3.6.1.2 Institut Géographique National (IGN)

The IGN ITRS Combination Centre concentrated its activity during the year 2006 on the production of the ITRF2005.

For the first time, the ITRF2005 benefited from the contribution of the two other ITRF combination centres, namely Deutsches Geodätisches Forschungsinstitut (DGFI) and Natural Resources Canada (NRCan). Comparisons between intra and inter-technique combinations of the three ITRF combination centres were undertaken that allow improving the final ITRF2005 reliability.

ITRF2005

Contrary to previous ITRF versions, the ITRF2005 integrates time series of station positions and daily Earth Orientation Parameters (EOPs). The time series solutions are now provided in a weekly basis by the Services of the International Association of Geodesy (IAG): International services of satellite techniques (IGS, ILRS, IDS) and in a daily (VLBI session-wise) basis by the IVS. Reasons for which it was decided to use time series of station positions and EOP as input to ITRF2005 include:

- Monitoring of non-linear station motions and all kinds of discontinuities in the time series: Earthquake related ruptures, site instability, seasonal loading effects, etc.;
- Examining the temporal behaviour of the frame physical parameters, namely the origin and the scale;
- Rigorously and consistently including EOPs in the combination and ensuring their alignment to the combined frame.

ITRF2005 Input data: Space Geodesy Solutions

One set of times series per space geodesy technique was considered as input to the ITRF2005 combination. These solutions are the official time series provided by the international services of the 4 techniques, known as Technique Centres (TC) by the IERS. Note that these official TCs' solutions result from a combination at the weekly (daily) basis of the corresponding individual solutions provided by the Analysis Centres (AC) participating to the activities of each TC. Official time series were submitted to the ITRF2005 by the International VLBI Service (IVS), the International Laser Ranging Service (ILRS), and the International GNSS Service (IGS). At the time of the ITRF2005 release, official weekly combined solutions from the International DORIS Service (IDS) were not available, so that individual solutions were submitted by two DORIS analysis centres, namely Institut Géographique National (IGN) in cooperation with Jet Propulsion Laboratory, and the Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS) in cooperation with Collecte Localisation Satellites (CLS), designated hereafter by (LCA). A specific analysis of DORIS solutions submitted to the ITRF2005 was performed prior to the ITRF2005 release. Table 1

Table 1: Summary of Submitted Solutions to ITRF2005

TC – AC	Time span	Type of constraints/solution	EOPs
IVS	1980.0-2006.0	Normal Equation	Polar Motion, rates, UT1, LOD
ILRS	1992.9-2005.9	Loose; variance-covariance	Polar Motion, LOD
IGS	1996.0-2006.0	Minimum; variance-covariance	Polar Motion, rates, LOD
IDS - IGN-JPL	1993.0-2006.0	Loose; variance-covariance	Polar Motion, rates, LOD
IDS - LCA	1993.0-2005.8	Loose; variance-covariance	Polar Motion, rates, LOD

summarizes the submitted solutions to ITRF2005, specifying the data-span, their type, the originally applied constraints and the nature of the included EOPs. Table 2 lists all the Analysis and Combination Centres for each one of the 4 techniques which contributed to the time series submitted to the ITRF2005.

The ITRF2005 is composed of 608 stations located at 338 sites as illustrated in Figure 1, with an imbalanced distribution between the northern hemisphere (268 sites) and the southern hemisphere (70 sites).

ITRF2005 Input data: Local Ties in Co-location Sites

As illustrated by Figure 1, there are in total 84 co-location sites for which local ties are available for the ITRF2005 combination. They are distributed as follows: 52 sites with two techniques, 26 with 3 techniques and 6 sites with 4 techniques. There are about 10 co-location sites where local ties are not available. Note also that, unfortunately, not all these co-located instruments are currently operating. For instance, among the 6 sites having 4 techniques, only two of them are currently operating: Hartebeesthoek, South Africa and Greenbelt, MD, USA.

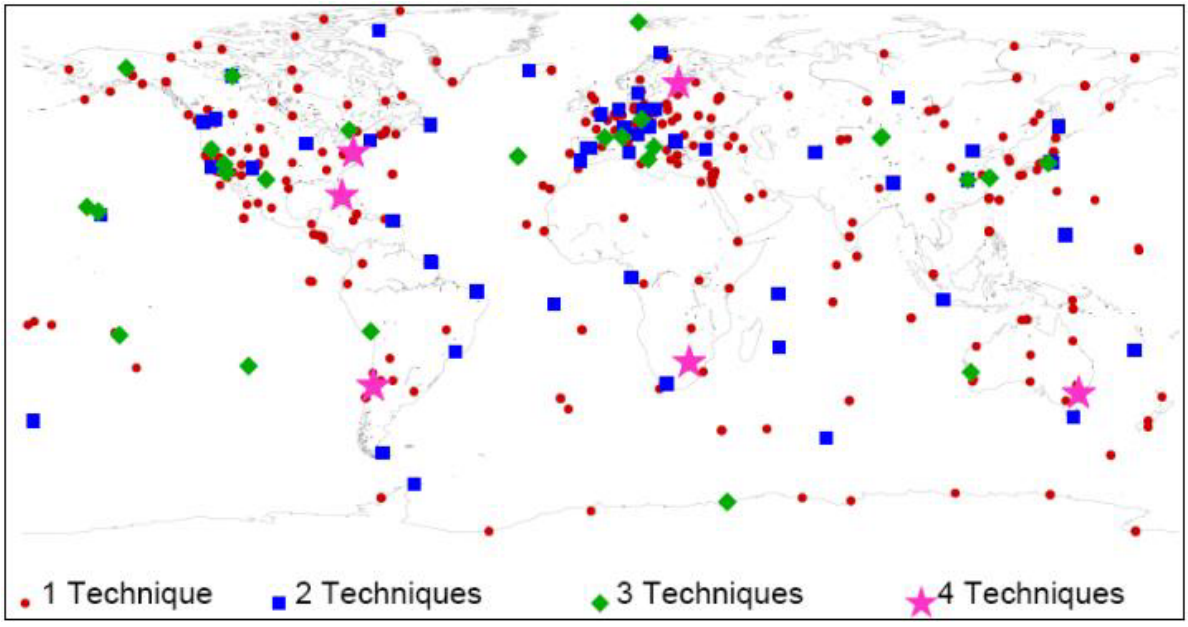

Fig. 1: ITRF2005 Sites with Co-located Techniques

Table 2: Analysis and Combination Centres Contributed to ITRF2005

TC ACs CC	**Institution**
IVS	http://ivscc.gsfc.nasa.gov/
BKG	Bundesamt für Kartographie und Geodäsie, Leipzig, Germany
DGFI	Deutsches Geodätisches Forschungsinstitut, Munich, Germany
GSFC	NASA Goddard Space Flight Center, Greenbelt, MD, USA
SHAO	Shanghai Observatory, Chinese Academy of Sciences, China
USNO	U.S. Naval Observatory, Washington D.C., USA
GIUB	Institut für Geodäsie und Geoinformation der Universität Bonn, Germany
ILRS	http://ilrs.gsfc.nasa.gov/
ASI	Agencia Spaziale Italiana, Matera, Italy
DGFI	See above
GFZ	GeoForschungsZentrum, Potsdam, Germany
JCET	Joint Center for Earth System Technology, at GSFC, USA
NSGF	NERC Space Geodesy Facility, formerly RGO Satellite, Laser Ranging Group, UK
ASI	See above, Primary ILRS-CC
DGFI	See above, Backup ILRS-CC
IGS	http://igscb.jpl.nasa.gov/
CODE	Center for Orbit Determination in Europe, Astronomical Institute of the University of Bern, Switzerland
ESOC	European Space Operations Center, European Space Agency, Darmstadt, Germany
GFZ	See above
JPL	Jet Propulsion Laboratory, Pasadena, CA, USA
NOAA	National Oceanic and Atmospheric Administration, NGS, Silver Spring, MD, USA
SIO	Scripps Institution of Oceanography, La Jolla, CA, USA
MIT	Massachusetts Institute of Technology, Cambridge, MA, USA
NRCan	See above
IDS	http://ids.cls.fr/
IGN	Institut Géographique National, Paris, France
LCA	Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS), in cooperation with Collecte Localisation Satellites (CLS), Toulouse, France
	IDS Combination Centre does not exist at the time of writing

The usual procedure adopted for the ITRF combination is to use the local ties as independent measurements with proper weighting. For the ITRF2005, about 45% of the available local ties are provided in SINEX files with full variance-covariance information as well as the measurement epochs: all sites in Australia; three sites in Italy: Medicina, Noto and Matera; Wettzell and Concepcion; and all the DORIS co-location sites were re-adjusted by the ITRS Centre in order to generate full SINEX files. The other 55% of the available local tie vectors were converted to SINEX format, following the procedure described in the ITRF article and technical notes. All the local tie SINEX files used in the ITRF2005 combination are available at <http://itrf.ensg.ign.fr/local_surveys.php>. The local tie

SINEX files were introduced in the ITRF2005 combination as independent solutions, in the same way as the long-term space geodesy solutions. Empirical variance factor estimation for each one of the individual local tie solutions (SINEX files) is operated following the procedure described in (Altamimi et al., 2002). The global combination is iterated as necessary and new variance factors are estimated at each run and in such a way that any position component should not exhibit a residual exceeding a certain chosen threshold. For the ITRF2005 solution it was decided to avoid having a position or velocity normalized residual (raw residual divided by its observation a priori error) exceeding a threshold of 4. Note that in each iteration, new individual variance factors are estimated which are then used to re-scale the individual matrices for the next iteration. A list of local tie vectors, together with their uncertainties as extracted from the re-scaled SINEX files, is also available at the same place as the SINEX files as mentioned above. In addition, all the post-fit residuals of the ITRF2005 combination are available at <ftp://igs.ensg.ign.fr/pub/igs/itrf2005/>. These residuals reflect, site by site, the level of agreement between the local ties and space geodesy estimates. There are some important co-located sites where we observe discrepancies larger than or equal to 1 cm, between local ties and space geodesy estimates. These discrepancies mean that either local ties or space geodesy estimates (or both) are imprecise or in error. Example of such sites are: GPS/VLBI: Westford, USA and Fortaleza, Brazil; GPS/SLR: Zimmerwald, Switzerland and Herstmonceux, UK. In order to preserve the implied co-locations in the combination, the local ties having normalized residuals exceeding the threshold of 4 were down-weighted rather than rejected, through the usage of appropriate variance factor as mentioned above.

ITRF2005 Main Results

In addition to the usual ITRF products (station positions and velocities), other important ITRF2005 results are also available to the users, namely:

- Full ITRF2005 and per technique SINEX files containing station positions, velocities and EOPs with complete variance-covariance matrices;
- Time series of station position residuals as results from the stacking of the individual time series of the 4 techniques;
- Geocentre time series from SLR and DORIS. There is no useful geocentre motion information from GPS/IGS, the submitted weekly solutions being aligned to ITRF2000;
- Full time series of EOPs consistent with the ITRF2005.

All the ITRF2005 files are available at the dedicated ITRF2005 web pages <http://itrf.ensg.ign.fr/ITRF_solutions/2005/ITRF2005.php>.

Reference Altamimi, Z., P. Sillard, and C. Boucher, 2002, ITRF2000: A New Release of the International Terrestrial Reference Frame for Earth Science Applications, J. Geophys. Res., 107(B10), 2214, doi: 10.1029/2001JB000561.

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