THE FOUR PRIMARY GEODETIC PARAMETERS

MILAN BURŠA

Astronomical Institute, Czechosl. Acad. Sci., Prague*)

Résumé: Обсуждаются четыре первичных геодезических параметра, определяющих геодезическую систему относительно, с точки зрения физического смысла и современной точности. Масштабный фактор геопотенциала обсуждается в качестве первичного геодезического параметра, определяющего размеры Земли.

Summary: The four primary geodetic parameters defining the geodetic reference system are discussed from the point of view of their physical meaning and current estimation of their actual accuracy. The geopotential scale factor has been treated as the primary geodetic parameter defining the Earth's dimensions.

1. INTRODUCTION

There are four geodetic primary parameters defining the Geodetic Reference System (GRS) based on the classical concept of an equipotential rotational ellipsoid (Pizzetti, 1894) [1].

The adoption of the equipotential ellipsoid concept means, that an additional a priori condition has to be imposed. However, the equipotential ellipsoid furnishes a simple, consistent and uniform GRS. The major disadvantage of this concept is, that it is not able to represent other geopotential (Stokes) parameters with the exception of $J_2$. For example, the discrepancy in $J_4$ is too high, about 50%. In spite of this, the level ellipsoid has been adopted by the IAG/IUGG and the four geodetic parameters uniquely defining the GRS should then be selected as primary.

The aim of the paper is to contribute to the problem of selecting the four primary parameters, especially from the point of view of the definition of the Earth's dimension.

2. THE FOUR PRIMARY GEODETIC PARAMETERS

In general, the basic aspects to be adopted a priori may be established as follows:

a) It should be possible to determine the primary geodetic parameters (PGP) from observations with a higher accuracy than that of the alternates.

b) The PGP should be natural physical quantities, i.e. quantities with a physical meaning.

c) The PGP should be free of additional a priori conditions.

However, the basic equipotential surface

$$W = W_0$$

(1)

(the geoid) should be specified in any solution, e.g. via the Major Vertical Datum ($W_0$ at the origin of heights), or as fitting the sea surface topography (SST) best, or in the Listing [2] sense etc.; for the other planets and satellites surface (1) should fit best the topography surface of the body, because of the absence of oceans. However,

*) Address: Budečská 6, 120 23 Praha 2.
the definition of (1) will not be discussed here, even if closely related to the problem. Two quantities should be adopted as PGP regardless of the discussion: the geocentric gravitational constant \( GM \) and the mean angular velocity of the Earth’s rotation \( \omega \). Both satisfy all the three aspects above. The current estimate of \( GM \), if the mass of the Earth’s atmosphere is included, is (Ries et al., 1989) \[3\]

\[
GM = (398,600 \pm 441 \pm 001) \times 10^9 \text{ m}^3 \text{ s}^{-2};
\]

\[
G = (6.67259 \pm 000 \pm 30) \times 10^{-11} \text{ m}^3 \text{ s}^{-2} \text{ kg}^{-1}.
\] (2)

As regards \( \omega \), the annual mean values taken from BIH (IERS) Annual Reports are in Table 1. The actual mean value

\[
\omega = 7,292,115 \times 10^{-11} \text{ rad s}^{-1}
\] (4)

can also be interpreted as the rounded standard value \( \omega_0 \) in the FK5 system defined by Sinclair (1990) \[4\]

\[
\omega_0 = 360.9856122880539 \text{ degrees/UT1 day} =
\]

\[
= 7,292,115.146 \times 10^{-11} \text{ rad s}^{-1}.
\] (5)

Using (5) Sinclair (1990) \[4\] gives the actual mean, \( \overline{\omega_{12}} \), between two dates \( t_1, t_2 \) (UTC scale) as

\[
\overline{\omega_{12}} = \omega_0 \{1 + \left[ (UT1 - UTC)_{t_2} - (UT1 - UTC)_{t_1} \right] (t_2 - t_1)^{-1} \}.
\] (6)

The changes in \( \omega_{12} \), computed as annual means over the last thirteen years, amount to \( 10^{-12} \text{ rad s}^{-1} \). Since the seasonal variations are of the same order of magnitude, this supports the decision to give the standard value (3) of the PGP to no more than seven significant digits.

The two parameters adopted, \( GM \) and \( \omega \), do not describe the Earth’s figure and

Table 1. The annual means of the angular velocity of the Earth’s rotation 1978—1990

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<th>Years</th>
<th>( \omega ) [( 10^{-11} \text{ rad s}^{-1} )]</th>
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<td>1978</td>
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