CORE Operation Center 2017–2018 Biennial Report

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Abstract This report gives a synopsis of the activities of the CORE Operation Center from January 2017 to December 2018. The report forecasts activities planned for the year 2019.

1 Changes to the CORE Operation Center's Program

The Earth orientation parameter goal of the IVS program is to attain precision at least as good as 3.5 μs for UT1 and 100 μas for pole position.

The IVS program, which started in 2002, used the Mark IV recording mode for each session. The IVS program began using the Mark 5 recording mode in mid-2003. By the end of 2007, all stations were upgraded to Mark 5. Due to the efficient Mark 5 correlator, the program continues to be dependent on station availability and media storage. The following are the network configurations for the sessions for which the CORE Operation Center was responsible in 2017 and 2018:

- IVS-R1 (2017): 49 sessions, scheduled weekly and mainly on Mondays, six to 13 station networks
- RV (2017): Six sessions, scheduled evenly throughout the year, 14 to 17 station networks
- IVS-R&D (2017): ten sessions, scheduled monthly, five to seven station networks
- CONT17: 35 sessions, two networks scheduled concurrent for 15 consecutive days (13 to 14 stations and 14 stations), one network scheduled for five consecutive days (six stations)
- IVS-R1 (2018): 52 sessions, scheduled weekly and mainly on Mondays, four to 13 station networks
- RV (2018): Six sessions, scheduled evenly throughout the year, 13 to 14 station networks
- IVS-R&D (2018): ten sessions, scheduled monthly, six to eight station networks

NVI, Inc./NASA Goddard Space Flight Center

CORE Operation Center

IVS 2017+2018 Biennial Report

2 IVS Sessions from January 2017 to December 2018

This section describes the purpose of the IVS sessions for which the CORE Operation Center is responsible.

- IVS-R1: During the period of January 2017 through December 2018, the IVS-R1s were scheduled weekly with six to 14 station networks. The last session of 2018 only had four stations because it ran on December 26, the day after Christmas, and most of the stations were not available. Twenty different stations participated in the IVS-R1 network and 14 stations participated in at least 26 of the 52 sessions. This was an increase since the period 2015–2016 when only seven stations participated in at least half of the scheduled sessions.
  The purpose of the IVS-R1 sessions is to provide weekly EOP results on a timely basis. These sessions provide continuity with the previous CORE series. The "R" stands for rapid turnaround because the stations, correlators, and analysts have a commitment to make the time delay from the end of data recording to the analysis results as short as possible. Participating stations are requested to ship

Table 1 Median and variability of EOP formal uncertainties for 2017 and 2018. For the IVS-R4s in 2018, two sessions had much larger formal uncertainties. The values without these sessions is given in parenthesis.

	Num	X-pole (μas)	Y-pole (μas)	UT1 (μas)	X nutation (μas)	Y nutation (μs/d)
R1	49, 52	38, 41	41, 43	2.3, 2.6	24, 27	23, 27
		12, 10	9, 7	0.6, 0.6	11, 10	9, 10
R4	50, 53 (51)	38, 44 (40)	41, 49 (44)	2.2, 2.1 (2.4)	28, 33 (30)	27, 33 (30)
		7, 21 (6)	5, 32 (5)	0.5, 1.7 (0.5)	8, 17 (8)	7, 20 (7)
RDV	6, 6	45, 52	44, 51	2.5, 3.0	27, 35	30, 33
		7, 8	4, 7	0.4, 0.6	4, 10	5, 9
CONT11	15	27	28	1.3	16	16
		0.7	0.7	0.1	1	1
CONT14	15	28	30	1.4	16	14
		0.7	0.3	0	1	1
CONT17-L1	15	34	36	1.8	17	17
		1.6	0.9	0.1	2	2
CONT17-L2	15	35	39	1.7	22	21
		1.4	1.7	0.1	2	2

Values are given for 2017 and 2018 in that order. The RMS variabilities are given in the second lines.

disks to the correlator as rapidly as possible or to transfer the data electronically to the correlator using e-VLBI. The “1” indicates that the sessions are mainly on Mondays. The time delay goal is a maximum of 15 days from the end of data recording to the end of correlation. Sixty-three percent of the IVS-R1 sessions were completed in 15 or fewer days during 2017. The remaining 37% were completed in 16 to 30 days [16 days (four), 17 days (two), 20–25 days (ten), 29 days (one), 30 days (one)]. During 2018, the precentage of R1 sessions being processed within 15 days decreased from 63% to 50%. The remaining 50% ranged from 16 to 54 days [16 days (four), 17 days (three), 18 to 25 days (15 days), 26 to 30 days (two), 31 days (one), 54 days (one)]. The largest delay in 2017 was 30 days, while in 2018 the largest delay was 54 days.

- RV: There are six bi-monthly coordinated astrometric/geodetic experiments each year that use the full ten-station VLBA plus up to seven geodetic stations.

  These sessions are coordinated by the geodetic VLBI programs of three agencies: 1) USNO performs repeated imaging and correction for source structure; 2) NASA analyzes RDV data to determine a high accuracy terrestrial reference frame; and 3) NRAO uses these sessions to provide a service to users who require high quality positions for a small number of sources. NASA (the CORE Operation Center) prepares the schedules for the RDV sessions.
- R&D: The purpose of the ten R&D sessions in 2017, as decided by the IVS Observing Program Committee (OPC), was to vet sources for the GAIA proposal (RD1703, RD1704, RD1705, RD1708, RD1709, and RD1710) and evaluate the INT1 sessions (RD1701, RD1702, RD1706, and RD1710).

  The purpose of the R&D sessions in 2018, as decided by the OPC, was to vet GAIA transfer sources. All ten R&D sessions were allocated for this purpose.

3 Current Analysis of the CORE Operation Center’s IVS Sessions

Table 1 provides the median formal Earth Orientation Parameter (EOP) errors for the R1, R4, and RDV for 2017 and 2018, and for the CONT sessions. The standard deviation of the formal errors for each case is also shown to give an idea how much variation there is. For comparison, we also show the formal error statistics for the CONT11, CONT14, and the CONT17 Legacy 1 and 2 networks. The R1 session formal uncertainties were not significantly different between 2017 and 2018. R4 uncertainties were less in 2017 than 2018 by 5–10%

Table 2 Offset and WRMS differences (2017 and 2018) relative to the IGS Finals Combined Series.

		X-pole		Y-pole		LOD	
	Num	Offset (μas)	WRMS (μas)	Offset (μas)	WRMS (μas)	Offset (μs/d)	WRMS (μs/d)
R1	49, 52 (883)	59, 93 (18)	90, 59 (89)	100, 107 (130)	69, 68 (85)	1.4, 7.4 (1.2)	17, 14 (16.2)
R4	50, 53 (882)	58, 61(7)	77, 57 (112)	124, 126 (137)	67, 74 (94)	0.6, 0.6 (0.8)	18, 15 (17.2)
RDV	6, 6 (115)	27, −71 (35)	98, 88 (97)	17, 128 (134)	51, 111 (81)	−4.2, 13.7 (1.1)	19.1, 21.7 (14.6)
CONT11	15	-10	26	107	29	7.1	5.7
CONT14	15	27	19	175	30	1.9	5.3
CONT17-L1	15	34	32	57	31	4.0	9.1
CONT17-L2	15	49	55	3	49	1.7	6.3

Values are for 2017 and then 2018 and in parentheses for the entire series (since 2000) for each session type.

The RDV formal errors are comparable to the R4 uncertainties. However, RDV uncertainties were about 10% greater in 2018 than in 2017.

For comparison, we also included the formal uncertainties for the CONT11 and CONT14 campaigns. These are significantly better than for any of the other networks. Median polar motion uncertainties are at or below 30 μas and the UT1 uncertainties are only 1.3–1.4 μs (or equivalently 20–21 μas). Uncertainties for the CONT17 Legacy networks are larger than for CONT11 or CONT14 because compromises had to made to design two independent networks to observe simultaneously.

Table 2 shows EOP biases and WRMS differences with respect to the IGS Finals series for the R1, R4, RDV, and the CONT series. To do this calculation, we used the latest operational GSFC EOP series based on the GSFC 2016a quarterly solution. This solution used the ITRF2014 reference frame model, which includes earthquake site models for co-seismic offsets and post-seismic deformation. In doing this, we no longer needed to estimate post-seismic station positions for TSUKUB32 and TIGOCONC. This reduces the formal uncertainties as well as allowing these stations to contribute fully to EOP estimation. We found that this leads to better agreement between VLBI and IGS polar motion.

The WRMS differences were computed after removing a bias, but estimating rates does not affect the residual WRMS significantly. Both the R1 and R4 series have better WRMS agreement in X-pole and LOD for 2018 than for 2017. The X-pole biases (58–93 μas) and Y-pole biases (100–126 μas) of the R1 and R4 sessions relative to IGS are significant and likely due to reference frame bias. The significant biases for the CONT and RDV are also an indication of overall reference frame bias between the VLBI solution and the IGS frame.

For comparison with the 2017–2018 operational R1 and R4 sessions discussed here, we included the statistics for the CONT11 and CONT14 campaigns. These sessions clearly have the best WRMS agreement with IGS. The X-Pole agreement with IGS for CONT14 is significantly better than for CONT11; otherwise, the WRMS differences are comparable. It is likely that a single CONT17 network would have performed better than either of the CONT17 Legacy networks since compromises had to be made to design two independent networks. The performance of the Legacy 2 network was compromised by the fact that it had only one southern hemisphere station.

4 The CORE Operations Staff

Table 3 lists the key technical personnel and their responsibilities so that everyone reading this report will know whom to contact about their particular question.

5 Planned Activities during 2019

The CORE Operation Center will continue to be responsible for the following IVS sessions during 2019:

- The IVS-R1 sessions will be observed weekly and recorded in Mark 5 mode. There is a strong possibility that mixed mode will be observed and processed. Westford may be added to the network as a Mark 6 station. The correlation of the IVS-R1 sessions will be reviewed to determine how the latency

Table 3 Key technical staff of the CORE Operations Center.

Name	Responsibility	Agency
Dirk Behrend	Organizer of CORE program	NVI, Inc./GSFC
Brian Corey	Analysis	Haystack
Jay Redmond	Receiver maintenance	Peraton
John Gipson	SKED program support and development	NVI, Inc./GSFC
David Horsley	Software engineer for the Web site	NVI, Inc./GSFC
David Gordon	Analysis	NVI, Inc./GSFC
Ed Himwich	Network Coordinator	NVI, Inc./GSFC
Dan MacMillan	Analysis	NVI, Inc./GSFC
Katie Pazamickas	Maser maintenance	Peraton
Lawrence Hilliard	Procurement of materials necessary for CORE operations	NASA/GSFC
Cynthia Thomas	Coordination of master observing schedule and preparation of observing schedules	NVI, Inc./GSFC

can be decreased so that most of the sessions will be completed in less than 15 days.

- The IVS-R&D sessions will be observed ten times during the year.
- The RV sessions will be observed six times during the year.
- The CN sessions will be observed six times during the year and will run concurrent with an even 512 Mbps IVS-R1 session. The network will consist of all ten VLBA stations.