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DIVISION A / WORKING GROUP
Third Realization of the International Celestial Reference Frame

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TRIENNIAL REPORT 2015-2018

1. Introduction

The Working Group on the Third Realization of the International Celestial Reference Frame (hereafter referred to as ICRF3) was created at the IAU General Assembly in Beijing in 2012. The goal of the Working Group was to produce a new realization of the International Celestial Reference Frame (ICRF), based on Very Long Baseline Interferometry (VLBI) observations of extragalactic radio sources, with targeted completion by the XXX General Assembly of the IAU in 2018. The Working Group comprises 20 members representing various aspects of the expertise necessary to reach the goal.

Building upon the work accomplished during the first triennium (2012-2015), mostly targeted to acquiring new VLBI data sets, the focus for the present triennium was placed on actually generating ICRF3. The charter originally established specifies that ICRF3 should be based on state-of-the-art astronomical and geophysical modeling and analysis strategies and utilize the entire relevant astrometric and geodetic VLBI data sets, while also considering the possibility to incorporate new observing frequencies. These terms served as guiding principles to the Working Group for constructing ICRF3.

The following sections describe the organisation of the work and achievements during the past three years along with dissemination activities and the outlook for the future.

2. Organisation of activities and achievements

The work towards ICRF3 was organised following a work plan and timeline established at the beginning of the triennium. Communication between members of the Working Group was arranged through email and regular telecons. Three such telecons took place in 2016 and six in 2017. Additionally, four face to face meetings were held, in Ekudeni (South Africa) on 18 March 2016, Haystack (USA) on 17-18 October 2016, Bologna (Italy) on 13-14 October 2017, and Bordeaux (France) on 22-23 February 2018. These meetings proved to be essential in that they provided opportunities for extensive discussions, solving issues and making decisions. All telecons and meetings are documented with minutes and a repository for internal documents and data was set up.

Specific areas of work included, among others, the selection of data sets (VLBI sessions) to build ICRF3, the definition of the configuration of the analysis, the treatment of Galactic aberration, the assessment of the astrometric quality of the sources, the identification of ICRF2 to ICRF3 transfer sources (to maintain alignment) and the selection of ICRF3 defining sources. Progress was accomplished through the generation of ICRF3 prototype solutions at three successive stages (September 2016, July 2017 and January 2018), as originally devised in the work plan. An important achievement was the delivery of one of such ICRF3 prototype catalogs to the Gaia Science team in July 2017 to enter as input for the generation of the Gaia Data Release 2 (to be released in April 2018). Extensive internal comparisons between prototype catalogs and with respect to ICRF2 and the Gaia Data Release 1 were carried out each time, which helped the group to identify issues and decide on the final configuration to produce ICRF3. Alternate solutions varying some components of the modeling (e.g. for the troposphere) or the parameterization were also made as a supplement to assess the level of systematic errors.

About twice as many VLBI observations have entered the generation of ICRF3 compared to ICRF2. The effect is an increase in the total number of sources, higher position accuracies and less systematics. Furthermore, the frame shows a much more uniform distribution of position accuracies compared to ICRF2, an improvement originating in the systematic re-observing of all sources that had a limited number of observations in ICRF2. A new feature also is the incorporation of VLBI data sets at 22 GHz (K band) and 8.4/32 GHz (X/Ka band) besides those available at the traditional 2.3/8.4 GHz (S/X band) geodetic and astrometric VLBI frequencies. The result is the availability of astrometric positions at three frequencies (8.4 GHz, 22 GHz and 32 GHz) for about 600 sources, a potentially very valuable product to investigate core shifts in those objects.

A resolution on the adoption of ICRF3 in replacement of ICRF2 at the upcoming IAU General Assembly was submitted to the IAU General secretary on February 15, 2018. Specifically, ICRF3 is meant to serve as the reference for aligning the Gaia optical frame onto the International Celestial Reference System with the highest accuracy in the future.

3. Dissemination

Progress in the construction of ICRF3 has been presented at a number of international meetings, including the following:

– *9th International VLBI Service for Geodesy and Astrometry General Meeting – New Horizons with VGOS*, Ekudeni, South Africa, 13–19 March 2016

– *13th European VLBI Network Symposium*, St Petersburg, Russia, 20–23 September 2016

– *23rd European VLBI for Geodesy and Astronomy Meeting*, Gothenburg, Sweden, 15–18 May 2017

– *European Week of Astronomy and Space Science, Symposium S2: 1st Gaia Data, New Science, New Opportunities, Synergies with Radio Astrometry - the GREAT Network*, Prague, Czech Republic, 26–30 June 2017
– *IAG-IASPEI Joint Assembly 2017, IAG Symposium 01: Reference Frames*, Kobe, Japan, 30 July–4 August 2017
– *Journées 2017, des Systèmes de Référence et de la Rotation Terrestre, "Furthering our knowledge of Earth Rotation"*, Alicante, Spain, 25–27 September 2017

Further presentations are also anticipated at two upcoming meetings prior to the IAU General Assembly 2018:
– *10^{th} International VLBI Service for Geodesy and Astrometry General Meeting – Global geodesy and the role of VGOS – fundamental to sustainable development*, Svalbard, Norway, 3–8 June 2018
– *13^{th} COSPAR 2018, References Frames for Applications of Geosciences*, Pasadena, California, USA, 14–22 July 2018

4. Outlook

While the release of ICRF3 represents a significant improvement over ICRF2, the generation of VLBI frames is by no means over. Radio sources vary in flux density and brightness distribution in unpredictable ways, requiring continued attention over the years to maintain the frame. Strengthening ICRF3 in the southern hemisphere and pursuing its extension at the higher radio frequencies (22 and 32 GHz) will also be important for further improvements. In order to accomplish these activities in a cooperative and international way, the present group is considering the possibility of requesting the creation of a new Working Group under the IAU umbrella, as devised for building ICRF3.