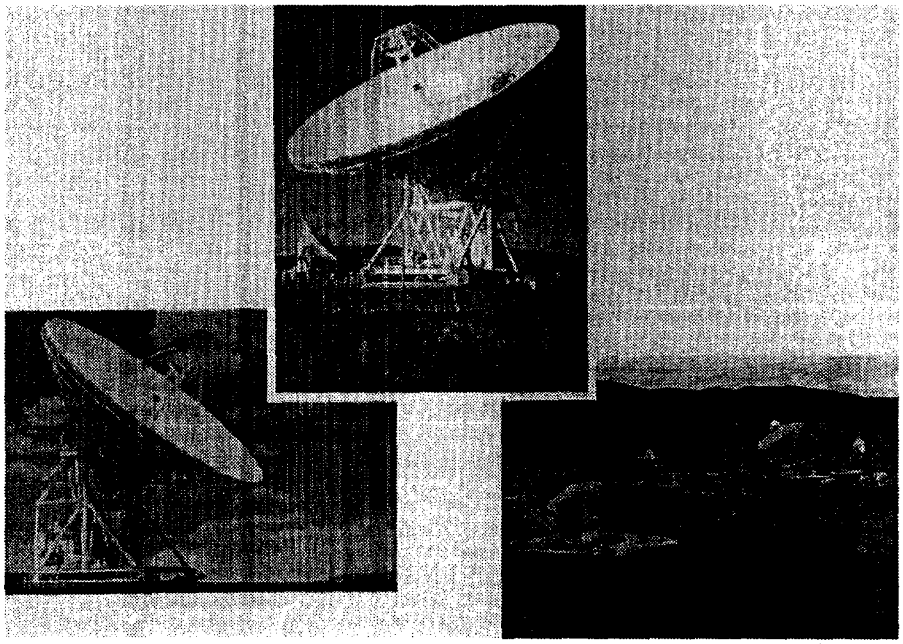

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