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Ultra-rapid UT1 measurement by e-VLBI

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1 Precision of UT1 and Latency

The earth orientation parameters (EOP) describes the relation between the International Terrestrial and Celestial Reference Systems (respectively ITRS and ICRS) (McCarthy and Petit, 2004) in conjunction with the conventional Precession-Nutation model. The EOP is measured by space geodetic techniques such as VLBI,GPS, SLR, and DORIS. VLBI is currently the only technique enabling determination of celestial pole offsets and observation of long term variability of UT1. Final values of EOP are released from IERS about one month later as Bulletin-B. For users who need present and future values of EOP, prediction data of EOP up to one year future is weekly published in Bulletin-A. Although the accuracy of the prediction value degrade rapidly with time. Fig.1 shows the latency and uncertainty of UT1 data published by IERS.

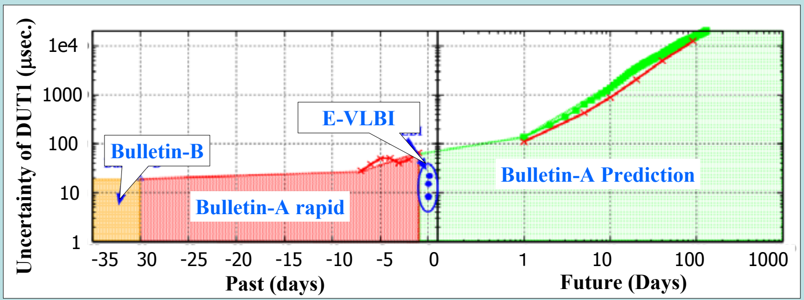


Fig.1 Precision of DUT1 and latency. Uncertainty of final solution (Bulletin-B), Rapid solution (Bulletin-A), and Prediction (Bulletin-A) of DUT1(=UT1-UTC) data are plotted. Center is present, left is past, and right is future.

With the aim to derive UT1-UTC data with minimum latency, intensive VLBI sessions are routinely operated with Wettzell-Kokee (INT1), Tsukuba-Wettzell (INT2), and Wettzell, Anayales-Tsukuba(INT3) baselines. Although they are using network data transfer with FTP, the latency is order of a few days. E-VLBI enables ultra-rapid UT1 measurement indicated at center of the Fig.1.

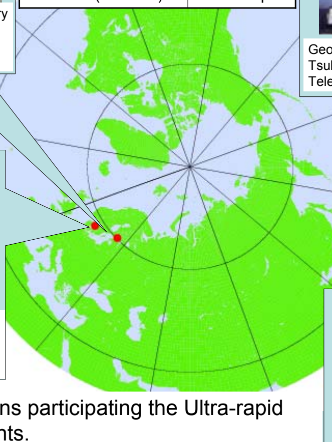
2 Improvement of Latency via e-VLB

The e-VLBI is an advanced VLBI technology by using highs speed network and software data processing. VLBI group of Kashima (Japan), Tsukuba (Japan), Onsala (Sweden), and Metsähovi (Finland) have started collaboration for the purpose of near real-time UT1 observation. Locations of these stations and accessible network speed are indicated in Fig. 2. NICT and Metsähovi has developed PC-based VLBI data acquisition system named **K5/VSSP**, and **VSI-B**, respectively. Additionally Metsähovi developed **"real-time Tsunami"**, wiihch is UDP-based network data trasnport software for for VLBI. These technologies enabled real-time data transfer in 256Mbps observation mode. We started near-real-time UT1-observation project

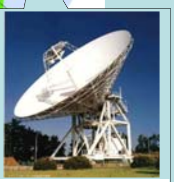
Metsähovi Radio Observatory of the Helsinki University of Technology, 14m Radio Telescope (Finland)

Station name	Network speed
Kashima(Japan)	～1Gbps
Tsukuba(Japan)	～1Gbps
Metsähovi(Finland)	～10Gbps
Onsala(Sweden)	～10Gbps

Geographycal Survey Institute, Tsukuba 32m Radio Telescope (Japan)



Onsala Space Observatory of Shalmers University of Technology 20m Radio Ttelescope (Sweden)



NICT Kashima 34m Radio Telescope (Japan)

Fig.2 VLBI stations participating the Ultra-rapid UT1 measurements.

3 Observations, Results, and Prospects

A list of e-VLBI experiments for UT1 observation conducted with Kashima34m, Onsala 20m, and Metsähovi 14m telescopes is displayed in Table 1. Observation data were transfered from Nordic stations to Kashima with the \`Tsunami' software in realtime. Then correlation processing and data analysis was with software correlator developed by NICT and CALC/SOLVE software package developed by GSFC. We made a automated pipeline data processing system. Consequently UT1 observation with the minimum latency 30 minutes became available since the end of May. Because these e-VLBI experiments are not scheduled routiely at present, the experiments are performed occationally when telescpe time became available. Observations are made by single baseline between Japanese and nordic stations. The UT1 data measured by this project is plotted on Fig.3, where the UT1 data by e-VLBI observation is compared with prediction and rapid combined solution of bulletin-A. That plot indicates the UT1 values observed on these baselines have the accuracy of the same level with rapid combined solution.

This e-VLBI project will be continues with aim of (a) confirmation of stable operability of ultra-rapid UT1 observation with e-VLBI technology, (b) improvement of observation precision with higher data rate, (c) consistency of ultra-rapid UT1 results with standard IVS results.

Table1. UT1 observations via e-VLBI experiments among Kashima(Kb), Onsala(On), Metsähovi(Mh) stations with e-VLBI. Latency is measured from the end of last scan.

Date in 2007	Observation Time (UT)	Data Rate (Mbps)	Baseline	Diff. from EOPc04 (μsec)	Formal Error (μsec)	Latency (hours)
23 Apr.	15:00-16:00	128	Kb-On	23	43	2
02 May	14:30-15:30	128	Kb-On	-2.3	15	1
18 May	08:00+09:00	128	Kb-Mh	52	98	3
30 May	16:00-17:00	128	Kb-On	18	9	1
31 May	06:30-07:30	128	Kb-On	-67	8	0.5
04 Jun.	07:00-08:00	256	Kb-On	-6.2	6	0.5
25 Oct.	15:00-16:00	256	Ks-On	96	640	--
26 Nov.	07:30-08:30	128	Kb-On	76	8	--
	08:45-09:45	256	Kb-On	78	16	--
	10:00-11:00	512	Kb-On	83	29	--
	11:30-12:30	128	Kb-On	77	8	0.5
	12:45-13:45	256	Kb-On	-2.3	14	0.5
	14:00-15:00	512	Kb-On	-8.8	30	--

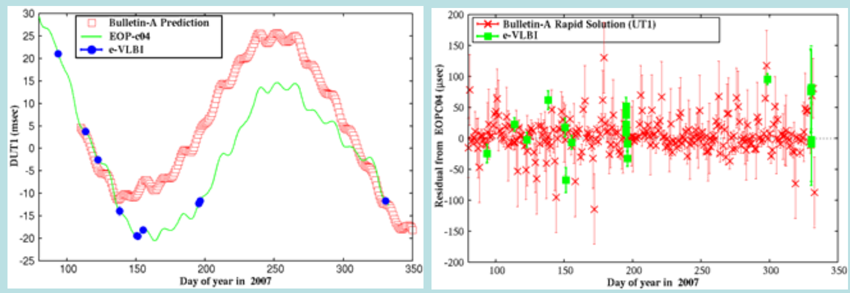


Fig. 3. Left panel shows comparison of UT1-UTC among EOPc04, prediction of Bulletin-A, and e-VLBI observation. Linear trend of UT1-UTC has been removed in advance. It is obvious that UT1 measured by e-VLBI observation has higher precision than prediction values. Right panel shows comparison of UT1-UTC values between rapid combined solution and e-VLBI. The values of EOPc04 series has been subtracted from both data series.

*: Tsunami is a UDP-based protocol originally developed by Indiana University and then successfully adapted by the Metsähovi group to support realtime and non-realtime VLBI applications.