## 3.6.2.11 Jet Propulsion Laboratory (JPL)

### Introduction

The uncertainty in our knowledge of the Earth's changing orientation in space is a major source of error in tracking and navigating interplanetary spacecraft. Because the Earth's orientation changes rapidly and unpredictably, measurements must be acquired frequently and processed rapidly in order to meet the near-real-time Earth orientation requirements of the interplanetary spacecraft navigation teams. These requirements are currently met at JPL by using the global positioning system (GPS) to provide daily determinations of polar motion and length-of-day within 24 hours of acquisition. Single baseline very long baseline interferometry (VLBI) measurements are taken twice-per-month by the Time and Earth Motion Precision Observations (TEMPO) project in order to provide the benchmark Universal Time (UT) measurements between which the GPS length-of-day measurements are integrated. The Kalman Earth Orientation Filter (KEOF) is then used to combine the GPS polar motion and length-of-day measurements with the TEMPO VLBI variation-of-latitude and UT0 measurements, along with other publicly available Earth orientation measurements including proxy measurements such as atmospheric angular momentum, in order to generate and deliver the required polar motion and UT1 Earth orientation parameters to the spacecraft navigation teams.

### Data Products

Reference series of Earth orientation parameters are generated annually at JPL. During 2005, three such reference series were generated: (1) SPACE2004, consisting of values and rates for polar motion and UT1 spanning September 28, 1976 to January 22, 2005 at daily intervals, was generated by combining Earth orientation measurements taken by the space-geodetic techniques of lunar and satellite laser ranging (SLR), VLBI, and GPS; (2) COMB2004, consisting of values and rates for polar motion and UT1 spanning January 20, 1962 to January 22, 2005 at daily intervals, was generated by additionally including the BIH optical astrometric measurements with the space-geodetic measurements used to generate SPACE2004; and (3) POLE2004, consisting of values and rates for just polar motion spanning January 20, 1900 to January 20, 2005 at monthly intervals, was generated by additionally including the ILS optical astrometric measurements with the other optical astrometric and space-geodetic measurements used to generate COMB2004. These reference series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/combinations/2004>. A report describing the generation of these series [Gross, 2005] is also available at this site.

The near-real-time Earth orientation requirements of the interplanetary spacecraft navigation teams are met by twice-per-week up-

dating the annually generated reference series. The updated Earth orientation series are generated by additionally incorporating measurements that are rapidly available such as the GPS measurements from the JPL Analysis Center of the IGS and the atmospheric angular momentum measurements from NCEP that are used as proxy length-of-day measurements. In addition, short-term predictions of the EOPs are produced in order to provide the navigation teams with an uninterrupted series of Earth orientation parameters. The updated and predicted EOP series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/predictions>.

## Research activities

Research activities during 2005 were largely concerned with improving KEOF's real-time determinations of UT1. This was accomplished by interpreting the GPS length-of-day measurement as being a finite difference of UT1 over some time interval, rather than as being an instantaneous time derivative of UT1. As a finite difference, an estimate of UT1 valid at the end of the time interval can be obtained by adding the length-of-day value to an initial estimate of UT1 valid at the beginning of the time interval. In practice, the initial UT1 value is taken to be the latest UT1 measurement, and all length-of-day values available after that latest UT1 measurement are summed. In this manner, estimates of UT1 can be extended to near real-time, greatly improving the accuracy of real-time UT1 determinations. In fact, with this approach, the accuracy of KEOF's real-time UT1 determinations was found to increase by about 33%.

## Acknowledgments

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## Reference

Gross, R. S., Combinations of Earth orientation measurements: SPACE2004, COMB2004, and POLE2004, Jet Propulsion Laboratory Publ. 05-6, 28 pp., Pasadena, Calif., 2005.

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