

The improvement of the equipment and also of the weighting procedures has led to a steady decrease of the standard errors, as shown in Table 2.

Table 2.

	Standard errors of raw 5-day values		
	<i>x</i>	<i>y</i>	UT
1967	0'016	0'015	0:0012
1971	0'011	0'011	0:0010

The UT results revealed some rapid irregularities of the Earth's rotation such as the one of March 1971, which may be associated with the circulation of the atmosphere. The polar path is very regular; however, a new change in amplitude of the Chandlerian wobble occurred in 1967 and was completed in about 6 months, without change of the mean pole, nor of the phase, thus confirming Runcorn's hypothesis of equatorial impulsive torques.

The following studies were performed.

1. Special attention was given to the results of new techniques for the polar motion determination, mainly by laser and Doppler measurements on artificial satellites. The Doppler results of the Dahlgren Polar Monitoring Service (DPMS) have a precision which almost reaches that of the classical data. However, systematic differences, some of them as yet unexplained, prevented the inclusion of the results with those of the classical instruments. Theoretical studies, as well as experiments and tests, are in progress for Doppler and laser observations (in collaboration with the DPMS and with French groups).

2. A study of the stability of classical instruments was completed and published in the Annual Report for 1971: this emphasizes the quality of the PZT both in short and medium terms. The study also makes clear that much precision could be gained by (a) full-time use of the existing instruments, (b) the installation (or transfer) of a few instruments in well-selected sites.

3. As global corrections for the short-term irregularities of UT due to the earth-tides and the diurnal nutation are not fully satisfactory, corrections were prepared for individual series. We are ready to apply these corrections for the 1972 data. On the 5-day values of UT1 the corrections may bring changes of more than 2 ms which is of the same order as the accidental errors: the corrections should be applied.

4. In May 1971, the BIH began to operate a rapid service under a contract for the Jet Propulsion Laboratory, giving *x*, *y*, UT1 – UTC on a weekly basis with a delay of 3 days. During critical periods of the Mariner 9 program, daily results were sent with one day delay. The results of the rapid service were found to be usually in agreement with the definitive ones to less than 0'03 for *x* and *y*, 0:003 for UT1. This was made possible through the diligence of 16 selected observatories which reduced and sent their data with minimum delays. The increasing requests for the results of the rapid service make it desirable to establish it on a permanent basis, with more satisfactory financing.

B. GUINOT

Director

REPORT OF THE WORKING GROUP ON THE POLE COORDINATES

The Working Group on the Pole Coordinates was organized by the Scientific Council of the IPMS in accordance with the request by Commission 19 at Brighton, 1970. The following were nominated: S. Yumi (President), E. P. Fedorov, E. Fichera, B. Guinot, G. Hall, W. Markowitz, P. Melchior, R. O. Vicente.

The terms of reference are to organize international cooperation and to promote international agreement on

- (a) The collection of the original data (or copies) of past ILS observations;
- (b) a new and homogeneous reduction of the ILS visual results;

- (c) an appropriate frame of reference;
- (d) the determination of the best possible coordinates of the pole.

There have been two formal meetings: at Brighton (1970) and Morioka (1971). An informal meeting was held at Cagliari in 1972 with the members of the Italian Geodetic Commission to discuss keypunching the Carloforte data.

The members of the Working Group inspected the list of data (period, name of the station, place of preservation) and the progress of the work which had been made at Mizusawa. They agreed to ask each station of the ILS to punch their own data by themselves or to make appropriate copies of original books and send them to Mizusawa. They also agreed to transfer all the observation books preserved in Italy to Mizusawa. The other agreements are that (a) apparent places of the stars are to be calculated by the use of the rectangular coordinates of the Sun (1950.0 eq.) taken from the Solar Coordinates 1800–2000 by Herget (*Astr. Papers*); (b) astronomical constants are to be referred to the present system of the IAU; (c) the Melchior Catalogue is preferable to the General Catalogue of Boss.

Almost all of the original books of observations or their photocopies were collected at Mizusawa from Potsdam, Napoli and Torino except for those of several years of Ukiah, photocopies of which are expected to be collected from Potsdam very soon.

A quarter of the data has already been punched on cards at Mizusawa with the financial aid of the Japanese Government.

The Gulbenkian Foundation of Portugal has kindly decided to grant an amount of U.S. \$16000 for the work on the Pole Coordinates through 1972, 1973 and 1974. U.S. \$5000 were already in hand for 1972. This grant will be spent for key-punching of Kitab, Gaithersburg and Ukiah for the period 1935–1961.

The Italian Geodetic Commission has agreed with the proposal that key-punching of the latitude data made at Carloforte for about 42 of the 62 years would be made in Italy at their own expense, the remaining 20 years having been already completed in Mizusawa.

The National Ocean Survey, National Oceanic and Atmospheric Administration of the U.S.A. is going to grant the money necessary for key-punching of Ukiah data for about 18 years. Of the 62 years, 17 have already been completed at Mizusawa and the remaining 27 years will be completed by the grant from the Gulbenkian Foundation. There may be no problem about the Gaithersburg data because key-punching for the period before 1935 was mostly completed at Mizusawa and that after 1935 will be done by the grant from the Gulbenkian Foundation.

The Astronomical Council of the Academy of Sciences in U.S.S.R. is considering key-punching the Tschardjui data for about 20 years at their own expense; a final decision will be made very soon. There should be no problem about the Kitab data which will be completed by the Gulbenkian and Japanese funds.

The data of Cincinnati, Adelaide, Batavia, La Plata, Oncativo and Bayswater will be dealt with by the Japanese fund.

All the key-punching of the data of the northern parallel stations is expected to be completed by 1974 and for the other stations by 1975.

The method of reduction, a definition of mean latitude based on an adopted frame of reference, errors in declination and proper motion and other matters are being studied.

The third meeting of the Working Group is scheduled to be held at Sydney during the General Assembly of the IAU, 1973.

S. YUMI

President, Working Group on the Pole Coordinates

LUNAR LASER RANGE MEASUREMENTS

The following report has been prepared by Dr. P. Bender, Former Chairman of the Laser Ranging Experiment Team (LURE).

Since the Apollo 11 landing in July, 1969 and the success of early laser range measurements

(02.094.067; 03.094.012, .023, .247; 06.094.188; 1, 2) three additional retro-reflector packages have been placed on the moon. A French package consisting of 14 solid glass corner reflectors of 11 cm edge length, which were mounted on the Lunakhod-1 remote-controlled vehicle, was landed by Luna 17 (05.053.026, .034; 06.094.222). A second U.S. package containing 100 solid 3.8 cm diameter fused silica corner reflectors, similar to the Apollo 11 array, was carried by Apollo 14 (3, 4). A third U.S. package containing 300 corner reflectors of the same design was landed by Apollo 15 (3, 5). The three Apollo reflectors form a large triangle roughly 1000 km on a side on the lunar surface, and their thermal properties permit measurements during both lunar night and day (2–6). The differences in range to the packages give accurate determinations of the lunar librations, so that the effects of the librations on the range can be separated out from the rest of the problem (7). The Apollo 15 reflector package was made three times larger than the other Apollo packages in order to make it particularly useful for geophysical applications (3, 8). The lunar ephemeris, librations, and reflector coordinates are expected to be improveable using the laser range data to the point where uncertainties in them do not significantly affect the use of Apollo 15 ranges for geophysical purposes (8, 9). A regular program of range measurements near meridian passage and roughly three hours earlier and later is being carried out at the McDonald Observatory (U.S.) whenever weather permits on all but about six days per month (10). The current accuracy is 15 cm for the average range residual over a period of roughly 10 minutes (11), including the effect of atmospheric uncertainties (12). A numerically integrated lunar ephemeris based on some of the early data has been obtained for temporary use in further analysis work, and a preliminary set of reflector coordinates was derived which give reduced residuals when used with this ephemeris (13). Extensive range measurements have also been reported by the Pic du Midi Observatory (France) and the Crimean Astrophysical Observatory (U.S.S.R.). Additional observing programs have been carried out by the Air Force Cambridge Research Laboratories (U.S.), the Tokyo Astronomical Observatory (Japan), and the Smithsonian Astrophysical Observatory (U.S.). The potential accuracy of lunar range measurements for obtaining polar motion and earth rotation, as well as for other purposes, is believed to be very high (03.094.229; 04.044.008; 06.094.283; 7, 8, 9, 14).

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Dr. J. E. Faller, successor to Dr. Bender as Chairman of the LURE Team, considers that a useful international program of polar motion and Earth rotation determinations on a regular basis could be started in late 1974 or soon thereafter.

PRIORITIES AND EXPECTED DEVELOPMENTS IN THE FIELD OF COMMISSION 19

Draft list

- (1) An essential feature of current programmes of observation and analysis of the rotation of the

Earth, polar motion, and associated astronomical and geophysical phenomena, is the collation of the results from individual observatories, and the rapid processing and dissemination of the data by an international agency. These permanent services merit increasing support to enable them to deal adequately with the rising flow of observational data.

(2) Some of the new observational techniques employing radio and laser astronomy show promise of achieving high accuracy, and should be developed in collaboration with classical methods. The latter should be further improved to permit useful comparisons to be made between the new and the old series of data.

(3) Major observing stations should be equipped for the routine acquisition of data relevant to all aspects of the study of the nature and motion of the Earth and of the dynamics of the Earth/Moon system.

(4) Theoretical studies and the analysis of observational data should be encouraged (a) to ensure that the maximum useful information is deduced and published; (b) to facilitate inter-disciplinary studies; (c) to provide guide-lines for the improvement of observational techniques.

H. M. SMITH

President of the Commission