

The IERS Rapid Service / Prediction Center Mission, **Challenges, and Developments**

Sharyl Byram and Maria Davis Earth Orientation Department, U.S. Naval Observatory



Abstract

The IERS Rapid Service / Prediction Center (RS/PC) is responsible for producing Earth Orientation Parameters (EOPs) from a combination of techniques that include Very Long Baseline Interferometry (VLBI), Global Navigation Satellite System (GNSS), Satellite Laser Ranging (SLR), Atmospheric Angular Momentum (AAM), and UTGPS. One of the most important contributors to the combination is GPS, as it provides LOD and Polar Motion-x and -y. The RS/PC is particularly dependent on GPS to measure Polar Motion. Access to robust time-series that includes regular, accurate, and precise observations produces a more accurate EOP combination. As EOPs relate the terrestrial and celestial reference frames, a more accurate RS/PC combination can in-turn improve spacecraft navigation and pointing systems, such as VLBI antenna.

Overview of EOP Combination

- Combine observed data to create a best estimate of the five Earth Orientation Parameters (EOPs):
 - Polar Motion x, Polar Motion y, UT1-UTC, dX, dY
 - 24h VLBI session observation is the only technique that observes all 5 EOPs
 - Use multiple techniques to validate accuracy of observations

• GPS (and UTGPS), VLBI, SLR, and AAM





VLBI Telescopes GPS Receivers Atmospheric Data Laser Ranging

Low-Latency Data is Critical for UT1-UTC Combination



- Illustration of RS/PC data contributors for UT1–UTC combined 0-day solution
- Alternate marker and alternate combined solution show a scenario where a low-latency observation (e.g., Alternate IGS Ultra rapid) reports a significantly different UT1–UTC value • Local combined-solution, including the UT1–UTC 0-day solution, would be reported in the daily products with a different UT1–UTC value

The RS/PC is committed to producing high-quality EOPs in a low-latency environment to support international geodesy. In this effort the RS/PC continues to develop quality standards used to evaluate current and potential combination contributors, and investigate additional data sources that can provide increased redundancy, reliability, and accuracy to the combination.

What are EOPs?

Earth Orientation Parameters (**EOPs**) provide a rotational relationship between the Terrestrial Reference Frame (**TRF**) of the Earth, and the Celestial Reference Frame (**CRF**) used for satellite navigation and other applications requiring an accurate relationship between frames.



• EOPs are *highly variable* –

- Utilize diversity of observation networks to ensure accuracy and redundancy
- Use contributors with varied analysis software
 - To detect software errors and systematic effects
- Generate predictions for:
 - 1 year for Polar Motion, UT1—UTC
 - 90 days for dX, dY
- Daily human-reviewed and human-approved solution



Station locations for ILRS, IGS, and IVS

Challenges and Future Updates

Challenges

Error in UT1-UTC on Orbit



EOP Combination Contributors

- daily measurements and predictions are required for real-time users
- Accurate, precise *daily* EOPs are critical in supporting modern society

Rotation \rightarrow UT1-UTC Polar Motion \rightarrow PMx, PMy Celestial Pole Offsets \rightarrow dX, dY



Contact Us

IERS Rapid Service / Prediction Center eopcp@us.navy.mil Maria Davis (Science Lead) maria.a.davis33.civ@us.navy.mil Nathan Shumate (Ops Lead) nathan.a.shumate.civ@us.navy.mil Sharyl Byram (Division Chief) sharyl.m.byram.civ@us.navy.mil

- IGS Rapid products released after 1700 UTC may not be included in EOP combination until next day (minutes matter for product release)
- Future Updates
 - Developing new combination method
 - Allows the use of IGS and AAM LOD data directly into the UT1-UTC combination
 - Preliminary results suggest improvement to 0day EOP values and 5-7 day predictions (Stamatakos, et. al, AGU, 2023)
 - Re-development of AAM pre-processing
 - Preliminary analysis suggests improvements to UT1-UTC combination and prediction values
 - Modernizing software
 - More dynamic and easier to maintain
 - Easier to integrate new contributors into combination
 - Continued improvements on internal software and infrastructure robustness
 - Improves reliability of product

Combined EOP Solution

• Combination produced using a smoothing cubic spline with weighted input series

UT2S-UTC Daily Solution

Polar Motion x Daily Solution

Technique	Contributor	Latency*	Product	EOP
GNSS (IGS)	IGS Finals	<= 21.5 days	IGS Combination	PM x,y
	IGS Rapids	29 hrs		
	IGS Ultra rapids	17 hrs		PM x,y, UT1—UTC [†]
VLBI (IVS + 1 VLBA)	GSFC VLBI AC USNO VLBI AC	22 hrs	1hr Intensives	UT1—UTC
	GSI VLBI AC	9 hrs		
	GSFC VLBI AC USNO VLBI AC	~ 2 weeks	24hr R1/R4	PM x,y, UT1—UTC, dX, dY
	IAA VLBI AC	N/A		
	IVS Combination AC	2-3 weeks		
SLR	ILRS	2.5 – 7 days	Series A	PM x,y
UTGPS	USNO GPS AC	17 hrs	Derived from IGS Ultra-rapid	UT1—UTC
AAM	NOAA U.S. Navy	17 hrs	Analysis + 7.5 days predictions	UT1—UTC [†]
	 * Latency is EOP con † Integrate 	s observatior nbination d LOD	n mid-point to time o	of

RS/PC Products & Publishing

Schedule

Products available at:

https://maia.usno.navy.mil/ser7



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