# Bordeaux Observatory Analysis Center Report

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**Abstract**

This report summarizes the activities of the Bordeaux Observatory Analysis Center from the establishment of IVS to the end of 2000. During this period, most of our efforts have been devoted to the development of an astrometric project on the European VLBI Network for densifying the International Celestial Reference Frame (ICRF). Another achievement is the evaluation of the astrometric quality of the ICRF sources based on their observed structures, and the diffusion of this information through a web page. Additionally, we have contributed to the implementation of a geodetic VLBI model in a multi-technique software, GINS, developed by the GRGS group in Toulouse. Changes in staff and equipment are also described, and the outlook for 2001 is given.

## 1. Celestial Frame Activities

As mentioned in our initial IVS report [1], our major scientific interest is the celestial frame, especially the maintenance and extension of the International Celestial Reference Frame (ICRF). The main achievements in this area since the establishment of IVS are reviewed below.

### 1.1. ICRF Densification

Along the lines described in [2], we have initiated an astrometric project on the European VLBI Network (EVN) for densifying the ICRF in the northern hemisphere. The aim of this project is to add 150 new sources at carefully selected sky locations to fill the "empty" regions of the frame and improve the overall source distribution. Most notably, the addition of these new sources will reduce the distance to the nearest ICRF source for any randomly-chosen location in the northern sky from a maximum of 13° (as it is now for the current ICRF-Ext. 1 frame) to a maximum of 6°. Further details on the source selection strategy are given in [2].

Table 1. Network used in ICRF densification experiment.

| EVN telescopes | Non-EVN telescopes |
|---|---|
| Effelsberg | Algonquin Park |
| Medicina | Goldstone (DSS 13) |
| Noto | Green Bank (NRAO 20) |
| Onsala | Hartebeestoek |
| Wettzell | Ny-Ålesund |
| Urumqi | |
| Shanghai | |

As a first step, a proposal was submitted to the EVN for observing 50 of these new sources. This proposal was approved and the subsequent experiment was carried out on May 31, 2000, using seven EVN telescopes along with five external non-EVN geodetic stations that agreed to participate in this project. The participating telescopes are listed in Table 1. The new sources

were scheduled jointly with a set of 10 highly-accurate ICRF sources so that their positions can be linked directly to the ICRF. Correlation of these data has just been carried out with the Bonn Mark IV correlator. A quick look at the correlation results indicates that all 50 new sources have been detected.

### 1.2. Source Classification Based on Observed Structure

Another achievement is the completion of source structure effect evaluation for most of the ICRF sources north of $-20^\circ$ declination [3]. For possible use by IVS operational and analysis centers, we have created a web page with false color images showing the magnitude of these effects at X band and S band as a function of baseline length and orientation. The current web page[1] provides such an evaluation for 392 ICRF sources and contains a total of 784 images. It also provides "structure indices" which reflect the astrometric suitability of each source according to the median structure effect in the bandwidth synthesis delay, as defined in Table 2.

Table 2. Structure index and astrometric quality.

| structure index | astrometric quality | median effect (ps) | observed structure |
|---|---|---|---|
| 1 | very good | 0–3 | point-like |
| 2 | good | 3–10 | resolved |
| 3 | use with caution | 10–30 | extended |
| 4 | not acceptable | $> 30$ | very extended |

Based on the above evaluation, we have searched for correlations between the observed radio structure and the ICRF source position accuracy and stability. Such correlations have been found and they indicate that the more extended sources have larger position uncertainties and are less positionally stable than the more compact sources [3]. This study also revealed that 16 ICRF defining sources have a structure index of 4, indicating that they are spatially extended and thus are not appropriate for defining the celestial frame with the highest level of accuracy [3].

## 2. Software Development

A collaboration has been established with the GRGS group (Groupe de Recherches de Géodésie Spatiale) in Toulouse (France) to implement a geodetic VLBI model in the GRGS space-geodesy software GINS for analysis of both Earth-based and space VLBI observations. The major goal of this project is to process space VLBI delay and delay rate measurements from the HALCA satellite to test the concept of space VLBI geodesy. Ultimately, the software will also be able to process standard Earth-based geodetic VLBI data and to combine them with other space geodetic measurements (SLR, GPS, DORIS) for multi-technique Earth orientation estimation and reference frame unification.

Progress on this project has been reported in [4]. Our contribution in Bordeaux has been especially to test the implemented geodetic VLBI model by carefully comparing results obtained with GINS to those obtained with the MODEST VLBI analysis software [5]. This comparison showed a very good agreement and indicates that the VLBI model in GINS is currently accurate

[1] http://www.observ.u-bordeaux.fr/public/radio/PCharlot/structure.html

at the few millimeter level. The new VLBI capability of GINS has also been used to process the space VLBI delay data acquired during a HALCA experiment carried out on December 4, 1997. The results of this analysis, although preliminary, suggest that the reconstructed HALCA orbit at the time of the experiment is accurate at the few meter level, somewhat better than the 10 m nominal accuracy given for this satellite [4] .

## 3. Staff and Equipment

- One member of our team (Bruno Viateau) spent 10 months (June 1999–April 2000) as a post-doc fellow in the VLBI group at the Jet Propulsion laboratory. Unfortunately, despite the experience gained there, he did not obtain a permanent research position after his return in Bordeaux. He left the Observatory in July 2000 and now works for a private company.
- One of us (Patrick Charlot) spent a few days at NASA/GSFC in April 2000 to learn the basics of the SKED scheduling software. This software was then successfully installed in Bordeaux and used for scheduling the ICRF densification experiment described above.
- Computer equipment has been significantly upgraded with two new Unix workstations, a Compaq DS20 acquired in September 1999, and a Compaq ES40 acquired in September 2000. The MODEST analysis software has been installed on these workstations, while the Goddard data base system and related software like SKED remain on our old HP workstation.

## 4. Outlook

- Starting next fall, we expect to have a new engineer for IVS analysis activities. This should allow us to increase our level of activity and develop regular analyses related to the celestial frame. Our goal is to produce time series of source positions and study the ICRF source position stability as initially proposed [1].
- In the immediate future, our aim will be to process the data of the ICRF densification experiment described above and to assess the results. This analysis will be carried out with the MODEST VLBI analysis software [5]. Once we have these results, a new proposal will be submitted to the EVN for observing the remaining 100 sources.
- Additionally, we will continue to evaluate the astrometric quality of the ICRF sources as new maps are available, and make structure indices and false color images available through our web page. Future work will also be targeted at incorporating source structure corrections to actual observations. Progress toward this goal has been reported in [6].

## References

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