THE DETERMINATION OF CRUSTAL MOTIONS USING LASER RANGING TO LAGEOS-2 AND LAGEOS-1

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During the period October 1992 through June 1993, Center for Space Research efforts under NASA Contract NAGW-1959 continued on four areas:

1) Production of a solution for terrestrial reference frame including site positions, velocities, and Earth orientation and rotation spanning the entire Lageos-1 mission.

2) Production of a solution for terrestrial reference frame including site positions and Earth orientation spanning the Lageos-2 mission, independently from Lageos-1.

3) Evaluation of numerical characteristics of the integration of the Lageos-2 orbit.

4) Evaluation of contributions of Lageos-1 and Lageos-2 to temporal variations in the geopotential and 18.6 year tidal response of the Earth.

5) Attendance and participation in Lageos-2 Investigator Working Group Meetings and Committees.

The CSR93L01 and CSR93L02 solutions spanning the period from May 1976 through December 1992 were completed in March 1993 and submitted to the International Earth Rotation Service. The solutions include site position adjustments for 111 sites, horizontal velocities for 45 sites, and Earth orientation and rotation in 3 day intervals. The UTCSR submissions form an integral part of the IERS combined Earth orientation and terrestrial reference frame combined solutions, defining both the geocenter location and the terrestrial reference system scale. Several manuscripts demonstrating the outstanding quality of this solution are currently in press or in review.

In addition to the CSR93L01 and CSR93L02 solutions for Lageos-1, we have performed an independent solution for Earth orientation and site positions from Lageos-2 to assess consistency. UTCSR identified the necessary adjustment to the order one coefficients of the geopotential to remove mean differences in the polar motion series and terrestrial reference frame origin. A modest preliminary tuning of JGM-1 was successfully performed, and the consequent agreement of the Earth orientation, geocenter, and relative site positions were all at the 10 mm level or better.

In addition, UTCSR researchers were able to demonstrate that the anomalously large alongtrack accelerations recovered from the data from several analysis groups around the world, including the Goddard Spaceflight Center, Telespazio, and UTCSR were in fact artifacts of poor selection of numerical integrator step size. Suggested step sizes were provided at the Spring AGU, and have been used successfully at GSFC.

Analyses of Lageos-1 and Lageos-2, responses to temporal variations in the geopotential continue to lead to better understanding of the uncertainties in the reported values, largely due to improved understanding of the atmospheric errors. A discussion of the separation of the first two even and odd degree variations in the geopotential using only Lageos-1 and Lageos-2 was presented at the European Geophysical Society meeting in Wiesbaden in May 1993.

Finally, the time history of variations in the location of the center of the solid Earth with respect to the center of mass of the Earth due to several large ocean tides was presented at the spring 1993 meeting of the American Geophysical Union. This is the first time such an effect has been observed, and can provide a new type of observation of the response of the Earth to global forcing. Observation and evaluation of center of mass variations is an area of particular expertise at UTCSR, and one that will continue to receive considerable attention in the coming year.

Planned Tasks for FY 1994

The effort to be completed during the period October 1993 through September 1994 includes the following specific tasks:

1. Continued development and improvement of force and measurement models for Lageos-1 and Lageos-2. These include gravitational (mean, tidal, nontidal), Earth and solar radiation pressure, thermal force, and relativity force models, and the refraction, instrument and clock biases and drifts measurement models.

2. Production of time series of geocenter location and temporally varying gravitational coefficients of geophysical interest.

3. Production, on an annual basis, of time series of site positions and/or velocities, and Earth orientation parameters derived from laser tracking of Lageos-1 and Lageos-2. These solutions will be reported to NASA databases as well as to the International Earth Rotation Service, of which the UTCSR solutions form a critical link.

4. Continued development and improvement of orbit determination software for multisatellite operation.

5. Continued evaluation and implementation of necessary constraints for the definition and maintenance of the terrestrial system in the multiple satellite environment and the relation of this terrestrial reference system to VLBI and DORIS defined systems.

6. Attendance at and support of Investigator Working Group Meetings for the Lageos-2 project.

Meetings Attended/Presentations

The meetings attended and the presentations funded by the Lageos-2 grant are as follows:

- 7th International Symposium on Geodesy and Geophysics of the Earth, Potsdam, Germany, October 1992.
    - Watkins, M. M., and R. J. Eanes, Diurnal and Semidiurnal Variations in Earth Orientation Determined From Lageos Laser Ranging
    - Eanes, R. J., and M. M. Watkins, Temporal Variability of Earth's Zonal Harmonics From Lageos
- Meeting of the American Geophysical Union, San Francisco, CA, December 1992.
    - Eanes, R. J., M. M. Watkins, B. D. Tapley, and B. E. Schutz, Temporal Variability of Earth's Gravitational Field From Satellite Laser Ranging Observations
    - Shum, C. K., D. P. Chambers, J. C. Ries, and B. D. Tapley, Determination of Large-Scale Sea Surface Topography and Its Variations Using Geosat Altimetry
    - Tapley, B. D., C. K. Shum, G. Kruizinga, S. R. Poole, J. C. Ries, and J. Seago, Results of Large-Scale and Mesoscale Oceanic Circulation From ERS-1 Altimetry
    - Watkins, M. M., and R. J. Eanes, High-Frequency EOP From Lageos Laser Ranging Including SEARCH 92
- European Geophysical Society Meeting, Wiesbaden, Germany, May 1993.
    - Eanes, R. J., M. M. Watkins, and B. D. Tapley, On the Use of Lageos-1 and Lageos-2 for the Determination of Zonal Harmonic Variations
- Spring Meeting of the American Geophysical Society, Baltimore, MD, May 1993.
    - Eanes, R. J., M. M. Watkins and B. D. Tapley, The Determination of Zonal Harmonic Variations Using Lageos-1 and Lageos-2
    - Eanes, R. J., Tidal Perturbations on Geodetic Satellite Orbits
    - Ries, J. C., R. J. Eanes, B. D. Tapley, and M. M. Watkins, Lageos-3: Measuring the Lense-Thirring Precession
    - Tapley, B. D., R. J. Eanes, M. M. Watkins, S. Bettadpur, J. C. Ries, and B. E. Schutz, Early Results from Analysis of Lageos-2 Laser Ranging Data
- Lageos-2 Principal Investigator's Working Group Meeting, Matera Italy, May 1993. Preliminary Results from Lageos-2 Analysis at UTCSR (M. M. Watkins, R. J. Eanes, B. D. Tapley)
- International Earth Rotation Service Meeting, Paris, France, May 1993.
    - Watkins, M. M., Measuring High Frequency Earth Rotation Using Lageos Laser Ranging