Dorothee Fischer et al.: UT1 Intensive Series Using K4 Technology, IVS 2004 General Meeting Proceedings, p.399–402
http://ivscc.gsfc.nasa.gov/publications/gm2004/fischer

UT1 Intensive Series Using K4 Technology

Dorothee Fischer [1], *Axel Nothnagel* [1], *Richard Kilger* [2], *Shinobu Kurihara* [3], *Wolfgang Schlüter* [2], *Kazuhiro Takashima* [3]

[1)] *Geodetic Institute of the University of Bonn*
[2)] *Bundesamt für Kartographie und Geodäsie*
[3)] *Geographical Survey Institute of Japan*

Contact author: Dorothee Fischer, e-mail: dorothee.fischer@uni-bonn.de

Abstract

In July 2002 the INT2 project on the Tsukuba – Wettzell baseline has been started for regular monitoring of UT1 using the K4 technology. It is a complement and independent control of the existing regular INT1 observation series on the Kokee Park – Wettzell baseline. A comparison of both independent UT1 series and a closer look at the differences will help to learn more about the error budget and the systematic effects of UT1 results from 1 - 1.5 hour observing sessions.

1. The INT2 Project

The INT2 series is a joint project of the Bundesamt für Kartographie und Geodäsie (BKG), the Geographical Survey Institute (GSI) and the Geodetic Institute of the University of Bonn (GIUB). A pilot phase with 20 almost weekly sessions was started in July 2002 [1] and since April 2003 observations have been carried out regularly on Saturdays. The INT2 observing series was established as complement and independent control of the Mark 5 Intensive sessions (INT1) using the baseline Wettzell–Tsukuba and recording with K4 technology. The correlation is done at GSI in Tsukuba and the schedules are prepared at GIUB. The time delay between observation and creation of the database on average is about 6 days.

Each session is scheduled manually and requires about 70 minutes. INT2 sessions contain 20 scans with a minimum duration of 120 seconds and a minimum SNR of 25 for X-Band and 20 for S-Band. The minimum elevation is fixed to 10°.

2. Analysis and First Results

Due to the low number of scans per session it is only possible to solve for the minimum number of five unknowns: clock offset and rate, wet zenith path delay per station and UT1-UTC as the primary objective. It is necessary to fix the celestial and terrestrial reference frame as well as the pole coordinates for the parameter estimation and, therefore, the estimated UT1-UTC parameters are directly connected with the selection of reference frames.

A first standard solution was calculated with source positions fixed to ICRF, station coordinates of ITRF2000 and pole information from usno_finals.erp. The dry part of the atmospheric path delay was modeled by the modified Saastamoinen model and the Niell dry and wet mapping functions were used for atmospheric mapping [3].

The results of both series (Fig. 1) mostly fit quite well to each other and differences are below 20 microseconds. However, at the end of 2002 as well as in November and December 2003 the

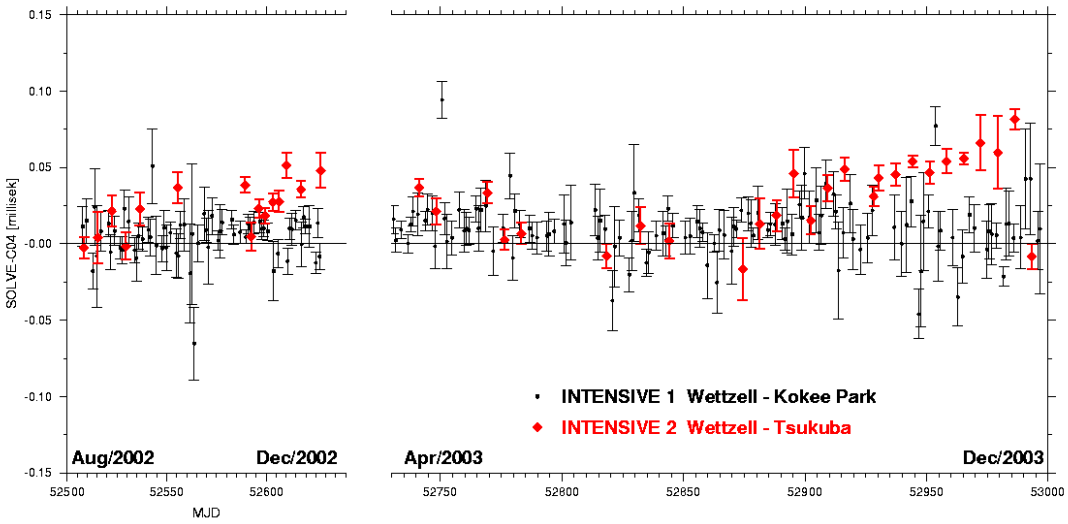

Figure 1. Results from uniform analysis of both Intensives series. A quadratic interpolation of C04 [2] is subtracted.

differences between the two series become larger and the INT2 series seems to drift off slightly.

In order to arrive at one consistent UT1 series from both Intensive observing programmes it is necessary to consider all possible differences between the two series which may influence the UT1 results in different ways. This will also lead to a better understanding of the error budget of the Intensive UT1 estimation itself and may help to find systematic effects. In the following, the most obvious differences between the two series will be discussed.

Geometry of baselines: The INT1 baseline Wettzell - Kokee Park is about 1900 km longer than Wettzell - Tsukuba and, therefore, it may be expected that INT1 is somewhat more senisitive to earth rotation than INT2. In addition, Tsukuba is approximately 14 degrees further north than Kokee Park. Owing to these differences it is not possible to use identical schedules or radio sources and individual scheduling is necessary.

Scheduling: Due to independent procedures of optimization and due to different baseline geometries the schedules of both Intensives differ in terms of source selection, sky coverage and number of scans per session. While each INT2 schedule contains 20 scans, the number of scans per INT1 session varies between 14 and 20. The schedules of INT2 are prepared manually in order to minimize the simulated formal errors of UT1-UTC and of atmospheric path delays. The simulated sigmas are computed by creating normal equation matrices from the schedules using the SOLVE

software package. A comparison of the simulated formal errors on average shows better results for the INT2 sessions than for INT1 (Table 1).

Table 1. Comparison of Intensive schedules.

		INT1 Wettzell - Kokee Park	**INT2** Wettzell - Tsukuba
Number of scans per schedule in average		17.5 (14 to 20)	20
Number of successful scans per session in average		17.1	19.6
Average Formal Errors from SOLVE simulation	σ **ATM(1)**	9.6 ps	4.3 ps
	σ **ATM(2)**	9.0 ps	4.0 ps
	σ **UT1-UTC**	8.5 μs	4.5 μs

Errors of pole coordinates: Due to the necessity of fixing the pole coordinates in the least squares adjustment, errors and inconsistencies of the pole coordinates affect the UT1-UTC estimates. Simulations have shown that there is a linear dependency of the UT1-UTC estimates on the variations of the pole components.

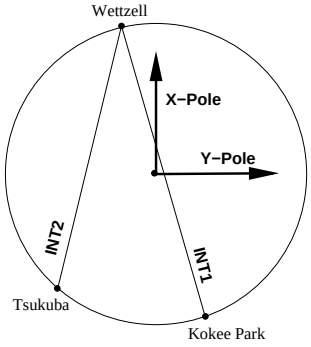

Figure 2. Geometry of Intensive baselines and direction of pole coordinates.

$[\frac{mas}{mas}]$	**INT1** Wettzell - Kokee Park	**INT2** Wettzell - Tsukuba
$\frac{d(UT1-UTC)}{dXpole}$	-0.13	0.47
$\frac{d(UT1-UTC)}{dYpole}$	-0.16	0.01

Figure 3. Linear effects of pole errors on UT1-UTC estimates from empirical study.

Fig. 2 shows the baseline geometry projected in the equatorial plane together with the directions of X and Y pole components. The results of an empirical test verify what has to be expected from the geometry (Fig. 2). Errors in the pole coordinates affect the UT1-UTC results of the two intensive sessions in a different way and with opposite sign. In particular, the X pole component has a significant effect on the INT2 UT1-UTC estimates. An error in the X pole component of 1 milliarcsec causes a change in UT1-UTC of -0.13 mas on the one baseline and +0.47 mas on the other baseline resulting in an accumulated effect of 0.6 milliarcsec which is equivalent to 40 μs.

3. Summary of Intensive Sessions in 2002 and 2003

Between July and December 2002 and between April and December 2003 a total number of 45 INT2 and 222 INT1 sessions were carried out successfully. The formal errors of the UT1-UTC estimates of INT2 are on average significantly lower than those of the INT1 sessions. The mean formal errors were 14.4 microsec for INT1 and 9.6 microsec for INT2 although. One reason for this may be the higher number of successful scans per INT2 session which are used in the analysis. On average the INT2 sessions contain about 18.7 successful scans while the INT1 sessions have only 16.5. The main reason for the smaller formal errors of the INT2 results, however, may be that the Tsukuba – Wettzell baseline provides a better geometry owing to its optimal length of 8400 km combined with careful scheduling of each individual session.

4. Outlook

Regular INT2 observations on Saturdays as they were started in April 2003 will be continued in 2004. Additional sessions on Sundays are currently being negotiated. Regular sessions on Thursdays will help to realize complete UT1 monitoring over the whole week.

The analysis of the observations will be refined taking into account thermal deformation effects of the antennas and vertical displacements due to ground water extraction.

In order to generate a uniform UT1-UTC series from both Intensives series, questions of consistency and accuracy need to be investigated further and a consistent integration into the results of 24 hour experiments is intended.

5. Acknowlegements

Part of this work is kindly supported by the German *Bundesministerium für Bildung und Forschung* under project *Geotechnologien*, 03F0336B.

References

[1] Fischer D., A. Nothnagel, R. Kilger, W. Schlüter, S. Kurihara, K. Takashima (2003), The K4 Intensive project 2002 for UT1 determination; Proceedings of the 16th Working Meeting on European VLBI for Geodesy and Astrometry, BKG, Leipzig , May 2003, 165–170

[2] IERS (2003), Data publically available under http://hpiers.obspm.fr/eoppc/eop/eopc04/eopc04.62-now

[3] Niell A.E. (1996), Global mapping functions for the atmosphere delay at radio wavelengths, J. of Geophys. Res.,Vol. 101, No. B2, 3227-3246

[4] Nothnagel A., G. Engelhardt, H. Hase, R. Kilger, S. Ogi, K. Takashima, V. Thorandt, D. Ullrich (2000): First Results of the 1999 Tsukuba - Wettzell UT1 Test Series; 2000 General Meeting Proceedings, International VLBI Service for Geodesy and Astrometry, Kötzting, Febr. 21-24, 2000, 252-256

[5] Vandenberg N.R. (1999), Sked: Interactive/Automatic Scheduling Program; Mark IV Software Documentation, NASA/ Goddard Space Flight Center, Space Geodesy Program