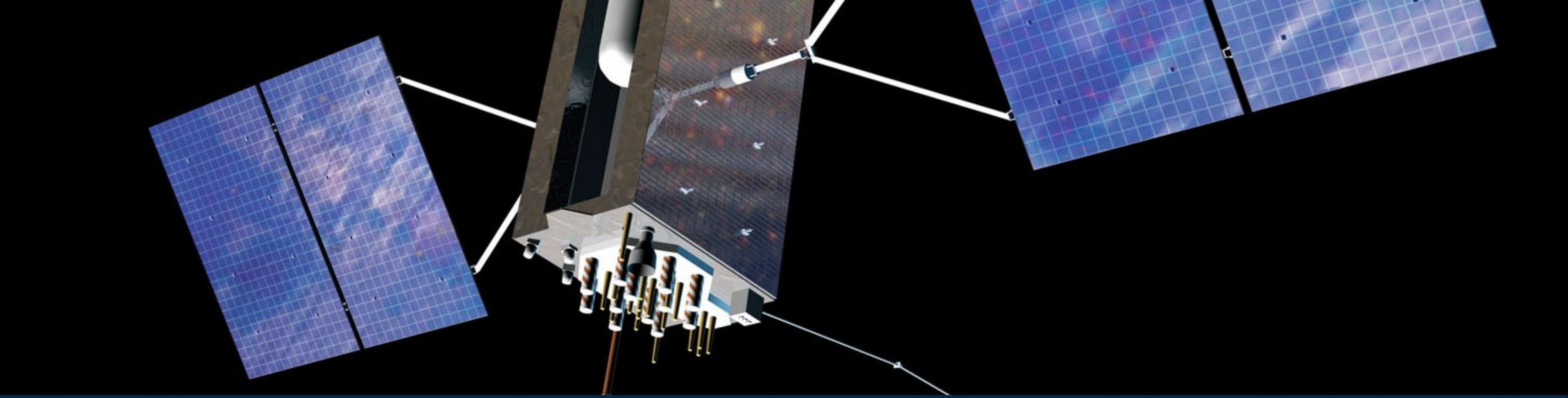

NGA GNSS Division Earth Orientation

The National Geospatial-Intelligence Agency provides Earth Orientation Parameter Prediction (EOPP) coefficients and predictions daily. Using NGA's EOPP coefficients allows a user to generate Polar X, Polar Y, and UT1-UTC predictions for any number of days in the future through the summation equations given below. The coefficients are recomputed every day at NGA and sent to the users after a quality control check. They are labeled to go into effect on the following day. Currently the NGA GNSS Division is utilizing the IERS Technical Note 36/IERS Conventions (2010) (TN36) which is covered in TN36/Chapter 8. The NGA EOPP restores the full 62 Gross zonal tide model along with the Oceans diurnal/semidiurnal model.

The coefficients are computed daily by using updated Polar x, Polar y, and UT1-UTC values from the International Earth Rotation and Reference Systems Service (IERS) at the United State Naval Observatory. These updated values are fit, in a least squares manner, to the math models below. Prior to the least-squares fit, NGA removes a 62-term Gross zonal tide model(TN36), with periods from 5.64 days to ~18.6 years from the UT1-UTC data prior to computing the coefficients. The resulting coefficients, constants and variables used in the math models are output in a five (5) line (80 columns per line) format. By simply substituting the output values back into the math model it is possible to get parameter predictions for any day in the future. One must know the Modified Julian Day (MJD) of your day of interest.

The following equations are the math models used in x_p, y_p, and UT1-UTC coefficient generation:

$$x_p(t) = A + B(t - t_a) + \sum_{j=1}^{2} C_j \sin\left\{\frac{2\pi(t - t_a)}{P_j}\right\} + D_j cos\left\{\frac{2\pi(t - t_a)}{P_j}\right\}$$

$$y_p(t) = E + F(t - t_a) + \sum_{k=1}^{2} G_k \sin\left\{\frac{2\pi(t - t_a)}{Q_k}\right\} + H_k cos\left\{\frac{2\pi(t - t_a)}{Q_k}\right\}$$

$$UT1 - UTC(t) = I + J(t - t_b) + \sum_{m=1}^{4} K_m \sin\left\{\frac{2\pi(t - t_b)}{R_m}\right\} + L_m cos\left\{\frac{2\pi(t - t_b)}{R_m}\right\}$$

NGA analysis shows that the weekly RMS difference between NGA predictions and final IERS values is under 0.003 arcsec (10 cm. at the equator) for Polar X and Y and under 0.8 msec for UT1-UTC. The accuracy of NGA's EOPP coefficients and model degrades with time. Always use the most recent set of NGA coefficients. The EOP predictions calculated from NGA coefficients and equations may not necessarily reproduce the NGA predicted EOP values. This is primarily due to differences in machine precision and the restoration of zonal and diurnal solid Earth tides.

1) NGA EOPP BULLETIN DOES NOT CONTAIN APPROXIMATE ZONAL TIDES.

The use of the 62-term Gross zonal tide model eliminates the need for approximate zonal tide coefficients. Thus, the zonal tide coefficients K_1, K_2, L_1, and L_2 are set to 0. The corresponding lunar and semi-lunar periods, R_1 and R_2, are set to 500.

Date last modified: February 20, 2020

Approved for public release, 17-805.

2) TOTAL RESTORATION TO THE POLAR X, POLAR Y, AND UT1-UTC PREDICTIONS.
In both EOPP output files (`EOPP####.TXT` and 'USAF####.DAT', where #### is the bulletin number), the 62-term Gross zonal tide model, representing periods from 5.64 days to~18.6 years, is added to the UT1-UTC value as calculated above. Similarly, the diurnal/semi-diurnal ocean tide model is added to the Polar X, Polar Y, and UT1-UTC. This method gives the best accuracy of all three components when compared to the IERS Finals. The Air Force GPS Master Control Station uses these coefficients and predictions in their process.

Solid Earth Tide Phases

Quantity	Period (days)	EOPP Model Parameters
Annual	365.25	P_1, Q_1, and R_3
Chandler cycle	435	P_2 and Q_2
Lunar	500.0 (no longer used)	R_1
Semilunar	500.0 (no longer used)	R_2
Semiannual	182.625	R_4

Seasonal Variation Coefficients (assumed constant)

EOPP Model Parameter	Coefficient (sec)
K_3	-0.022
K_4	0.006
L_3	0.012
L_4	-0.007

These constants were computed by I. I. Mueller in the 1960's (Moritz, H. and I.I. Mueller, Earth Rotation: Theory and Observations, 1987, Ungar, New York).

Sample EOPP 5-Line Products

```
57134.00  .096535  .000000  .079560 -.001056 -.094888  .011426365.25
 435.00  .360340  .000000  .110327 -.043663  .056139  .001909365.25435.00
  57387.00  .037772 -.001042  .000000  .000000 -.022000  .006000
   .000000  .000000  .012000 -.007000 500.0000 500.0000 365.2500 182.6250
  36 6166 57553 57552 00000  -1.041778
        57553   .11412908   .49412727   -.20154468
        57554   .11622101   .49396709   -.20219709
        57555   .11832966   .49378092   -.20277489
        57556   .12045747   .49355565   -.20326385
        57557   .12260569   .49327790   -.20365996
        57558   .12477375   .49293417   -.20397038
        57559   .12695799   .49251222   -.20421432
```

All dates are given in Modified Julian Date (MJD)

EOPP 5-Line Output Format

Line	Column Start	Format	Value	Variable
1	1	F10.2	Start Date of the Polar X-Y Motion Model (MJD)	t_a
1	11	F10.6	Polar X offset (arcsec)	A
1	21	F10.6	Polar X linear drift (arcsec/day)	B
1	31	F10.6	Sine Coefficient of the Annual Variations in Polar X (arcsec)	C_1
1	41	F10.6	Sine Coefficient of the Chandler Variations in Polar X (arcsec)	C_2
1	51	F10.6	Cosine Coefficient of the Annual Variations in Polar X (arcsec)	D_1
1	61	F10.6	Cosine Coefficient of the Chandler Variations in Polar X (arcsec)	D_2
1	71	F6.2	Annual Period (days)	P_1
1	77	4X	Blank	
2	1	F6.2	Chandler Period (days)	P_2
2	7	F10.6	Polar Y offset (arcsec)	E
2	17	F10.6	Polar Y linear drift (arcsec/day)	F
2	27	F10.6	Sine Coefficient of the Annual Variation in Polar Y (arcsec)	G_1
2	37	F10.6	Sine Coefficient of the Chandler Variations in Polar Y (arcsec)	G_2
2	47	F10.6	Cosine Coefficient of the Annual Variation in Polar Y (arcsec)	H_1
2	57	F10.6	Cosine Coefficient of the Chandler Variations in Polar Y (arcsec)	H_2
2	67	F6.2	Annual Period (days)	Q_1
2	73	F6.2	Chandler Period (days)	Q_2
2	79	2X	Blank	
3	1	F10.2	Start Date of the UT1-UTC Model (MJD)	t_b
3	11	F10.6	UT1-UTC offset (sec)	I
3	21	F10.6	UT1-UTC linear drift (sec/day)	J
3	31	F10.6	Sine Coefficient of the Lunar Variations in UT1-UTC (sec)	K_1
3	41	F10.6	Sine Coefficient of the Semilunar Variations in UT1-UTC (sec)	K_2
3	51	F10.6	Sine Coefficient of the Annual Variations in UT1-UTC (sec)	K_3
3	61	F10.6	Sine Coefficient of the Semiannual Variations in UT1-UTC (sec)	K_4
3	71	10X	Blank	
4	1	F10.6	Cosine Coefficient of the Lunar Variations in UT1-UTC (sec)	L_1
4	11	F10.6	Cosine Coefficient of the Semilunar Variations in UT1-UTC (sec)	L_2
4	21	F10.6	Cosine Coefficient of the Annual Variations in UT1-UTC (sec)	L_3
4	31	F10.6	Cosine Coefficient of the Semiannual Variations in UT1-UTC (sec)	L_4
4	41	F9.4	Lunar Period (days)	R_1
4	50	F9.4	Semilunar Period (days)	R_2
4	59	F9.4	Annual Period (days)	R_3

EOPP 5-Line Output Format (cont'd)

Line	Column Start	Format	Value	Variable
4	68	F9.4	Semiannual Period (days)	R_4
4	77	4X	Blank	
5	1	I4	Number of Leap Seconds since the beginning of GPS time	TAI-UTC
5	5	I5	Bulletin Number (EOPP year/day)	
5	10	I6	Effectivity Date (MJD)	t
5	16	1X	Blank	
5	17	A18	Generation Date (MJD)	
5	23	1X	Blank	
5	24	I5	Time of Effectivity (sec)	ToE
5	29	1X	Blank	
5	30	F11.6	UT1-UTC linear drift (msec/day)	rJ
6-12	1	16X	Blank	
6-12	17	I5	MJD of predictions	
6-12	18	1X	Blank	
6-12	19	F13.8	Polar X (arcsec)	
6-12	32	1X	Blank	
6-12	33	F13.8	Polar Y (arcsec)	
6-12	46	1X	Blank	
6-12	47	F13.8	UT1-UTC (arcsec)	

Before June 14th, 2016, NGA GNSS Division used the Tech Note 21 conventions which restored a 41-term Yoder zonal tide model with periods from 5.64 days to 34.85 days. This was accomplished by using the unused UT1-UTC coefficients and fitting the two dominant periods, 27.56 days (lunar cycle, R_1) and 13.66 days (semi-lunar cycle, R_2), of the zonal tides. Zonal tide approximation for TN21 utilized the unused UT1-UTC coefficients, K_1, K_2, L_1, and L_2 (all formerly set = 0.000000), as specified in the NGA bulletin in the web file named 'EOPP####.TXT'. The web tabular file named 'USAF####.DAT' had the 41-term Yoder zonal tide model applied to the UT1-UTC predictions and the Ray diurnals/sub-diurnals model applied to the polar X, polar Y, and UT1-UTC. This second method of restorations was used by the Air Force GPS Master Control Station .