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1.2	A	16/01/2006	Issue taking into account HPF internal and external review results	Chapter 3: Time system definitions updated. Chapter 4.1.3: Description updated. Chapter 4.1.5: ITRF4000 replaced by ITRF2005; Description updated. Chapter 4.2.2: Explanation improved. Chapter 4.2.3: Explanation about time in formulas included. Chapter 4.2.4: Additional references included and description improved. Chapter 4.2.5: minor editorial updates; additional references included; 1.1.2006 Leap second taken into account in formulas. Chapter 4.2.6: formely chapter 4.2.8. Chapter 4.2.7: formely chapter 4.2.6: small editorial update; equation corrected; additional references included. Chapter 4.2.8: New chapter included Chapter 4.2.9: formely chapter 4.2.7. Chapter 5.1: Explanations improved. Chapter 5.2: Descriptions updated and improved. Chapter 5.3: Description updated. Chapter 5.4: Summary table

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2.2	R	01/10/2007	Update during bridging phase	Chapter 4.1.5: IGS Reference updated.

				Chapter 9: Reference [31] added
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3.2	R	23/06/2010	Update for MOP-1	Complete document: Web links updated. Chapter 8.2: Figure 8-1 updated. Chapter 8.3: Note on rotation matrices from SSRF to GRF included.
4.0	R	14/05/2014	General update taking into account new external standards	Chapter 4.1.5: ITRF2005 replaced by ITRF2008. Chapter 4.2.8: EOP 05 C04 replaced by EOP 08 C04 Chapter 5.2: ITRF2005 replaced by ITRF2008.

				Chapter 5.3: Link to antenna characteristics web site included. Chapter 5.4: Table 5-1 updated. Chapter 9: References updated. Chapter 11.2: C04 Example file replaced.

Table of Contents

1. Introduction

This technical note serves as a record of the processing standards, models and parameters adopted for the generation of the GOCE level 2 products by the HPF.

2. Numerical Standards

The numerical standards defined for the GOCE HPF are summarized in Table 2-1.

Table 2-1: Numerical Standards to be applied for GOCE Level 2 Data Processing [1], [29] and [36]

Parameter	**Value**	**Unit**
Speed of Light [1]	299792458	$\frac{m}{s}$
Constant of Gravitation [29]	$6.67259 \cdot 10^{-11}$	$\frac{m^3}{kg \cdot s^2}$
GM_{Sun}: Heliocentric Gravitational Constant [1]	$1.32712442076 \cdot 10^{20}$	$\frac{m^3}{s^2}$
Astronomical Unit in [sec] [1]	499.0047838061	s
Astronomical Unit in [m] [1]	149597870691	m
Moon-Earth Mass Ratio [1]	0.0123000383	-
GM_{Earth}: Geocentric Gravitational Constant (including the Mass of the Earth's Atmosphere) [36]	$3.986004415 \cdot 10^{14}$	$\frac{m^3}{s^2}$
Earth Equatorial Radius in - Tide-free System (from [36]) - Mean-tide System (conversion see 6.1) - Zero-tide System (conversion see 6.1)	 6378136.46 6378136.59 6378136.49	m
Flattening Factor of the Earth 1/f in - Tide-free System (from [29]) - Mean-tide System (from [29]) - Zero-tide System (from [29])	 298.25765 298.25231 298.25642	-
Nominal Mean Angular Velocity of the Earth [1]	$7.292115 \cdot 10^{-5}$	$\frac{\text{rad}}{\text{s}}$
Mass of Planets	[same as for DE405, see chapter 4.1.3]	-

3.Time Systems and Relations

TCB: Barycentric Coordinate Time.

TDB: Barycentric Dynamical Time.

TT: Terrestrial Time, time which would be observed by an atomic clock on the geoid. It differs from TDB only by periodic terms (from relativity theory) the largest with an amplitude of 1.7 ms.

TAI: International Atomic Time realized by weighted mean of atomic clocks. TAI has a constant offset to TT of -32.184s (TAI = TT – 32.184s).

TGPS: Time realized by the GPS system. GPS time has a constant offset to TAI of -19s (TGPS = TAI – 19s).

UTC: The Universal Time Coordinated is on one hand kept synchronous with TAI and on the other hand it is kept to follow the actual angular rate of the Earth by introducing leap seconds within small bounds. Currently UTC has an offset to TAI of -33 (status: July 2008).

JD: The Julian Date continuously counts the number of days with a length of 86400s starting at 1.1.4713, 12:00 BC. The 1.1.2000 12:00 corresponds to a JD of 2451545.0

UT1: Universal Time corresponding to mean solar time corrected for polar motion of the observing station (including tidal variations). It represents the actual phase angle of the rotating Earth. The difference between UT1 and UTC is provided by the IERS.

GMST: Greenwich Mean Sidereal Time represents the mean angle of a terrestrial meridian with respect to the vernal equinox. The relation to compute GMST is given in Section 4.2.5, formula (46).

GST: Greenwich apparent Sidereal Time corresponds to GMST but corrected for nutation.

4. Reference Systems

4.1 Reference System Definitions

4.1.1 ICRS – International Celestial Reference System

The celestial reference system is based on a kinematical definition, making the axis directions fixed with respect to the distant matter of the universe. IERS has computed realizations of the ICRS every year between 1989 and 1995. The number of defining sources increased from 23 in 1988 to 212 in 1995. Solutions converged such that IERS proposed to define the 1995 solution as the ICRS. This was formally accepted by the IAU in 1997.

The principal (equatorial) plane of the reference frame is close to the mean equator at J2000.0. VLBI observations are used to monitor the motion of the celestial pole in the ICRF (precession and nutation). VLBI analyses provide corrections to the conventional IAU models for precession and nutation and accurate shifts of the mean pole at J2000.0 relative to the ICRS pole.

The origin of the right ascension of the ICRS is close to the dynamical equinox at J2000.0. The x-axis of the IERS celestial system was implicitly defined in its initial realization by adopting the mean right ascension of 23 radio sources in a group of catalogues that were compiled by fixing the right ascension of quasar 3C273B to the usual conventional FK5 value.

For a more detailed description see [1].

4.1.2 ICRF – International Celestial Reference Frame

The ICRS is materialized by the ICRF. A realization of the ICRF consists of a set of precise coordinates of extragalactic radio sources. All together 667 objects have been used from which 212 are defining sources and the rest are candidate and other sources. The most precise direct access to the quasars is done through VLBI observations. Therefore the tie of the ICRF to the major practical reference frames may be obtained through the use of the IERS terrestrial reference frame ITRF (see chapter 4.1.5), the HIPPARCOS galactic reference frame, and the JPL ephemerides of the solar system (see chapter 4.1.3). Maintenance of the ICRS requires the monitoring of the source coordinate stability based on new observations and new analyses. The appropriate warnings and updates appear in IERS publications.

The IERS Earth orientation parameters provide the permanent tie of the ICRF to the ITRF. They describe the orientation of the celestial ephemeris pole in the terrestrial system and in the celestial system and the orientation of the Earth around this axis as a function of time (see chapter 4.2). The tie is available daily.

For a more detailed description see [1].

4.1.3 CDRS – Conventional Dynamical Reference System

The planetary and lunar ephemerides recommended for the IERS standards are the JPL Development Ephemerides DE405 and the Lunar Ephemerides LE405 (see http://ssd.jpl.nasa.gov/iau-comm4). The time system scale for DE405/LE405 is not Barycentric Coordinate Time (TCB) but rather a coordinate time T_{eph}, which is related to TCB by an offset and a scale. Space coordinates obtained from the ephemerides are consistent with Barycentric Dynamical Time (TDB). Without loss of accuracy TT may be used as time argument for the JPL Development Ephemerides [24].

The reference frame of DE405 is that of the ICRF. The numerical values of the GOCE standards must be consistent with the planetary masses and astronomical constants used in creation of these two ephemerides. The table below provides the numerical values for DE405/LE405 (see [1], Chapter 3).

Table 4-1: JPL DE405/LE405 Numerical Standards

Constant	Value	Remark
Mass Mercury	6023600	reciprocal solar mass
Mass Venus	408523.71	reciprocal solar mass
Mass Earth & Moon	328900.5614	reciprocal solar mass
Mass Mars	3098708	reciprocal solar mass
Mass Jupiter	1047.3486	reciprocal solar mass
Mass Saturn	3497.898	reciprocal solar mass
Mass Uranus	22902.98	reciprocal solar mass
Mass Neptune	19412.24	reciprocal solar mass
Mass Pluto	135200000	reciprocal solar mass
Scale distance	149597870.691	[km/au]
Scale time	499.0047838061	[s/au]
Obliquity of the ecliptic	23°26'21.409''	
GM Ceres	4.7×10^{-10} GM Sun	
GM Pallas	1.0×10^{-10} GM Sun	
GM Vesta	1.3×10^{-10} GM Sun	
Density Class C	1.8	
Density Class S	2.4	
Density Class M	5.0	

For a more detailed description see [1].

4.1.4 CTRS - Conventional Terrestrial Reference System

The Terrestrial Reference System (TRS) is a spatial reference system co-rotating with the Earth in its diurnal motion in space. The Terrestrial Reference Frame (TRF) in the realization of the TRS is a set of physical points with precisely determined coordinates in a specific coordinate system attached to the TRF.

The CTRS is defined by the set of all conventions, algorithms and constants which provide the origin, scale and orientation of that system and their time evolution. The CTRS is an orthogonal, right-handed system with the same length for the basis vectors. Its origin is close to the Earth's center of mass (geocenter), the orientation is equatorial (z-axis is the direction of the pole) and the scale is close to an SI meter. The standard transformation between two reference systems is an Euclidian similarity of seven parameters: three translations, one scale factor, and three rotation angles.

For a more detailed description see [1].

4.1.5 CTRF/ITRF – Conventional/International Terrestrial Reference Frame

A Conventional Terrestrial Reference Frame (CTRF) is defined as a set of physical points with precisely determined coordinates in a specific coordinate system as a realization of a CTRS. Two types of frames are distinguished, namely dynamical and kinematical, depending on whether or not a dynamical model is applied in the process of determining these coordinates.

The International Terrestrial Frames (ITRF) produced and distributed by the IERS are such CTRF's. ITRF solutions are produced by combination of individual TRF solutions computed by the IERS analysis centers using observations of space geodetic techniques. Currently ITRF solutions are published nearly annually by the IERS. The latest release is ITRF2008, where 2008 indicates that observations up to the year 2008 have been included.

For GOCE data processing the most recent consolidated ITRF solution (ITRF2008) is used. GOCE orbit positions are expressed in the ITRF2008 reference frame.

The following description is based on ITRF2008 [34].

The ITRF2008 is characterized by the following properties:

- The scale of the ITRF2008 is defined in such a way that there are null scale factor at epoch 2005.0 and null scale rate with respect to the mean scale and scale rate of VLBI and SLR time series.The ITRF2008 origin is defined in such a way that there are null translation parameters at epoch 2005.0 and null translation rates with respect to the ILRS SLR time series.The ITRF2008 orientation is defined in such a way that there are null rotation parameters at epoch 2005.0 and null rotation rates between ITRF2008 and ITRF2005. These two conditions are applied over a set of 179 reference stations located at 131 sites. The reference sites include 107 GPS, 27 VLBI, 15 SLR and 12 DORIS.
- All analysis centers use a conventional tide-free correction. Therefore the ITRF2008 is a tide-free frame.
- ITRF solutions are specified by Cartesian equatorial coordinates X, Y and Z.
- The orientation of ITRF is originally given by the IERS reference pole (~ CIO) and reference meridian (~ BTS).

The ITRF2008 point positions can be expressed in several ways:

- Direct use of ITRF2008 station positions (see http://itrf.ensg.ign.fr/ITRF_solutions/2008/).
- Use of IGS products (e.g. GPS orbits, clock corrections and Earth Rotation Parameters) which are nominally all referred to the ITRF. Users should be aware of the ITRF version and other conventions and models used in the generation of the IGS products (see http://igscb.jpl.nasa.gov and. [31]).
- Use of transformation formulas between a particular TRF and ITRF2008.

4.2 Transformation between Celestial and Terrestrial Frames

This chapter describes the sequence of computations needed for the transformation from the International Terrestrial Reference Frame (ITRF) to the International Celestial Reference Frame (ICRF) based on [1], Chapter 5.

Two equivalent ways to compute the transformation from ITRF to ICRF can be used, namely

- the new transformation based on the Celestial Ephemeris Origin and the Earth Rotation Angle and
- the classical transformation based on the equinox and Greenwich Sidereal Time.

For both cases, the required procedure is to compute the various components of the transformation in the form of respective rotation matrices and then to combine these components into the complete terrestrial-to-celestial matrix.

Two types of rotation matrices are defined in mathematics. These are *axis rotation* matrices, which describe rotations of a reference frame, and *vector rotation* matrices, which describe rotations of a vector in a fixed reference frame. Numerically, vector rotation is equivalent to the axis rotation in the opposite direction. This can lead to confusion. This is why the elementary *axis rotation* matrixes, which should be used in frame transformations, are described in Section 4.2.1.

The classical, equinox-based, transformation from the ITRF to the ICRF is described in details in the subsequent sections 4.2.2 to 4.2.7. This description is a compilation of the IERS Conventions 2003 [1][7] and 1996 [2], the SOFA software collection [14], the IAU2000A subroutine, provided by T. Herring [8][9][15], the PMUT1_OCEANS subroutine, provided by Ch. Bizouard [16], and the descriptions of the data sets, provided by the IERS [11][12][13][17]. Numerical values of coefficients of all series, which are used in the transformation, are collected in the attachments (Chapter 11) to this document.

The complete terrestrial-to-celestial matrices, computed by our implementation of the above mentioned procedure, have been compared with the matrices, computed by the interactive tool provided at the IERS Web site [17]. A brief description of the results of the comparison is presented in Section 4.2.9. Maximal deviations from the IERS results are in a good agreement with an overall precision of the models used for the transformation.

The classical transformation, based on the equinox and Greenwich Sidereal Time, from the

Terrestrial Reference Frame (ITRF) to the Celestial Reference Frame (ICRF) is defined in the form

$$[ICRF] = \mathbf{B}(t)\mathbf{P}(t)\mathbf{N}(t)\mathbf{S}(t)\mathbf{W}(t)[ITRF] \tag{1}$$

where $\mathbf{B}(t)$ is the frame bias matrix, $\mathbf{P}(t)$ is the precession matrix, $\mathbf{N}(t)$ is the nutation matrix, $\mathbf{S}(t)$ is the Earth rotation matrix, and $\mathbf{W}(t)$ is the polar motion matrix. All these matrices are described below in detail.

4.2.1 Elementary Rotations of 3D Reference Frame

Matrices describing *positive rotations of 3D reference frame* around the coordinate axes are defined in the form

$$\mathbf{R}_1(\alpha) = \mathbf{R}_X(\alpha) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha \\ 0 & -\sin\alpha & \cos\alpha \end{pmatrix}, \tag{2}$$

$$\mathbf{R}_2(\beta) = \mathbf{R}_Y(\beta) = \begin{pmatrix} \cos\beta & 0 & -\sin\beta \\ 0 & 1 & 0 \\ \sin\beta & 0 & \cos\beta \end{pmatrix}, \tag{3}$$

$$\mathbf{R}_3(\gamma) = \mathbf{R}_Z(\gamma) = \begin{pmatrix} \cos\gamma & \sin\gamma & 0 \\ -\sin\gamma & \cos\gamma & 0 \\ 0 & 0 & 1 \end{pmatrix}. \tag{4}$$

By definition, *a rotation is positive when the reference frame rotates anticlockwise as seen looking towards the origin from the positive region of the specified axis*. The matrix $\mathbf{R}_1(\alpha)$ describes a rotation by an angle α around the X-axis. The matrix $\mathbf{R}_2(\beta)$ describes a rotation by an angle β around the Y-axis. The matrix $\mathbf{R}_3(\gamma)$ describes a rotation by an angle γ around the Z-axis. Each discussed rotation transforms 3D Cartesian coordinates of a vector referred to the original frame, (X,Y,Z), into 3D Cartesian coordinates of the same vector referred to the respective new frame, $(X,Y,Z)_j$:

$$\begin{pmatrix} X_j \\ Y_j \\ Z_j \end{pmatrix} = \mathbf{R}_j \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}. \tag{5}$$

Figure 4-1 illustrates these rotations.

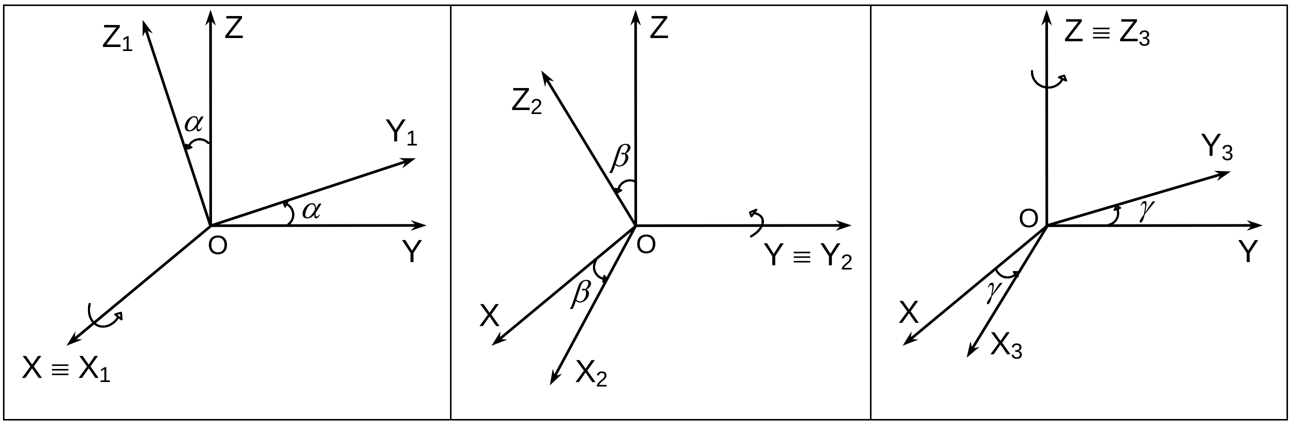

Figure 4-1: Frame Rotations around Coordinate Axes

4.2.2 The Frame Bias Matrix

The frame bias matrix transforms from the dynamic equator and equinox of J2000.0 to which precession and nutation refer to the ICRF. It is defined by:

$$\mathbf{B}(t) = \mathbf{R}_3(-d\alpha_0)\mathbf{R}_2(-d\psi_0 \sin\varepsilon_0 - \delta X)\mathbf{R}_1(d\varepsilon_0 + \delta Y)\,, \qquad (6)$$

where

$$d\alpha_0 = -0.01460'' \qquad (7)$$

is the frame bias in right ascension at the basic epoch J2000.0,

$$d\psi_0 = -0.041775'' \qquad (8)$$

is the frame bias in longitude at the basic epoch J2000.0,

$$d\varepsilon_0 = -0.0068192'' \qquad (9)$$

is the frame bias in obliquity at the basic epoch J2000.0, and

$$\varepsilon_0 = 84381.448'' \qquad (10)$$

is the obliquity at the basic epoch J2000.0. Numerical values of parameters (7) – (10) are stored in the attached file `precession.txt` (see attachment 11.7).

The quantities δX , δY are celestial pole offsets determined from VLBI observations. Daily values of these offsets are published by the IERS within the EOP 05 C04 series [13] (see example file in attachment 11.2). They must be interpolated to the epoch of computation.

4.2.3 The Precession Matrix

The precession matrix is defined by the canonical 4-rotation sequence

$$\mathbf{P}(t) = \mathbf{R}_1(-\varepsilon_0)\mathbf{R}_3(\psi_A)\mathbf{R}_1(\omega_A)\mathbf{R}_3(-\chi_A)\,, \qquad (11)$$

where the obliquity at the basic epoch J2000.0, ε_0, is given by formula (10), and the precession parameters are given by the expressions

$$\psi_A = 5038.47875'' \cdot t - 1.07259'' \cdot t^2 - 0.001147'' \cdot t^3, \tag{12}$$

$$\omega_A = 84381.448'' - 0.02524'' \cdot t + 0.05127'' \cdot t^2 - 0.007726'' \cdot t^3, \tag{13}$$

$$\chi_A = 10.55260'' \cdot t - 2.38064'' \cdot t^2 - 0.001125'' \cdot t^3. \tag{14}$$

Numerical values of coefficients of these polynomials are stored in the attached file **`precession.txt`** (see attachment 11.7).

The argument *t*, used in formulas (12) – (14), is expressed in Julian centuries of Terrestrial Time (TT) elapsed since the basic epoch J2000.0 (2000 January 1d 12h TT):

$$\begin{aligned} t &= \frac{\left(TT - J2000.0(TT)\right) \text{ days}}{36525} \\ &= \frac{JD(TT) - 2451545.0}{36525} \\ &= \frac{MJD(TT) - 51544.5}{36525} \end{aligned} \quad . \tag{15}$$

The time argument of precession and nutation, i.e., in Eqn. (15), is in fact TDB. Without loss of precision TT can be used.

4.2.4 The Nutation Matrix

The nutation model recommended by the IAU 2000 resolutions and [1] is based on a non-rigid Earth model, taking into account effects of mantle anelasticity, ocean tides, electromagnetic couplings between inner core, outer core, and mantle, and includes 662 lunisolar and 658 planetary terms [26]. The nutation matrix is defined in the standard form

$$\mathbf{N}(t) = \mathbf{R}_1(-\varepsilon_A)\mathbf{R}_3(\Delta\psi)\mathbf{R}_1(\varepsilon_A + \Delta\varepsilon), \tag{16}$$

where $\Delta\psi$, $\Delta\varepsilon$ are nutation angles in longitude and obliquity, respectively, represented by the sums of luni-solar and planetary terms

$$\begin{aligned} \Delta\psi &= \Delta\psi^{LS}(t) + \Delta\psi^{Pl}(t), \\ \Delta\varepsilon &= \Delta\varepsilon^{LS}(t) + \Delta\varepsilon^{Pl}(t), \end{aligned} \tag{17}$$

ε_A is mean obliquity of date

$$\varepsilon_A = 84381.448'' - 46.84024'' \cdot t - 0.00059'' \cdot t^2 + 0.001813'' \cdot t^3, \tag{18}$$

and the argument *t* is given by expression (15). Numerical values of coefficients of this polynomial are stored in the attached file **`precession.txt`** (see attachment 11.7).

4.2.4.1 Luni-Solar Nutation

Luni-solar constituents of the nutation angles are given by the trigonometric series

$$\Delta\psi^{LS}(t) = \sum_{k=1}^{662}\left(A_{Sk}\sin\alpha_k(t) + A_{Ck}\cos\alpha_k(t)\right)$$
$$+t\cdot\sum_{k=1}^{38}\left(A'_{Sk}\sin\alpha_k(t) + A'_{Ck}\cos\alpha_k(t)\right), \quad (19)$$

$$\Delta\varepsilon^{LS}(t) = \sum_{k=1}^{662}\left(B_{Sk}\sin\alpha_k(t) + B_{Ck}\cos\alpha_k(t)\right)$$
$$+t\cdot\sum_{k=1}^{38}\left(B'_{Sk}\sin\alpha_k(t) + B'_{Ck}\cos\alpha_k(t)\right), \quad (20)$$

where the arguments $\alpha_k(t)$ of trigonometric functions are linear combinations

$$\alpha_k(t) = \sum_{j=1}^{5} n_{kj}F_j(t) \quad (21)$$

of the fundamental arguments $F_j(t)$ of luni-solar nutation with integer valued coefficients n_{kj}. Numerical values of multipliers n_{kj} and coefficients A_{Sk}, A_{Ck}, B_{Sk}, B_{Ck}, A'_{Sk}, A'_{Ck}, B'_{Sk}, B'_{Ck} are stored in the attached file **`nutation_luso.txt`** (see attachment 11.4).

The fundamental arguments $F_j(t)$ are represented by the polynomials

$$F_1(t) \equiv l = \textit{Mean Anomaly of the Moon}$$
$$= 485868.249036'' + 1717915923.2178''\cdot t + 31.8792''\cdot t^2$$
$$+0.051635''\cdot t^3 - 0.00024470''\cdot t^4 \quad , \quad (22)$$

$$F_2(t) \equiv l' = \textit{Mean Anomaly of the Sun}$$
$$= 1287104.79305'' + 129596581.0481''\cdot t - 0.5532''\cdot t^2$$
$$+0.000136''\cdot t^3 - 0.00001149''\cdot t^4 \quad , \quad (23)$$

$$F_3(t) \equiv F = L - \Omega \quad (L \textit{ is the Mean Longitude of the Moon})$$
$$= 335779.526232'' + 1739527262.8478''\cdot t - 12.7512''\cdot t^2$$
$$-0.001037''\cdot t^3 + 0.00000417''\cdot t^4 \quad , \quad (24)$$

$$F_4(t) \equiv D = \textit{Mean Elongation of the Moon from the Sun}$$
$$= 1072260.70369'' + 1602961601.2090''\cdot t - 6.3706''\cdot t^2$$
$$+0.006593''\cdot t^3 - 0.00003169''\cdot t^4 \quad , \quad (25)$$

$$F_5(t) \equiv \Omega = \text{ Mean Longitude of the Ascending Node of the Moon}$$
$$= 450160.398036'' - 6962890.5431'' \cdot t + 7.4722'' \cdot t^2$$
$$+0.007702'' \cdot t^3 - 0.00005939'' \cdot t^4 \quad . \qquad (26)$$

The argument t in formulas (19), (20) and (22) to (26) is given by expression (15). Numerical values of coefficients of these polynomials are stored also in the attached file **`nutation_luso.txt`** (see attachment 11.4 or in [8]). (Note that the different number of terms with respect to [8] is caused by collecting terms with same multipliers of fundamental arguments into a single term.)

4.2.4.2 Planetary Nutation

Planetary constituents of the nutation angles are given by the trigonometric series

$$\Delta\psi^{Pl}(t) = \sum_{k=1}^{658}\left(C_{Sk} \sin\beta_k(t) + C_{Ck} \cos\beta_k(t)\right), \qquad (27)$$

$$\Delta\varepsilon^{Pl}(t) = \sum_{k=1}^{658}\left(D_{Sk} \sin\beta_k(t) + D_{Ck} \cos\beta_k(t)\right), \qquad (28)$$

where the arguments $\beta_k(t)$ of trigonometric functions are linear combinations

$$\beta_k(t) = \sum_{j=1}^{14} n_{kj} f_j(t) \qquad (29)$$

of the fundamental arguments $f_j(t)$ of planetary nutation with integer valued coefficients n_{kj}. Numerical values of multipliers n_{kj} and coefficients C_{Sk}, C_{Ck}, D_{Sk}, D_{Ck} are stored in the attached file **`nutation_plan.txt`** (see attachment 11.5 or in [8]). (Note that the different number of terms with respect to [8] is caused by collecting terms with the same multipliers of fundamental arguments into a single term.)

The first five arguments on the right-hand side of (29) are nothing else but the fundamental arguments of luni-solar nutation. However, in the original MHB2000 code, simplified expressions are used for these arguments during the computation of the angles $\beta_k(t)$. Thus, we should apply just these simplified expressions instead of (22) – (26) to the computation of planetary nutation. This is why all 14 arguments of planetary nutation are written below:

$$f_1(t) \equiv l = 2.355555980 + 8328.6914269554 \cdot t, \qquad (30)$$

$$f_2(t) \equiv l' = 6.240060130 + 628.3019550000 \cdot t, \qquad (31)$$

$$f_3(t) \equiv F = 1.627905234 + 8433.4661581310 \cdot t, \qquad (32)$$

$$f_4(t) \equiv D = 5.198466741 + 7771.3771468121 \cdot t, \qquad (33)$$

$$f_5(t) \equiv \Omega = 2.182439200 - 33.7570450000 \cdot t\,, \tag{34}$$

$$f_6(t) \equiv l_{Me} = 4.402608842 + 2608.7903141574 \cdot t\,, \tag{35}$$

$$f_7(t) \equiv l_{Ve} = 3.176146697 + 1021.3285546211 \cdot t\,, \tag{36}$$

$$f_8(t) \equiv l_E = 1.753470314 + 628.3075849991 \cdot t\,, \tag{37}$$

$$f_9(t) \equiv l_{Ma} = 6.203480913 + 334.0612426700 \cdot t\,, \tag{38}$$

$$f_{10}(t) \equiv l_{Ju} = 0.599546497 + 52.9690962641 \cdot t\,, \tag{39}$$

$$f_{11}(t) \equiv l_{Sa} = 0.874016757 + 21.3299104960 \cdot t\,, \tag{40}$$

$$f_{12}(t) \equiv l_{Ur} = 5.481293871 + 7.4781598567 \cdot t\,, \tag{41}$$

$$f_{13}(t) \equiv l_{Ne} = 5.321159000 + 3.8127774000 \cdot t\,, \tag{42}$$

$$f_{14}(t) \equiv p_a = 0.0243817500 \cdot t + 0.00000538691 \cdot t^2\,. \tag{43}$$

Coefficients of these polynomials are expressed in radians, and the argument t is given by expression (15). Numerical values of coefficients of the polynomials are stored also in the attached file **`nutation_plan.txt`** (see attachment 11.5).

4.2.5 The Earth Rotation Matrix

The Earth rotation matrix is

$$\mathbf{S}(t) = \mathbf{R}_3(-GST)\,. \tag{44}$$

GST is Greenwich Sidereal Time given by the expression

$$GST = \theta(T_U) + p(t) + \Delta\psi \cos\varepsilon_A + q(t) \tag{45}$$

where $\theta(T_U)$ is the Earth rotation angle, $p(t)$ is the polynomial part of *GST*, $\Delta\psi$ is nutation in longitude, ε_A is obliquity of date given by expression (18), $q(t)$ is the non-polynomial part of GST. Obviously, the sum of the first two terms on the right-hand side of formula (45) can be considered as Greenwich Mean Sidereal Time (GMST):

$$GMST = \theta(T_U) + p(t)\,, \tag{46}$$

and the well-known relationship between GST and GMST is still valid

$$GST = GMST + \Delta\psi \cos\varepsilon_A + q(t)\,. \tag{47}$$

4.2.5.1 The Earth Rotation Angle

The Earth rotation angle, $\theta(T_U)$, is represented by the first-order polynomial of *UT1*:

$$\theta(T_U) = 2\pi(0.7790572732640 + 1.00273781191135448 \cdot T_U)\,. \tag{48}$$

The coefficients in parenthesis are given in cycles. Their numerical values are stored in the attached file **`sidereal_time.txt`** (see attachment 11.8).

The argument T_U of the polynomial (48) is defined in days elapsed since the basic epoch J2000.0 in time scale *UT1*:

$$T_U = JD(UT1) - 2451545.0\,. \tag{49}$$

Here

$$\begin{aligned} UT1 &= UTC + (UT1 - UTC) \\ &= TAI + (UTC - TAI) + (UT1 - UTC) \\ &= TT + (TAI - TT) + (UTC - TAI) + (UT1 - UTC)\,. \end{aligned} \tag{50}$$

The difference (*TAI – TT*) is defined as

$$TAI - TT = -32.184^s\,. \tag{51}$$

Information on the difference (*UTC – TAI*) is published by the IERS in the Bulletin C. From 2006 January 1, 0h UTC up to now (status of July 2008) the difference is:

$$UTC - TAI = -33^s\,, \tag{52}$$

The instantaneous value of the difference (*UT1-UTC*) can be obtained, after interpolation of the daily EOP 05 C04 series published by the IERS [13], by applying the additional component to account for the effect of ocean tides with periods less than two days:

$$(UT1 - UTC)_t = (UT1 - UTC)_t^{IERS} + \Delta UT1_{tidal}(t)\,. \tag{53}$$

With (50) and (53), one can write the argument T_U of the Earth rotation angle in the form

$$T_U = T_U' + \frac{\Delta UT1_{tidal}(t)}{86400}\,, \tag{54}$$

where

$$T_U' = JD(TT) - 2451545.0 + \frac{(UT1 - UTC)_t^{IERS} + (UTC - TAI) + (TAI - TT)}{86400}\,. \tag{55}$$

The second term on the right-hand side of expression (53), tidal correction of *UT1*, includes 41 diurnal and 30 semidiurnal tidal constituents in the form:

$$\Delta UT1_{tidal}(t) = \sum_{k=1}^{71}\left(U_{Sk}^{tidal}\sin\xi_k(t) + U_{Ck}^{tidal}\cos\xi_k(t)\right). \tag{56}$$

The arguments $\xi_k(t)$ of trigonometric functions are linear combinations

$$\xi_k(t) = \sum_{j=1}^{5} n_{kj} F_j(t) + n_{k6}\chi(t_u) \tag{57}$$

with integer valued coefficients n_{kj}. Numerical values of multipliers n_{kj} and coefficients U_{Sk}^{tidal}, U_{Ck}^{tidal} are stored in the attached file **`eop_corr_tidal.txt`** (see attachment 11.1, table 8.3 in [1] or [16]).

The fundamental arguments $F_j(t)$ of luni-solar nutation are given by expressions (22) to (26). The last function in (57), $\chi(t_u)$, is GMST + π as it is used traditionally in tidal expansions. Unfortunately, we cannot apply formula (46) for the computation of $\chi(t_u)$ because the numerical values of the coefficients in (56) are determined with the expression for GMST from the IAU Resolutions 1979 (see [35]). Therefore

$$\begin{aligned}\chi(t_u) &= 110510.54841^s + \left(3600 \cdot 876600^s + 8640184.812866^s\right) \cdot t_u \\ &\quad + 0.093104^s \cdot t_u^2 - 0.0000062^s \cdot t_u^3 \end{aligned}, \tag{58}$$

where

$$t_u = \frac{T_U'}{36525}, \tag{59}$$

and T_U' is defined by expression (55). Numerical values of coefficients of polynomial (58) are stored in the attached file **`eop_corr_tidal.txt`** (see attachment 11.1).

4.2.5.2 The Polynomial Part of GST

The function $p(t)$ in the expression for GST, (45), is the polynomial of Terrestrial Time *TT*:

$$\begin{aligned} p(t) &= 0.014506'' + 4612.15739966'' \cdot t + 1.39667721'' \cdot t^2 \\ &\quad - 0.00009344'' \cdot t^3 + 0.00001882'' \cdot t^4 . \end{aligned} \tag{60}$$

The argument t is given by expression (15). Numerical values of coefficients of polynomial (60) are stored in the attached file **`sidereal_time.txt`** (see attachment 11.8).

4.2.5.3 The Non-Polynomial Part of GST

The last term in the right-hand side of (45) is expressed by the trigonometric series

$$\begin{aligned} q(t) &= \sum_{k=1}^{33} \left(E_{Sk} \sin\gamma_k(t) + E_{Ck} \cos\gamma_k(t) \right) \\ &\quad + t \cdot \left(E_{S1}' \sin\gamma_1(t) + E_{C1}' \cos\gamma_1(t) \right), \end{aligned} \tag{61}$$

where time t is given by expression (15). The arguments $\gamma_k(t)$ of trigonometric functions on the right-hand side of (61) are linear combinations

$$\gamma_k(t) = \sum_{j=1}^{5} n_{kj} F_j(t) + \sum_{j=6}^{14} n_{kj} f_j(t) \tag{62}$$

of the fundamental arguments of luni-solar and planetary nutation with integer valued coefficients n_{kj}. The fundamental arguments $F_j(t)$ are given by expressions (22) – (26) whereas the arguments $f_j(t)$ (j = 6,…,14) are given by expressions (35) – (43). Numerical values of multipliers n_{kj} and coefficients E_{Sk}, E_{Ck}, E'_{Sk}, E'_{Ck} are stored in the attached file **`sidereal_time.txt`** (see attachment 11.8).

4.2.6 Tidal Variation in Earth's Rotation and Interpolation of UT1

The computation of instantaneous values of the difference ($UT1$-UTC) in the formula (53) requires an interpolation of the daily EOP 05 C04 series published by the IERS [13]. To be consistent with the techniques applied to derive these combined series, the long-periodic zonal tides have to be first subtracted from the values $(UT1-UTC)_{node}^{IERS}$ at interpolation nodes:

$$(UT1_{Red} - UTC)_{node}^{IERS} = (UT1-UTC)_{node}^{IERS} - \delta UT1_{zonal}(t_{node}) \tag{63}$$

and then added to the interpolated values $(UT1_{Red} - UTC)_{t}^{IERS}$:

$$(UT1-UTC)_{t}^{IERS} = (UT1_{Red} - UTC)_{t}^{IERS} + \delta UT1_{zonal}(t) \tag{64}$$

With this expression (53) becomes

$$(UT1-UTC)_t = (UT1_{Red} - UTC)_{t}^{IERS} + \delta UT1_{zonal}(t) + \Delta UT1_{tidal}(t) \tag{65}$$

The tidal variation $\delta UT1_{zonal}(t)$ includes 62 constituents of periods longer than 5 days in the form:

$$\delta UT1_{zonal}(t) = \sum_{k=1}^{62} \left(U_{Sk}^{zonal} \sin \eta_k(t) + U_{Ck}^{zonal} \cos \eta_k(t) \right) \tag{66}$$

The arguments $\eta_k(t)$ of trigonometric functions are linear combinations

$$\eta_k(t) = \sum_{j=1}^{5} n_{kj} F_j(t) \tag{67}$$

with integer valued coefficients n_{kj}. Numerical values of multipliers n_{kj} and coefficients U_{Sk}^{zonal}, U_{Ck}^{zonal} are stored in the attached file **ut1_zonal.txt** (see attachment 11.9 or table 8.1 in [1]). The fundamental arguments $F_j(t)$ of luni-solar nutation are given by expressions (22) to (26).

4.2.7 The Polar Motion Matrix

The polar motion matrix is defined in the form

$$\mathbf{W}(t) = \mathbf{R}_3(-s')\mathbf{R}_2(x_p)\mathbf{R}_1(y_p), \qquad (68)$$

where s' is the position of the Terrestrial Ephemeris Origin (TEO) on the equator of the Celestial Intermediate Pole (CIP). This quantity can be computed as

$$s' = -0.000047'' \cdot t \qquad (69)$$

with t given by expression (15). The numerical value of the coefficient on the right-hand side of (69) is stored in the attached file **sidereal_time.txt** (see attachment 11.8).

The polar coordinates, x_p and y_p, are the coordinates of the CIP in the Terrestrial Reference System (TRS). After interpolation of daily series EOP 05 C04 published by the IERS [13], instantaneous values of (x_p, y_p) can be obtained by applying two additional components to account for the effects of ocean tides and for nutation terms with periods less than two days:

$$\begin{pmatrix} x_p \\ y_p \end{pmatrix}_t = \begin{pmatrix} x_{IERS} \\ y_{IERS} \end{pmatrix}_t + \begin{pmatrix} \Delta x_{tidal}(t) \\ \Delta y_{tidal}(t) \end{pmatrix} + \begin{pmatrix} \Delta x_{nutation}(t) \\ \Delta y_{nutation}(t) \end{pmatrix}. \qquad (70)$$

4.2.7.1 Tidal Corrections of Pole Coordinates

Tidal corrections for pole coordinates include 41 diurnal and 30 semidiurnal tidal constituents in the form:

$$\Delta x_{tidal}(t) = \sum_{k=1}^{71} \left(X_{Sk}^{tidal} \sin \xi_k(t) + X_{Ck}^{tidal} \cos \xi_k(t) \right), \qquad (71)$$

$$\Delta y_{tidal}(t) = \sum_{k=1}^{71} \left(Y_{Sk}^{tidal} \sin \xi_k(t) + Y_{Ck}^{tidal} \cos \xi_k(t) \right). \qquad (72)$$

The tidal constituents are exactly the same as for the correction of *UT1* (56). Thus, the argument $\xi_k(t)$ of trigonometric functions in (71), (72) is given by expression (57). Numerical values of coefficients X_{Sk}^{tidal}, X_{Ck}^{tidal}, Y_{Sk}^{tidal}, Y_{Ck}^{tidal} are stored in the attached file **eop_corr_tidal.txt** (see attachment 11.1, Table 8.2 in [1] or [16]).

4.2.7.2 Nutational Corrections of Pole Coordinates

Nutational corrections for pole coordinates include 10 diurnal and subdiurnal constituents in the form:

$$\Delta x_{nutation}(t) = \sum_{k=1}^{10} \left(X_{Sk}^{nutation} \sin \zeta_k(t) + X_{Ck}^{nutation} \cos \zeta_k(t) \right), \tag{73}$$

$$\Delta y_{nutation}(t) = \sum_{k=1}^{10} \left(Y_{Sk}^{nutation} \sin \zeta_k(t) + Y_{Ck}^{nutation} \cos \zeta_k(t) \right). \tag{74}$$

The arguments $\zeta_k(t)$ of trigonometric functions are linear combinations

$$\zeta_k(t) = \sum_{j=1}^{5} n_{kj} F_j(t) + n_{k6} \chi(t_u) \tag{75}$$

with integer valued coefficients n_{kj}. The fundamental arguments $F_j(t)$ of luni-solar nutation are given by expressions (22) – (26). The function $\chi(t_u)$ is given by expression (58). Numerical values of multipliers n_{kj} and coefficients $X_{Sk}^{nutation}$, $X_{Ck}^{nutation}$, $Y_{Sk}^{nutation}$, $Y_{Ck}^{nutation}$ are stored in the attached file **`pole_corr_nutational.txt`** (see attachment 11.6, second part of table 5.1 in [1] or [16]).

4.2.8 C04 Series and Interpolation

Pole coordinates of polar motion, UT1-UTC, LOD, and celestial pole offsets used within HPF are obtained from the IERS Earth orientation parameter series EOP 08 C04, which is provided consistent to IAU2000 nutation and available at [13]. The series is a result from the combination of measured EOP series by different techniques and is updated several times a week. Values are given in daily intervals and are slightly smoothed.

With each new input data set included by the IERS, the EOP 08 C04 series may be updated also for earlier epochs. The EOP values for the last epochs may still change significantly with each update of the series and converge to stable values within about 30 days. In order to have a stable EOP 08 C04 series available within HPF the following procedure is applied to construct the internal product:

1. The EOP 08 C04 series is downloaded from [13] whenever IERS updated the series.
2. The most up-to-date 30 daily values are removed from the file.
3. Remaining new values in this truncated file are appended to the HPF-internal EOP 08 C04 file.

Since 1 December 2011, the EOP C04 series are delivered every day with a 30-day latency and only final definitive values are included [13a]. Therefore only the latest record of an updated IERS series is appended to the HPF-internal EOP C04 file since that time.

With this update procedure each entry included in the HPF-internal C04 series keeps its value for all time thus defining a stable time series. The resulting EOP series shows an RMS scatter as compared to the C04 series available a few months later of about 15 µas in x_p and y_p pole, of 10 μsec in UT1-UTC, and of 40 μas in δX and δY pole offsets. The typical scatter for the last entries in the IERS C04 series is of the order of 100 μas, 40 μsec, and 600 μas, respectively.

Because the EOP 08 C04 series provides daily values interpolation to the actual epoch is required for celestial pole offsets δX and δY (section 4.2.2), UT1-UTC (section 4.2.5) and pole coordinates x_p and y_p (section 4.2.7). The exact procedure used for interpolation is not critical (as long as a reduced value for UT1 is interpolated as described in section 4.2.6) because interpolation errors are of the order of 50μas for pole coordinates, 140μas for $UT1_{red}$ and 20μas for celestial pole offsets and below the masurement noise of EOP parameters. For the rotation matrices provided with the PSO Lagrange interpolation is used (see [16])

4.2.9 Comparison with the IERS Transformation Matrices

The above described transformation from the ITRS to the ICRS is implemented in the HPF software. At different stages of the implementation, results for particular components of the transformation (1) have been compared with those, provided by the software mentioned in References. All comparisons demonstrated differences at the level of 10^{-15}, which is in a good agreement with the REAL*8 accuracy.

Final comparison was performed for the complete terrestrial-to-celestial matrix (see appendix 11.3). The standard set of the transformation matrices was generated by means of the IERS interactive tool in the interval from 2002 December 1, 23h 59m 57s UTC to 2002 December 4, 23h 59m 57s UTC with a step size of 1h. This interactive tool

- does not apply nutational corrections (73), (74) of pole coordinates,
- uses linear interpolation for pole coordinates and UT1, and probably, for the VLBI determined celestial pole offsets δX , δY (section 4.2.2) as well (since summer 2005 cubic spline interpolation is used).

Besides, it is not mentioned explicitly, what approach (CEO-based or equinox-based) is implemented in the interactive tool. Therefore, in our computations performed for the comparison

- nutational corrections (73), (74) were not introduced into pole coordinates,
- linear interpolation was used for pole coordinates, UT1, and the celestial pole offsets.

The IERS EOP 05 C 04 daily series of the Earth Orientation Parameters [13] were taken from the file **`eopc04_IAU2000.62-now`**, available at the IERS Web site (http://hpiers.obspm.fr/eoppc/eop/eopc04_05/eopc04_IAU2000.62-now)

The comparison results are shown in Figure 4-2 in terms of individual elements of the deviation from the IERS transformation matrix

$$\Delta\mathbf{Q}(t) = \mathbf{Q}_{HPF}(t) - \mathbf{Q}_{IERS}(t)\,, \tag{76}$$

and in terms of the Euclidean norm of the non-orthogonality

$$\|\delta \mathbf{Q}\|_2(t) = \sqrt{\sum_{k=1}^{3}\sum_{l=1}^{3}\delta Q_{kl}^{\;2}(t)}, \qquad \delta \mathbf{Q}(t) = \mathbf{Q}_{IERS}^{\mathrm{T}}(t)\mathbf{Q}_{HPF}(t) - \mathbf{I}\,. \tag{77}$$

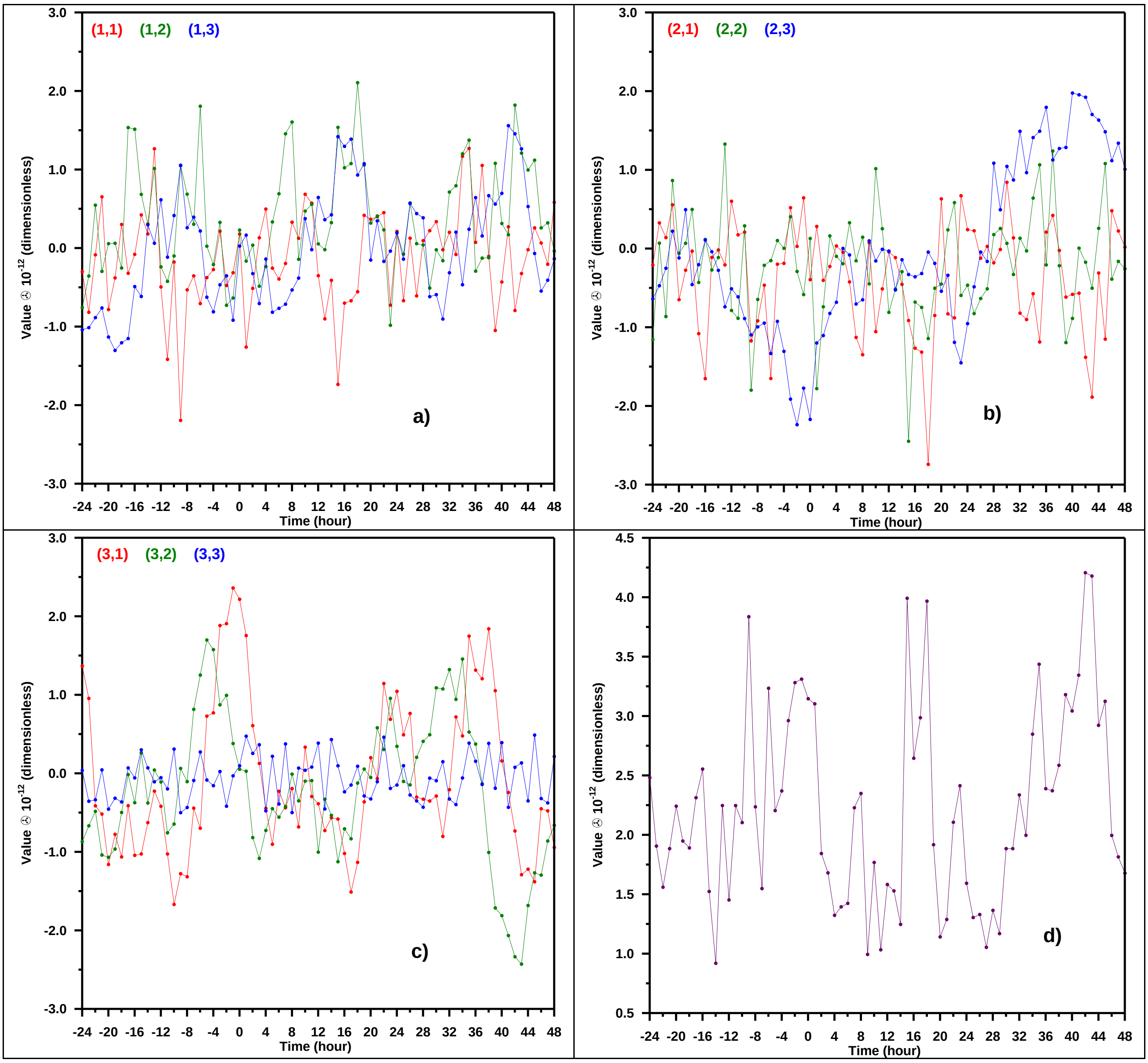

Figure 4-2: Comparison of the transformation matrix with that provided by the IERS Interactive tool:
a), b), c) – elements of the difference matrix (76);
d) – Euclidean norm (77) of the non-orthogonality;
Time is counted from 2002 December 2, 23h 59m 57s UTC.

Maximal deviations from the IERS results do not exceed 4.5×10^{-12} (Figure 4-2d). This estimation corresponds to a displacement of 0.03 mm in a point position at GOCE altitude, or to the uncertainty of 0.9 microarcseconds in the frame rotation. It seems to be in a good agreement with the overall precision of the models used for the transformation.

Thus, at this moment the above described procedure together with the numerical values provided in the attachments is recommended for the GOCE HPF.

5. Geometrical Models

5.1 Propagation Models

Tropospheric Refraction

Marini and Murray model is adopted for Laser data processing. The model includes the zenith delay determination and the mapping function, to project the zenith delay to a given elevation angle, in a non-explicit form.

Global Mapping Function (GMF) [32] for GPS with estimation of zenith delay is adopted. The mapping function is based on numerical weather model data.
For applications that do not require highest precision, Niell mapping function can be used instead. This model is valid to 3° elevation. The mapping function is based on global climatology (independent of surface meteorology) and requires only input of time and location.

Ionospheric Refraction

First order effects are removed by analysis of the ionosphere-free linear combination of the two frequencies of GPS observations. Higher order effects are ignored.

Relativistic Corrections

Propagation delay shall be applied for SLR and GPS observations according to the details described in [1], Section 11.2. GPS periodic relativistic clock corrections shall be corrected according to the ICD-GPS 200C [30].

Phase Windup

The phase windup, caused by the varying relative orientation of emitting and receiving antenna in conjunction with the circularly polarized GPS microwave radiation, is taken into account as described in [27].

5.2 Site Displacement

Station Coordinates and Velocities

They are taken from ITRF2008. For the SLR stations the rescaled realization for the ILRS is used

Ocean Loading

The site displacement due to ocean loading shall be computed according to [1], chapter 7.1.1. The most recent altimetric and hydrodynamic tide models are available from the automatic loading service (see [1], Table 7.2). The tide model for computing ocean loading site displacements applied for GOCE is FES2004.

Solid Earth Tides

The site displacement due to solid Earth tides shall be computed according to [1], chapter 7.1.2. The solid Earth tides shall be considered up to third degree spherical harmonics. The numerical values of the Love numbers depend on the latitude (due to ellipticity and rotation of the Earth) and on the frequency (due to the nearly diurnal free wobble). The anelasticity is considered. The permanent tide deformation is not removed in order to guarantee consistency with conventionally tide-free ITRF coordinates.

Rotational Deformation due to Polar Motion

IERS Conventions 2003 [1] (section 7.1.4, page 83) are applied including the conventional linear model for the motion of the mean pole [1] (section 7.1.4, equation 23). The maximum radial displacement is approximately 25 mm, and the maximum horizontal displacement is about 7 mm. Therefore, the effect has to be taken into account during GOCE data processing.

Atmospheric Loading

The IERS Special Bureau for Loading [18] has published the general form for S1 atmospheric pressure thermal tides:

$$P(\varphi,t) = P_{max}\cos^3\varphi\cdot\sin(t+12^o) \tag{78}$$

where P_{max} is the maximum loading amplitude at the equator, φ is the latitude, and the longitudinal variation depends on the time of day, t, with a phase offset of 12°. Assuming a non-inverted barometer ocean Earth model, P_{max} is estimated to be approximately -0.8 mm for the S1 tide and about -1.5 mm for S2. In view of these estimations, it is not necessary to account for the atmospheric loading effect during GOCE data processing.

Postglacial Rebound

Implicitly accounted for by ITRF velocities.

Geocenter Variations

All orbit positions and velocities contained in GOCE products are provided in the ITRF terrestrial reference frame (centre of network). In order to obtain coordinates in the centre of mass frame, a geocenter correction has to be applied.

5.3 Geometric Corrections

Geometric GPS Corrections

Antenna related geometric corrections for GPS observations shall be applied. These include antenna phase centre offset and phase centre pattern corrections. The latter includes zenith/nadir dependency and, where available, azimuth dependency of the phase pattern.

- For the SSTI the antenna characteristics are provided by the Agency (see: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/goce => GOCE SSTI-A ANTEX). Measured attitude information is used to orient the antenna.
- For GPS ground stations and GPS satellites the antenna characteristics are taken from the IGS (absolute phase centre offsets and patterns, see http://igscb.jpl.nasa.gov).

5.4 Summary of Geometrical Models

Table 5-1 summarizes the reference systems to be applied in GOCE level 2 data processing.

Table 5-1: Summary of Geometric Models used for GOCE Data Processing

Effect	Model
Tropospheric Refraction	• Marini & Murray for SLR • Global mapping function for GPS .
Ionospheric Refraction	• GPS dual frequency • Second and higher order ignored
Relativistic Corrections	• SLR: IERS Conventions 2003 • GPS observations and clock corrections: IERS Conventions 2003
Phase Windup	• According to [27]
Station Positions	• ITRF2008
Station Velocities	• ITRF2008
Ocean Loading	• According to IERS Conventions 2003 • Tide Model: FES2004
Solid Earth Tides	• According to IERS Conventions 2003 • Anelastic Earth Model • Permanent Tide Deformation not removed • Lunar and Solar Ephemerides from JPL LE405, DE405
Rotational Deformation due to Polar Motion	• IERS2003, linear model of mean pole
Atmospheric Loading	• Not applied
Postglacial Rebound	• Implicitly considered with ITRF velocities
Geocenter Variations	• Not applied
Geometric GPS Correction	For GOCE SSTI, GPS satellites and GPS ground stations: • Antenna Phase Center Offset Correction • Zenith/Nadir and Azimuth Dependency of Phase Center Corrections

6. Dynamic Models

6.1 Gravitational Field

Mean Geopotential

The a-priori static gravity field models applied for the GOCE level 2 data processing are the EIGEN-05S and EIGEN-05C models [36]. The EIGEN-05S model is solely based on satellite data from GRACE and LAGEOS, while for the EIGEN-05C combined model surface gravity as well as altimeter data have been incorporated, in addition. The satellite-only model is complete to degree and order 150, while the combined solution contains all spherical harmonic coefficients up to degree and order 360. Both models and information about references can be downloaded from the Web-site of the IAG International Center for Global Earth Models (ICGEM) (see: http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html).

Table 6-1 gives a summary of the parameters of the EIGEN-05S/C mean geopotential fields.

Table 6-1: Summary of Parameters of mean Geopotential

Parameter	Value	Remark
GM_{Earth}	$3.986004415 \cdot 10^{14}\left[m^3/s^2\right]$	including Mass of the Atmosphere
a_e	6378136.46[m]	in Tide-free System
$\bar{C}_{n,m}, \bar{S}_{n,m}$	See files	Spherical Harmonic Coefficients of degree n and order m up to Degree 150 for EIGEN-05S and Degree 360 for EIGEN-05C, respectively.

Direct Tides of Sun, Moon and Planets

The perturbations due to Sun, Moon and all planets are directly computed as accelerations acting on the spacecraft. The direct effects of the objects on the satellite are evaluated using point-mass attraction formulas. The indirect effects due to the acceleration of the Earth's center of mass by the planets are also modelled as point-mass interactions.

For the Sun and Moon, the indirect effects include, in addition, the interaction between a point-mass perturbing object and an oblate Earth – the so-called indirect J_2 effect:

$$\left.\begin{matrix}\delta\ddot{x}\\ \delta\ddot{y}\\ \delta\ddot{z}\end{matrix}\right\} = -\frac{3\sqrt{5}}{2}\bar{C}_{20}\sum_{j=1}^{2}\frac{GM_j}{r_j^3}\left(\frac{a}{r_j}\right)^2\left\{\begin{matrix}\left[5\left(\frac{z_j}{r_j}\right)^2-1\right]x_j\\ \left[5\left(\frac{z_j}{r_j}\right)^2-1\right]y_j\\ \left[5\left(\frac{z_j}{r_j}\right)^2-3\right]z_j\end{matrix}\right. \tag{79}$$

where $\bar{C}_{20}$ is the fully normalized second zonal harmonic coefficient of the Earth's gravity model; a is the semimajor axis of the Earth's ellipsoid; index j indicates the Moon (j = 1) or the Sun (j = 2); GM_j is the product of the universal gravitational constant G times the mass of j-th body; (x_j, y_j, z_j) are Earth-centered coordinates of the j-th body and $r_j = \sqrt{x_j^2 + y_j^2 + z_j^2}$.

Table 6-2: Summary of direct Tides

Effect	Model
Third-body Perturbation (direct tides)	• For SSTI: Direct & indirect Terms of Point-mass 3rd Body Perturbations • For SGG: Correction of Gravity Gradients
Indirect J_2 Effect	• Sun and Moon only
Planetary Ephemerides	• JPL DE405 and LE405

Solid Earth Tides

The changes induced by the solid Earth tides are modelled as variations of the geopotential coefficients. The contributions of these variations to the geopotential coefficients are expressible in terms of the k Love number. The effects of ellipticity and of the Coriolis force due to Earth rotation on tidal deformations requires the use of three k parameters to characterize the changes produced by tides of spherical harmonic degree (n and m). For degree 2 only two parameters are needed due to mass conservation. The effect of the anelasticity of the Earth is included.

The solid Earth tidal contribution to the geopotential is computed as described in [1]. Corrections to specific harmonic coefficients are computed and added to the mean field coefficients. For the gravity gradients the correction is computed directly and provided in the gradient products.

Table 6-3: Solid Earth Tide Geopotential to be used in dynamic Model

Effect	Model
Solid Earth Tide Perturbation	• For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Planetary Ephemerides	• JPL DE405 and LE405
Frequency Independent Terms	• Contributions from Degree 2 to Degree 4 Tides; IERS Conventions 2003 • External Potential Love Numbers: IERS Conventions 2003 • Anelastic Contributions: IERS Conventions 2003
Frequency Dependent Terms	• Tidal Corrections to $C_{2,0}$ - $C_{2,1}$ - $S_{2,1}$ - $C_{2,2}$ - $S_{2,2}$ for 21 long-period, 48 diurnal and 2 semi-diurnal tides used: See GRACE Standards [5] • Anelastic Contributions: IERS Conventions 2003
Permanent Tide in $C_{2,0}$	• -4.201E-9; In IERS Conventions 2003 it is included in the solid Earth Tide Contribution and is implicitly removed from the mean $C_{2,0}$ Value (see also sub-chapter on permanent tides below. The value adopted correspond to the difference between the zero tide and tide free systems).

Permanent Tide

Tides of sun and moon are composed of a time variable and a time invariant component. The time invariant component has a permanent influence on the gravitational potential of the Earth, whil the time variable part is taken account via models (see other items in this chapter). This effect is denoted as permanent tide. Depending on the strategy of the permanent tide correction as it is applied in gravity field determination we distinguish between three types of systems:

1. The mean tide system (MT): This system represents the Earth gravity field with presence of direct and indirect components of permanent tides. In other words, this is the system, which implicitely is adopted when observing gravity field quantities.
2. The zero tide system (ZT): This system represents an Earth gravity field without the presence of direct permanent tidal effects, but with the indirect permanent deformation of the Earth due to the permanent tides.
3. The tide free system (TF): This system represents an Earth gravity field without presence of sun and moon, i.e. without the effect of permanent tides.

The impact of permanent tides is latitude dependent, because sun and moon are moving fairly close to the equator [40]. This implies that only zonal terms of the gravity potential spherical harmonic series are affected. Traditionaly, only the second degree zonal coefficient is regarded for the conversion between the three tide systems. The following formulas are applied for conversion (see [1],[20] and [40]):

$$\begin{aligned} \bar{C}_{20}^{MT} - \bar{C}_{20}^{ZT} &= \left\langle \Delta\bar{C}_{20} \right\rangle \\ \bar{C}_{20}^{ZT} - \bar{C}_{20}^{TF} &= k_{20} \cdot \left\langle \Delta\bar{C}_{20} \right\rangle \\ \bar{C}_{20}^{MT} - \bar{C}_{20}^{TF} &= \left(1 + k_{20}\right) \cdot \left\langle \Delta\bar{C}_{20} \right\rangle \end{aligned} \quad (80)$$

where:

$\langle \Delta\bar{C}_{20} \rangle = -1.391412 \cdot 10^{-8}$

average value of the second degree zonal tidal correction for sun and moon [1].

$k_{20} = 0.30190$

loading Love number for second degree zonal coefficient [1].

In order to convert gravity observations (g in m/s^2) or geoid heights (N in m) between the tide systems the formulas and constants derived by Ekman can be applied [40]:

$$\begin{aligned} g^{MT} - g^{ZT} &= \left(-30.4 + 91.2 \sin^2\varphi\right)\cdot 10^{-8} \\ g^{ZT} - g^{TF} &= 0.16\cdot\left(-30.4 + 91.2 \sin^2\varphi\right)\cdot 10^{-8} \\ g^{MT} - g^{TF} &= 1.16\cdot\left(-30.4 + 91.2 \sin^2\varphi\right)\cdot 10^{-8} \end{aligned} \tag{81}$$

$$\begin{aligned} N^{MT} - N^{ZT} &= \left(9.9 - 29.6 \sin^2\varphi\right)\cdot 10^{-2} \\ N^{ZT} - N^{TF} &= k_{20}\left(9.9 - 29.6 \sin^2\varphi\right)\cdot 10^{-2} \\ N^{MT} - N^{TF} &= \left(1 + k_{20}\right)\left(9.9 - 29.6 \sin^2\varphi\right)\cdot 10^{-2} \end{aligned} \tag{82}$$

Note: When computing the disturbing potential by subtracting the ellipsoidal potential from the gravity potential both have to be in the same tide system in order to generate a tide free disturbing potential.

Solid Earth Pole Tide

The pole tide is generated by the centrifugal effect of polar motion. The deformation which constitutes this tide produces a perturbation in the external potential, which is equivalent to changes in the geopotential coefficients $C_{2,1}$ and $S_{2,1}$.

Pole Tide in an Earth fixed Reference Frame (for an object attached to the Earth)

In the Earth-fixed frame the pole tide potential becomes $(1+k_2)U_c$ (where U_c is the change in centrifugal potential due to polar motion):.

$$\left(\Delta\bar{C}_{21} - i\Delta\bar{S}_{21}\right) = -\left(1 + k_{20}\right)\frac{R^3\omega^2}{\sqrt{15}\cdot GM}\cdot\frac{\pi}{648000}\left(m_1 - i m_2\right) \tag{83}$$

where k_{20} is the elastic Love number, ω is the Earth's mean rotation rate; R is the Earth's equatorial radius and GM is the product of the universal gravitational constant G times the Earth's mass (without atmosphere). The value of the complex valued Love number k_{20} in accordance with [1] is

$$k_{20} = 0.3077 + i \cdot 0.0036 \tag{84}$$

and quantities m_1, m_2 are connected with pole coordinates by the relationships [1]:

$$\begin{aligned} m_1 &= x_p - \bar{x}_p \\ m_2 &= -(y_p - \bar{y}_p) \end{aligned} \tag{85}$$

where (x_p, y_p) are coordinates of instantaneous pole (70), and $(\bar{x}_p, \bar{y}_p)$ are coordinates of mean pole computed in accordance with the linear model proposed in [1], Chapter 7. All constituents on the right-hand side of (85) are expressed in arcseconds.

Inserting (84) in (83) yields:

$$\begin{aligned} \Delta\bar{C}_{21} - i\Delta\bar{S}_{21} &= -\frac{R^3\omega^2}{\sqrt{15}\cdot GM}\cdot\frac{\pi}{648000}\left(m_1 - i\,m_2\right)\left(1.3077 + i\,0.0036\right) = \\ &= -\frac{R^3\omega^2}{\sqrt{15}\cdot GM}\cdot\frac{\pi}{648000}\left(\left[1.3077 m_1 + 0.0036 m_2\right] - i\left[1.3077\ m_2 - 0.0036\ m_1\right]\right) \end{aligned} \tag{86}$$

and after inserting constants defined in chapter 2 we get the final equations for the solid Earth pole tide in the Earth fixed frame.

$$\begin{Bmatrix} \Delta\bar{C}_{21} \\ \Delta\bar{S}_{21} \end{Bmatrix} = -5.6662 \cdot 10^{-9} \begin{Bmatrix} m_1 + 0.00275 m_2 \\ m_2 - 0.00275 m_1 \end{Bmatrix} \tag{87}$$

Pole Tide in an Earth fixed Reference Frame (for an object not attached to the Earth)

We assume that the observer is not attached to the Earth surface; a consequence is that the centrifugal potential is not sensed by the observer. In this case the pole tide spherical harmonic coefficients are:

$$\left(\Delta\bar{C}_{21} - i\Delta\bar{S}_{21}\right) = -k_{20}\frac{R^3\omega^2}{\sqrt{15}\cdot GM}\cdot\frac{\pi}{648000}\left(m_1 - i m_2\right) \tag{88}$$

With the same conventions and specifications as before we get the final equations for the solid Earth pole tide.

$$\begin{Bmatrix} \Delta\bar{C}_{21} \\ \Delta\bar{S}_{21} \end{Bmatrix} = -1.333 \cdot 10^{-9} \begin{Bmatrix} m_1 + 0.0115 m_2 \\ m_2 - 0.0115 m_1 \end{Bmatrix} \tag{89}$$

Table 6-4: Solid Earth Pole Tide for dynamic Model

Effect	Model
Anelastic Earth Model Contribution to $C_{2,1}$ and $S_{2,1}$	• Scaled Difference between Epoch Pole Position and mean Pole. • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients (included in solid Earth Tide)
Polar Motion	• IERS Standard Product: Daily Earth Rotation Parameters C04
Constant Parameters	• Love Number: k_{20}=0.3077+0.0036i; IERS Conventions 2003 [1]

Ocean Tides

The dynamical effects of ocean tides are most easily incorporated by periodic variations in the normalized Stokes coefficients. The coefficients are determined by a spherical harmonic decomposition of the ocean tide height for the ocean tide due to the constituents of the tide generating potential. For each constituent in the diurnal and semi-diurnal tidal bands, these coefficients are obtained from the ocean tide model to be selected for GOCE. The ocean tide model to be applied for GOCE is FES2004 [37].

Table 6-5: Ocean Tide Model for dynamic Model

Effect	Model
Ocean Tide Model	• FES2004 [37] • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Tidal Amplitudes and Phase Convention	• Doodson • Schwiderski
Tidal Harmonics Selection	• Complete to degree and order 100 for all FES2004 constituents.

General Relativistic Perturbations

The general relativistic contributions to the accelerations are computed as specified in [1] (chapter 10).

Atmosphere and Ocean Variability

Global atmospheric parameters and an ocean model are used to eliminate the short-term mass variations of the atmosphere-ocean system. These mass variations are expressed in terms of corrections to the spherical harmonic coefficients of the mean geopotential. The variations have to be referenced to a long time mean field. For GOCE a mean value for the years 2004 to 2007 is chosen.

Table 6-6: Atmosphere and Ocean Variability for dynamic Model

Effect	Model
Atmosphere and Ocean De-Aliasing	• 6 hourly Spherical Harmonic Coefficients as Corrections to the mean Geopotential. • Interpolation to Observation Epoch by linear Interpolation between 6 hourly Epochs of Correction Coefficients • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Atmosphere	• Based on ECMWF Operational Analysis Output • Referenced to Multi Year Mean Atmosphere (for the years 2004 to 2007) • Vertical Integration
Ocean Model	• Baroclinic Ocean Model OMCT • Referenced to Multi Year Mean Ocean Bottom Pressure (for the years 2004 to 2007) • Driven by ECMWF operational Analysis and Forecast Fields • Correction for Atmosphere Tides: Atmospheric tide S2 shall not be taken into account in the ocean model, but S1 (because this is usually not taken into consideration in the ocean tide models)
Inverse Barometer	• Taken Care in Ocean Model

Monthly Geopotential Field Variability

Monthly gravity field variations from other sources than atmosphere and ocean are taken into account by applying a GRACE monthly gravity field time series in order to take into account seasonal variations from these sources. For this purpose the annual variations of gravity coefficients up to degree and order 30 are computed from the GFZ Release 04 GRACE gravity field time series [38]. These annual variations of potential coefficients are interpolated per 6-hourly time step and added to the atmospheric and oceanic de-aliasing coefficients (see above).

6.2 Non-Gravitational Forces

For GOCE the non-gravitational forces in flight direction are compensated by the drag-free control system of the satellite. The control of this system is based on the measured common mode accelerations from the six accelerometers forming the gravity gradiometer instrument. As the drag-free compensation is one-dimensional and not fully free of systematic effects, e.g. due to imperfections of the closed-loop control system itself, variations of the centre of mass of the satellite due to fuel consumption and differences in the biases and scale factors of the individual accelerometers there will be some remaining signal of non-gravitational forces, which is not compensated. It should be reflected in the residual common-mode accelerations.

For GOCE level 2 processing the common-mode accelerations shall be applied for the two core instruments differently.

- For gravity gradiometer data analysis the impact of the residual non-gravitational forces on the gravity gradients will be outside the measurement bandwidth of the instrument. This implies that the common mode accelerations play no role in the processing of these observations.

- For the SSTI data analysis dealing with the long wavelength gravity field determination based on orbit perturbation analyses, the remaining non-gravitational forces sensed by the common-mode accelerations have to be taken into consideration. The approach to be applied here will be similar to the CHAMP and GRACE cases with the difference that the main part of the non-gravitational signal is already compensated by the drag-free control system, i.e. the orbit will be almost gravitational and only the residual signal observed by the common-mode accelerations has to be taken into account.

As GOCE will be kept in a nearly drag-free mode it is not foreseen to use any model for non-gravitational forces (e.g. atmospheric drag model, solar radiation model, Earth albedo model).

7. Other System Definitions

7.1 Height System

Ellipsoidal Height

Ellipsoidal height, h: The height above the adopted reference ellipsoid measured along the ellipsoidal normal.

Physical Heights

(a) Geopotential number is the (negative) potential difference between a terrain point and the adopted height system reference point; units [m^2/s^2]..

(b) Normal height, H^N is the height of terrain points above the quasi-geoid or eauivalently the height of the telluroid above the reference ellipsoid. They are defined as geopotential number (see a) divided by the mean normal gravity between quasi-geoid and terrain; units [m].

(c) Height anomaly, ζ is the difference $h - H^N$, i.e. the vertical difference between the quasi-geoid and the adopted reference ellipsoid; units [m].

For all definitions see also [23].

7.2 Gravity System

(a) measured gravity g, refers to the IGSN71 [22].

(b) normal gravity, γ, is the magnitude of the gravity vector computed from the normal potential.

(c) (free-air) gravity anomaly in a point (P) with geodetic latitude φ and normal height H^N is the difference between g in point P and γ evaluated in a point (Q) with the same latitude φ and having an ellipsoidal height equal to H^N.

(d) gravity disturbance is the difference between measured gravity g and normal gravity evaluated in the same point.

Unit of all quantities is m/s^2

7.3 GRS80 Reference/Normal Ellipsoid

For the computation of gravity field quantities derived from the GOCE gravity potential spherical harmonic series as reference/normal ellipsoid the GRS80 system is applied [21].

The following defining constants are used:

Parameter	**Notation**	**Magnitude**	**Unit**
semi-major axis	a	*6378137.0*	m
invers flattening	1/f	*298.257222101*	
gravitational constant times Earth mass	GM	398600.5×10^9	m^3/s^2
Angular velocity of the Earth	ω	7.292115×10^{-5}	rad/sec

8. GOCE Reference Frames and Time System

8.1 GOCE Spacecraft Parameters

For the GOCE spacecraft parameters it is referred to the GOCE spacecraft documentation.

8.2 Major Reference Frames for Gradiometry

LORF – Local Orbit Reference Frame

- Origin O_{LORF} located at the actual (nominal) satellite centre of mass;
- X_{LORF} axis (roll) parallel to instantaneous direction of the orbital velocity vector ($\underline{V}$) with the same sign as this vector.
- Y_{LORF} axis (pitch) axis parallel to instantaneous direction of the orbital angular momentum ($\underline{N}$), with the same sign as $\underline{N}$ ($\underline{V}$ and $\underline{N}$ are orthogonal by definition, since $\underline{N} = \underline{R} \times \underline{V}$, where $\underline{R}$ is the vector from the Earth centre to the origin).
- Z_{LORF} (yaw) axis parallel to $\underline{V} \times \underline{N}$, with the same sign as $\underline{V} \times \underline{N}$

GRF - Gradiometer Reference Frame

This is the coordinate system in which the gravity gradients are measured by GOCE. The GRF represents the Three-Axis Gradiometer common reference for the mutual positioning and alignment of the three One Axis Gradiometers and for the positioning and orientation of the whole instrument with respect to external reference frames. Details of the other reference frames mentioned below are specified in chapter 8.3.

- Origin O_{GRF} located at the origin of the $OAGRF_3$
- X_{GRF} ,Y_{GRF} ,Z_{GRF} axes are parallel to the corresponding axes of $OAGRF_3$ with the same sign.

Nominally the origins of all OAGRF’s coincide in one intersection point. The corresponding axes of each of the 3 OAGRF’s are parallel and point in the same directions. The corresponding 6 ARF’s are nominally parallel and point in the same direction.

LNOF – Local North Pointing Frame

The Local North Oriented Frame (LNOF) is a right-handed North-West-Up frame with the X-axis pointing North, the Y-axis pointing West and the Z-axis Up. The calibrated gravity gradients of the EGG_TRF_2 products are provided in this system.

- The origin O_{LNOF} is located at the actual (or nominal) satellite centre of mass
- Z_{LNOF} is defined as the vector from the geocenter to the origin O_{LNOF}, pointing radially outward,
- Y_{LNOF} is parallel to the normal vector to the plane of the geocentric meridian of the satellite center of mass, pointing westward,

- X_{LNOF} is parallel to the normal vector to the plane defined by Y_{LNOF} and Z_{LNOF} and forms a right-handed system.

In geocentric latitude and East longitude (φ, λ) of the GOCE center of mass in the CTRS the 3 axes are defined as follows:

$$Z_{LNOF} = \begin{pmatrix} \cos\varphi\cos\lambda \\ \cos\varphi\sin\lambda \\ \sin\varphi \end{pmatrix} \; ; \; Y_{LNOF} = \begin{pmatrix} \sin\lambda \\ -\cos\lambda \\ 0 \end{pmatrix} \; ; \; X_{LNOF} = \begin{pmatrix} -\sin\varphi\cos\lambda \\ -\sin\varphi\sin\lambda \\ \cos\varphi \end{pmatrix} \qquad (90)$$

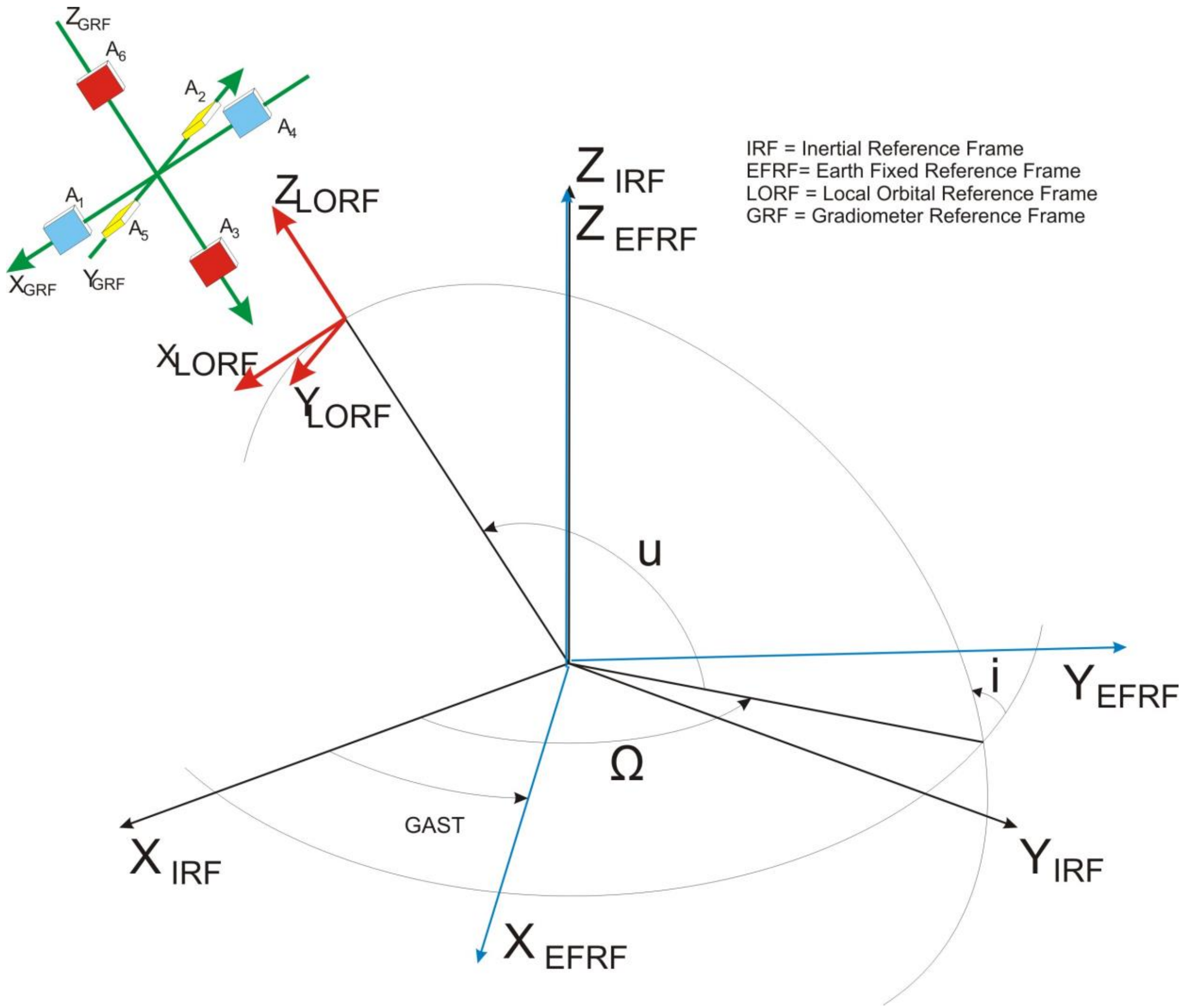

Figure 8-1: Definition of fundamental Reference Systems for GOCE. Ω corresponds to the right ascension of the ascending node of the GOCE orbital plane, u corresponds to the argument of latitude of the GOCE spacecraft at a specific time.

Figure 8-1 shows how the fundamental reference frames are oriented with respect to each other. Because the satellite attitude is controlled with magneto-torquers, the GRF does not coincide with the LORF. In science mode the satellite will operate in drag-free mode for the flight direction only.

8.3 Specific Reference Frames on Instrument Level

AESRF – Accelerometer Electrode System Reference Frame

This is the coordinate system with respect to which the locations of the control electrodes of the accelerometer proof mass are referred (see Figure 8-2). For each accelerometer it is defined as follows:

- Origin O_{AESRF} located at the centre of the accelerometer
- X_{AESRF} ,Y_{AESRF} , and Z_{AESRF} axes parallel to the axes of the ARF but not corresponding (see below)
- with X_{AESRF} along the less sensitive axis of the accelerometer (pointing from the ground plate to the proof mass)
- and Y_{AESRF} , Z_{AESRF} along the ultra sensitive axes of the accelerometer, so to form a right handed coordinate system.

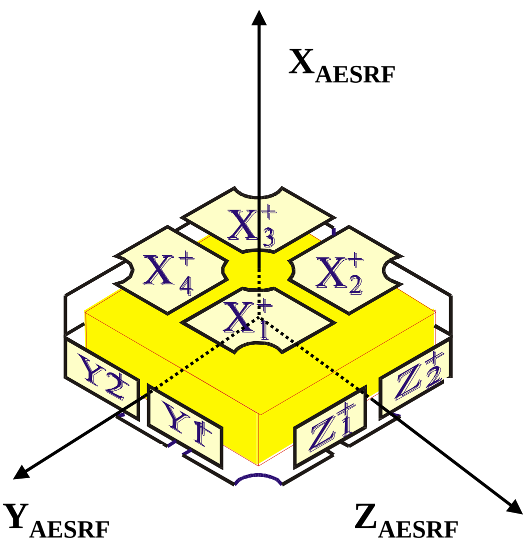

Figure 8-2: Accelerometer Electrode System Reference Frame and location of the 8 electrode pairs

ARF – Accelerometer Reference Frame

This is the reference frame in which the components of the acceleration of the proof mass relative to the cage are measured by the sensor. It is defined in a different way for each of the three accelerometer pairs belonging to the three One-Axis-Gradiometers (OAG's) (see below), so that the corresponding axes of all ARF's are nominally aligned when the six accelerometers are installed in the Three-Axis-Gradiometer. All ARF's for the 6 accelerometers are shown in Figure 8-3.

- For the accelerometers the origin of each ARF O_1 to O_6 is located in the centre of the accelerometer A_1 to A_6.
- For the accelerometers A_1 and A_4 forming the OAG_1 the ARF is defined as:
  - $X_{ARF1/4}$ axis is parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG_1 baseline, positive from A_4 to A_1.
  - $Y_{ARF1/4}$ is normal to the ground plate and pointing parallel to the OAG_2 baseline, positive from A_5 to A_2.

  - $Z_{ARF1/4}$ completes the right-handed orthonormal triad (compare Figure 8-3).
- For the accelerometers A_2 and A_5 forming the OAG_2 the ARF is defined as:
  - $Y_{ARF2/5}$ axis is parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG_2 baseline, positive from A_5 to A_2.
  - $Z_{ARF2/5}$ is normal to the ground plate and pointing parallel to the OAG_3 baseline, positive from A_6 to A_3.
  - $X_{ARF2/5}$ completes the right-handed orthonormal triad (compare Figure 8-3).
- For the accelerometers A_3 and A_6 forming the OAG3 the ARF is defined as:
  - $Z_{ARF3/6}$ axis is parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG_3 baseline, positive from A_6 to A_3.
  - $Y_{ARF3/6}$ is normal to the ground plate and pointing parallel to the OAG_2 baseline, positive from A_5 to A_2.
  - $X_{ARF3/6}$ completes the right-handed orthonormal triad (compare Figure 8-3).

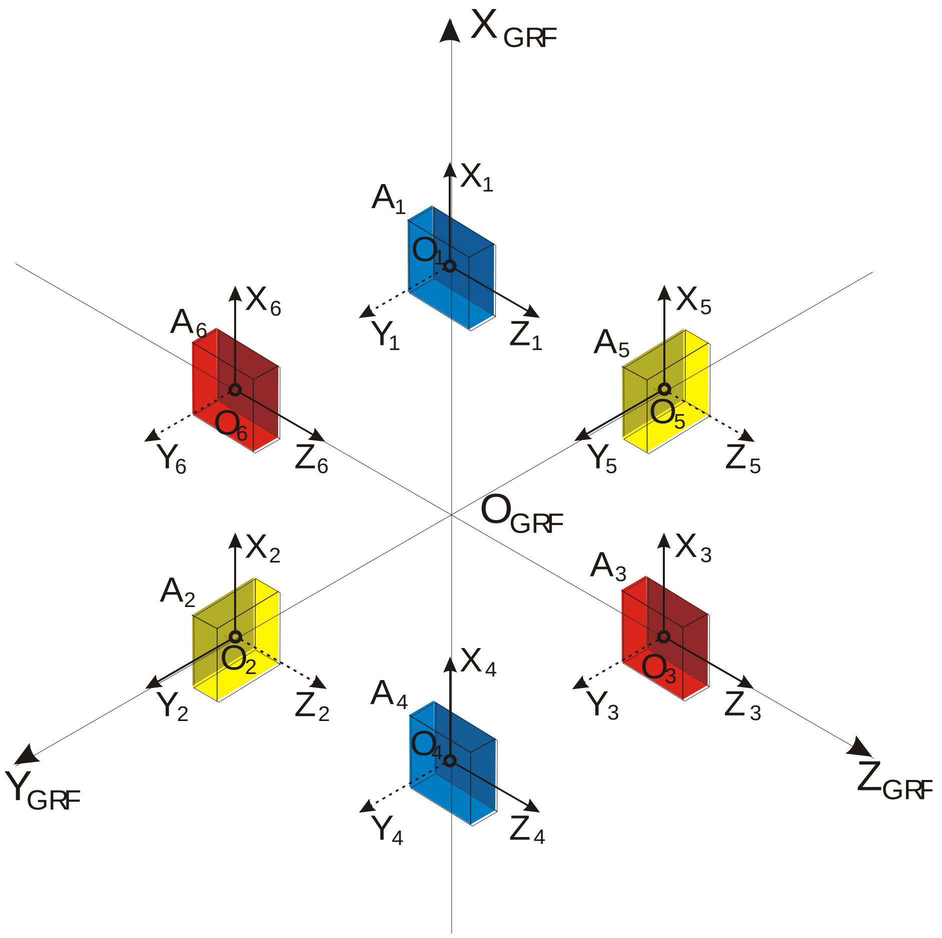

Figure 8-3: Nomenclatura and location of the 6 accelerometers of the GOCE gradiometer in the GRF and with all ARF's. The axes of the ARF shown by solid arrows are aligned with ultra sensitive axes of the accelerometer. The axes of the ARF shown by dashed arrows are aligned to the less sensitive axes of the accelerometer. Each colour represents a one-axis gradiometer. The shadowed surfaces represent the locations of the ground plate**.**

OAGRF – One Axis Gradiometer Reference Frame

This is the reference frame in which the components of the gravity gradients are measured by the One Axis Gradiometer and it is defined as follows (see Figure 8-3).

For OAG_1, which consists of accelerometers A_1 and A_4:

- Origin O_{OAG1} located at the midpoint of the straight line joining the origin of ARF_4 and ARF_1.
- X_{OAG1} axis parallel to the line joining O_4 to O_1, oriented from O_4 to O_1
- Y_{OAG1} axis parallel and with the same direction as Y_{ARF1} and Y_{ARF4} through the origin O_{OAG1}.
- Z axis is parallel to $X_{OAG1} \times Y_{OAG1}$ with the same sign of $X_{OAG1} \times Y_{OAG1}$

For OAG_2, which consists of accelerometers A_2 and A_5:

- Origin O_{OAG2} located at the midpoint of the straight line joining the origin of ARF_5 and ARF_2.
- Y_{OAG2} axis parallel to the line joining O_5 to O_2, oriented from O_5 to O_2
- Z_{OAG2} axis parallel and with the same direction as Z_{ARF2} and Z_{ARF5} through the origin O_{OAG2}.
- X_{OAG2} axis is parallel to $Y_{OAG2} \times Z_{OAG2}$ with the same sign of $Y_{OAG2} \times Z_{OAG2}$

For OAG_3, which consists of accelerometers A_3 and A_6:

- Origin O_{OAG3} located at the midpoint of the straight line joining the origin of ARF_6 and ARF_3.
- Z_{OAG3} axis parallel to the line joining O_6 to O_3, oriented from O_6 to O_3
- Y_{OAG3} axis parallel and with the same direction as Y_{ARF3} and Y_{ARF6} through the origin O_{OAG3}.
- X_{OAG3} axis is parallel to $Y_{OAG3} \times Z_{OAG3}$ with the same sign of $Y_{OAG3} \times Z_{OAG3}$

SSRF – Star Sensor Reference Frame

This is the reference frame whose inertial orientation is provided by the measurements of the star sensor itself. The nominal orientation of the star sensor boresights with respect to the GRF is shown in Figure 8-4.

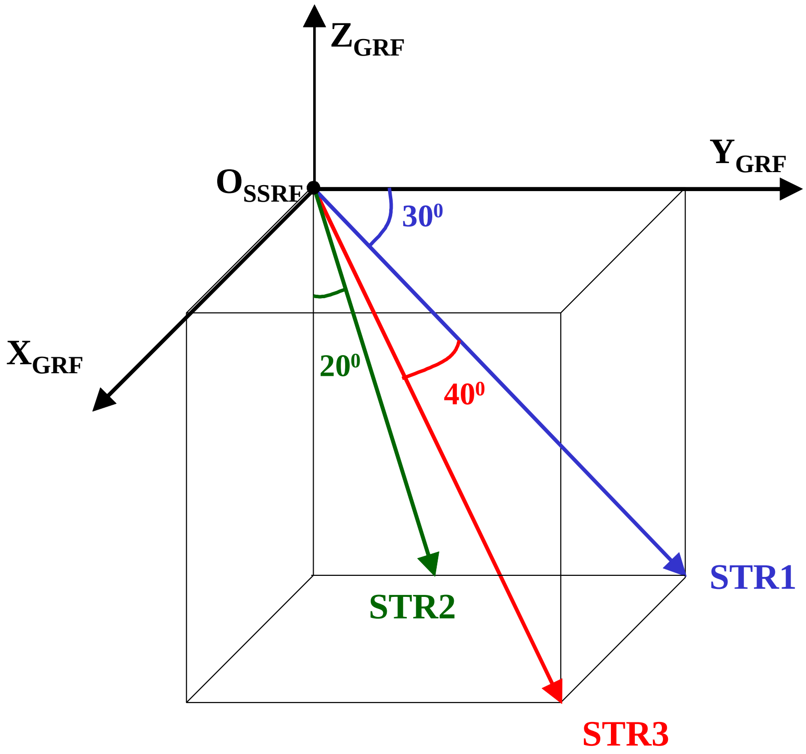

Figure 8-4: Relation of the star sensor boresight direction to the GRF.

The star sensor reference frame is defined as follows:

- The origin of each star sensor head $O_{SSRF1/2/3}$ is in the centre of each star sensor head respectively.
- The boresight direction of the three star camera heads are defined by the vectors: O_{SSRF1} to STR1, O_{SSRF2} to STR2 and O_{SSRF3} to STR3. These vectors can be expressed in the GRF by applying the following rotation matrices.

Star-tracker 1:

$$\boldsymbol{R}_{SSRF\_GRF} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sin\alpha_{STR} & -\cos\alpha_{STR} \\ 0 & \cos\alpha_{STR} & \sin\alpha_{STR} \end{bmatrix} \quad (91)$$

Star-tracker 2:

$$\boldsymbol{R}_{SSRF\_GRF} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\beta_{STR} & -\sin\beta_{STR} \\ 0 & \sin\beta_{STR} & \cos\beta_{STR} \end{bmatrix} \quad (92)$$

Star-tracker 3:

$$\boldsymbol{R}_{SSRF\_GRF} = \begin{bmatrix} 0 & \sin\alpha_{STR} & -\cos\alpha_{STR} \\ -\cos\gamma_{STR} & \cos\alpha_{STR}\sin\gamma_{STR} & \sin\alpha_{STR}\sin\gamma_{STR} \\ \sin\gamma_{STR} & \cos\alpha_{STR}\cos\gamma_{STR} & \sin\alpha_{STR}\cos\gamma_{STR} \end{bmatrix} \quad (93)$$

with the nominal design values of the angles α_{STR}, β_{STR}, γ_{STR}:

Angle	Nominal value dusk-dawn orbit (summer launch)
α_{STR}	-30°
β_{STR}	160°
γ_{STR}	40°

Note: The final rotation matrices from the SSRF to the GRF for each star tracker will be made available in product AUX_EGG_DB (see document GO-ID-ACS-GS-0109 L1B Product Specification Format and GO-ID-ACS-GS-0147 PDS-RPF ICD).

8.4 GOCE Time System

All level 1B data will be delivered in GPS-time. This time will be derived by correlating the on-board time with the GPS time. In case no GPS time is available (due to receiver outage) the GPS time will be determined by correlating the on-board time with UTC and applying the constant and leap second time shift.

9.References

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10. Glossary

AESRF	Accelerometer Electrode System Reference Frame
ARF	Accelerometer Reference Frame
BIH	Bureau International de l'Heure
BTS	BIH Terrestrial System
CDRS	Conventional Dynamical Reference System
CEO	Celestial Ephemeris Origin
CEP	Celestial Ephemeris Pole
CIO	Conventional International Origin
CIP	Celestial Intermediate Pole
CoM	Center of Mass
CTRF	Conventional Terrestrial Reference Frame
CTRS	Conventional Terrestrial Reference System
DE405	JPL Development Ephemerides
ECMWF	European Center for Medium-range Weather Forecast
EFRF	Earth-fixed Reference Frame
EOP	Earth Orientation Parameters
GAST	Greenwich Apparent Sidereal Time
GMST	Greenwich Mean Sidereal Time
GRF	Gradiometer Reference Frame
GST	Greenwich Sidereal Time
HIPPARCOS	HIgh Precision PARallax COllecting Satellite
IAU	International Astronomical Union
ICRF	International Celestial Reference Frame
ICRS	International Celestial Reference System
IGSN71	International Gravity Standardization Net 1971
IERS	International Earth rotation and Reference system Service
ITRF	International Terrestrial Reference Frame
ITRS	International Terrestrial Reference Systems
IRF	Inertial Reference Frame
JD	Julian Date
JPL	Jet Propulson Laboratory, Pasadena
LE405	JPL Lunar Ephemerides
LNOF	Local NOrth pointing reference Frame
LORF	Local Orbit Reference Frame
OAG	One-Axis Gradiometer
OAGRF	One-Axis Gradiometer Reference Frame
OMCT	Hamburg Ocean Model for Circulation and Tides
SLR	Satellite Laser Ranging
SSRF	Star Sensor Reference Frame
SSTI	Satellite-to-Satellite Tracking Instrument on GOCE
TAI	International Atomic Time
TCB	Barycentric Coordinate Time
TDB	Barycentric Dynamical Time
TGPS	GPS Time
TRF	Terrestrial Reference Frame
TRS	Terrestrial Reference System
TT	Terrestrial Time

UT1	Universal Time
UTC	Universal Time Coordinated
VLBI	Very Long Baseline Interferometry

11. Attachments

11.1 Tidal Corrections of Earth Orientation Parameters

```
* Tidal corrections of EOP (IERS Conventions 2003)
*
* chi (seconds)
*         tu**0            tu**1          tu**2       tu**3
   110510.54841  3164400184.812866   0.093104   -0.0000062
*
* Trigonometric series
* Number of terms
  71
*    Argument multipliers                         Coefficients
*                                Pole  (microarcseconds)       UT1  (microseconds)
*  F1   F2  F3   F4  F5  chi     Xts      Xtc      Yts     Ytc        Uts      Utc
*
   -1    0  -2   -2  -2   1     -0.05     0.94    -0.94   -0.05      0.396   -0.078
   -2    0  -2    0  -1   1      0.06     0.64    -0.64    0.06      0.195   -0.059
   -2    0  -2    0  -2   1      0.30     3.42    -3.42    0.30      1.034   -0.314
    0    0  -2   -2  -1   1      0.08     0.78    -0.78    0.08      0.224   -0.073
    0    0  -2   -2  -2   1      0.46     4.15    -4.15    0.45      1.187   -0.387
   -1    0  -2    0  -1   1      1.19     4.96    -4.96    1.19      0.966   -0.474
   -1    0  -2    0  -2   1      6.24    26.31   -26.31    6.23      5.118   -2.499
    1    0  -2   -2  -1   1      0.24     0.94    -0.94    0.24      0.172   -0.090
    1    0  -2   -2  -2   1      1.28     4.99    -4.99    1.28      0.911   -0.475
    0    0  -2    0   0   1     -0.28    -0.77     0.77   -0.28     -0.093    0.070
    0    0  -2    0  -1   1      9.22    25.06   -25.06    9.22      3.025   -2.280
    0    0  -2    0  -2   1     48.82   132.91  -132.90   48.82     16.020  -12.069
   -2    0   0    0   0   1     -0.32    -0.86     0.86   -0.32     -0.103    0.078
    0    0   0   -2   0   1     -0.66    -1.72     1.72   -0.66     -0.194    0.154
   -1    0  -2    2  -2   1     -0.42    -0.92     0.92   -0.42     -0.083    0.074
    1    0  -2    0  -1   1     -0.30    -0.64     0.64   -0.30     -0.057    0.050
    1    0  -2    0  -2   1     -1.61    -3.46     3.46   -1.61     -0.308    0.271
   -1    0   0    0   0   1     -4.48    -9.61     9.61   -4.48     -0.856    0.751
   -1    0   0    0  -1   1     -0.90    -1.93     1.93   -0.90     -0.172    0.151
    1    0   0   -2   0   1     -0.86    -1.81     1.81   -0.86     -0.161    0.137
    0   -1  -2    2  -2   1      1.54     3.03    -3.03    1.54      0.315   -0.189
    0    0  -2    2  -1   1     -0.29    -0.58     0.58   -0.29     -0.062    0.035
    0    0  -2    2  -2   1     26.13    51.25   -51.25   26.13      5.512   -3.095
    0    1  -2    2  -2   1     -0.22    -0.42     0.42   -0.22     -0.047    0.025
    0   -1   0    0   0   1     -0.61    -1.20     1.20   -0.61     -0.134    0.070
    0    0   0    0   1   1      1.54     3.00    -3.00    1.54      0.348   -0.171
    0    0   0    0   0   1    -77.48  -151.74   151.74  -77.48    -17.620    8.548
    0    0   0    0  -1   1    -10.52   -20.56    20.56  -10.52     -2.392    1.159
    0    0   0    0  -2   1      0.23     0.44    -0.44    0.23      0.052   -0.025
    0    1   0    0   0   1     -0.61    -1.19     1.19   -0.61     -0.144    0.065
    0    0   2   -2   2   1     -1.09    -2.11     2.11   -1.09     -0.267    0.111
   -1    0   0    2   0   1     -0.69    -1.43     1.43   -0.69     -0.288    0.043
    1    0   0    0   0   1     -3.46    -7.28     7.28   -3.46     -1.610    0.187
    1    0   0    0  -1   1     -0.69    -1.44     1.44   -0.69     -0.320    0.037
    0    0   0    2   0   1     -0.37    -1.06     1.06   -0.37     -0.407   -0.005
    2    0   0    0   0   1     -0.17    -0.51     0.51   -0.17     -0.213   -0.005
    0    0   2    0   2   1     -1.10    -3.42     3.42   -1.09     -1.436   -0.037
    0    0   2    0   1   1     -0.70    -2.19     2.19   -0.70     -0.921   -0.023
    0    0   2    0   0   1     -0.15    -0.46     0.46   -0.15     -0.193   -0.005
    1    0   2    0   2   1     -0.03    -0.59     0.59   -0.03     -0.396   -0.024
    1    0   2    0   1   1     -0.02    -0.38     0.38   -0.02     -0.253   -0.015
   -3    0  -2    0  -2   2     -0.49    -0.04     0.63    0.24     -0.089   -0.011
   -1    0  -2   -2  -2   2     -1.33    -0.17     1.53    0.68     -0.224   -0.032
   -2    0  -2    0  -2   2     -6.08    -1.61     3.13    3.35     -0.637   -0.177
    0    0  -2   -2  -2   2     -7.59    -2.05     3.44    4.23     -0.745   -0.222
    0    1  -2   -2  -2   2     -0.52    -0.14     0.22    0.29     -0.049   -0.015
   -1   -1  -2    0  -2   2      0.47     0.11    -0.10   -0.27      0.033    0.013
   -1    0  -2    0  -1   2      2.12     0.49    -0.41   -1.23      0.141    0.058
   -1    0  -2    0  -2   2    -56.87   -12.93    11.15   32.88     -3.795   -1.556
   -1    1  -2    0  -2   2     -0.54    -0.12     0.10    0.31     -0.035   -0.015
    1    0  -2   -2  -2   2    -11.01    -2.40     1.89    6.41     -0.698   -0.298
    1    1  -2   -2  -2   2     -0.51    -0.11     0.08    0.30     -0.032   -0.014
   -2    0  -2    2  -2   2      0.98     0.11    -0.11   -0.58      0.050    0.022
    0   -1  -2    0  -2   2      1.13     0.11    -0.13   -0.67      0.056    0.025
    0    0  -2    0  -1   2     12.32     1.00    -1.41   -7.31      0.605    0.266
    0    0  -2    0  -2   2   -330.15   -26.96    37.58  195.92    -16.195   -7.140
    0    1  -2    0  -2   2     -1.01    -0.07     0.11    0.60     -0.049   -0.021
   -1    0  -2    2  -2   2      2.47    -0.28    -0.44   -1.48      0.111    0.034
    1    0  -2    0  -2   2      9.40    -1.44    -1.88   -5.65      0.425    0.117
```

-1	0	0	0	0	2	-2.35	0.37	0.47	1.41	-0.106	-0.029
-1	0	0	0	-1	2	-1.04	0.17	0.21	0.62	-0.047	-0.013
0	-1	-2	2	-2	2	-8.51	3.50	3.29	5.11	-0.437	-0.019
0	0	-2	2	-2	2	-144.13	63.56	59.23	86.56	-7.547	-0.159
0	1	-2	2	-2	2	1.19	-0.56	-0.52	-0.72	0.064	0.000
0	0	0	0	1	2	0.49	-0.25	-0.23	-0.29	0.027	-0.001
0	0	0	0	0	2	-38.48	19.14	17.72	23.11	-2.104	0.041
0	0	0	0	-1	2	-11.44	5.75	5.32	6.87	-0.627	0.015
0	0	0	0	-2	2	-1.24	0.63	0.58	0.75	-0.068	0.002
1	0	0	0	0	2	-1.77	1.79	1.71	1.04	-0.146	0.037
1	0	0	0	-1	2	-0.77	0.78	0.75	0.45	-0.064	0.017
0	0	2	0	2	2	-0.33	0.62	0.65	0.19	-0.049	0.018

11.2 Earth Orientation Parameters C04 - Example

```
INTERNATIONAL EARTH ROTATION AND REFERENCE SYSTEMS SERVICE
     EARTH ORIENTATION PARAMETERS
       EOP (IERS) 08 C04


FORMAT(3(I4),I7,2(F11.6),2(F12.7),2(F11.6),2(F11.6),2(F11.7),2F12.6)
**************************************************************************************
```

Date			MJD	x	y	UT1-UTC	LOD	dX	dY	x Err	y Err	UT1-UTC Err	LOD Err	dX Err	dY Err
				"	"	s	s	"	"	"	"	s	s	"	"
(0h UTC)															
1962	1	1	37665	-0.012700	0.213000	0.0326338	0.0017230	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	2	37666	-0.015900	0.214100	0.0320547	0.0016690	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	3	37667	-0.019000	0.215200	0.0315526	0.0015820	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	4	37668	-0.021999	0.216301	0.0311435	0.0014960	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	5	37669	-0.024799	0.217301	0.0308154	0.0014160	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	6	37670	-0.027599	0.218301	0.0305353	0.0013820	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	7	37671	-0.030199	0.219301	0.0302682	0.0014130	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	8	37672	-0.032798	0.220202	0.0299280	0.0015050	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	9	37673	-0.035198	0.221102	0.0294869	0.0016280	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
1962	1	10	37674	-0.037498	0.222002	0.0289268	0.0017380	0.000000	0.000000	0.030000	0.030000	0.0020000	0.0014000	0.004774	0.002000
…															
…															
2013	8	1	56505	0.171614	0.360801	0.0508664	0.0000354	-0.000115	-0.000041	0.000029	0.000032	0.0000116	0.0000088	0.000061	0.000092
2013	8	2	56506	0.171449	0.359906	0.0508698	-0.0000262	-0.000184	-0.000031	0.000029	0.000032	0.0000021	0.0000088	0.000024	0.000033
2013	8	3	56507	0.171812	0.358758	0.0508896	-0.0000357	-0.000185	-0.000041	0.000029	0.000032	0.0000159	0.0000088	0.000015	0.000019
2013	8	4	56508	0.172184	0.357514	0.0508920	-0.0000184	-0.000157	-0.000058	0.000029	0.000029	0.0000092	0.0000091	0.000017	0.000021
2013	8	5	56509	0.172401	0.356273	0.0508653	0.0000659	-0.000111	-0.000073	0.000033	0.000029	0.0000153	0.0000097	0.000019	0.000026
2013	8	6	56510	0.172554	0.355256	0.0507705	0.0001743	-0.000076	-0.000090	0.000033	0.000032	0.0000055	0.0000096	0.000021	0.000028
2013	8	7	56511	0.172778	0.354263	0.0505584	0.0002672	-0.000114	-0.000073	0.000030	0.000031	0.0000125	0.0000098	0.000031	0.000044
2013	8	8	56512	0.173427	0.353372	0.0502377	0.0003265	-0.000172	-0.000048	0.000030	0.000028	0.0000059	0.0000098	0.000043	0.000062
2013	8	9	56513	0.173697	0.352904	0.0498320	0.0004346	-0.000232	-0.000025	0.000030	0.000028	0.0000021	0.0000099	0.000054	0.000079
2013	8	10	56514	0.173888	0.352080	0.0493378	0.0005192	-0.000260	-0.000042	0.000030	0.000028	0.0000104	0.0000101	0.000053	0.000076
2013	8	11	56515	0.173994	0.351257	0.0487936	0.0005298	-0.000274	-0.000075	0.000030	0.000028	0.0000082	0.0000101	0.000047	0.000064
2013	8	12	56516	0.173765	0.350190	0.0482710	0.0004758	-0.000286	-0.000107	0.000033	0.000032	0.0000091	0.0000098	0.000041	0.000053
2013	8	13	56517	0.173651	0.348912	0.0477934	0.0004126	-0.000288	-0.000146	0.000033	0.000032	0.0000033	0.0000099	0.000035	0.000042
2013	8	14	56518	0.173705	0.347770	0.0473953	0.0003477	-0.000236	-0.000091	0.000031	0.000030	0.0000013	0.0000103	0.000053	0.000067
2013	8	15	56519	0.173741	0.346387	0.0470610	0.0002979	-0.000223	-0.000112	0.000034	0.000033	0.0000087	0.0000105	0.000058	0.000074
2013	8	16	56520	0.173646	0.345159	0.0467545	0.0002797	-0.000226	-0.000167	0.000034	0.000033	0.0000096	0.0000108	0.000055	0.000071
2013	8	17	56521	0.173383	0.343912	0.0464163	0.0003744	-0.000223	-0.000214	0.000031	0.000033	0.0000089	0.0000111	0.000052	0.000067
2013	8	18	56522	0.173288	0.342890	0.0459741	0.0005323	-0.000213	-0.000249	0.000034	0.000033	0.0000088	0.0000111	0.000049	0.000064
2013	8	19	56523	0.173168	0.341865	0.0453977	0.0006168	-0.000174	-0.000272	0.000033	0.000034	0.0000079	0.0000104	0.000044	0.000057

2013	8	20	56524	0.173063	0.340726	0.0446799	0.0007632	-0.000177	-0.000287	0.000029	0.000034	0.0000025	0.0000104	0.000042	0.000054
2013	8	21	56525	0.172398	0.339375	0.0438305	0.0008525	-0.000179	-0.000249	0.000028	0.000031	0.0000139	0.0000103	0.000051	0.000063
2013	8	22	56526	0.171684	0.337844	0.0429512	0.0008717	-0.000185	-0.000190	0.000031	0.000031	0.0000092	0.0000097	0.000064	0.000076
2013	8	23	56527	0.170625	0.336442	0.0420842	0.0008230	-0.000194	-0.000127	0.000031	0.000031	0.0000041	0.0000097	0.000076	0.000089
2013	8	24	56528	0.169798	0.334944	0.0412703	0.0007489	-0.000217	-0.000093	0.000031	0.000031	0.0000090	0.0000099	0.000118	0.000146
2013	8	25	56529	0.169189	0.333577	0.0405795	0.0006309	-0.000243	-0.000073	0.000031	0.000034	0.0000072	0.0000099	0.000169	0.000220
2013	8	26	56530	0.168893	0.332209	0.0400021	0.0005207	-0.000239	-0.000063	0.000028	0.000034	0.0000114	0.0000100	0.000282	0.000295
2013	8	27	56531	0.168519	0.330738	0.0395337	0.0003777	-0.000247	-0.000057	0.000028	0.000031	0.0000100	0.0000100	0.000348	0.000369
2013	8	28	56532	0.168415	0.329414	0.0391717	0.0002806	-0.000228	-0.000070	0.000029	0.000030	0.0000139	0.0000093	0.000235	0.000293
2013	8	29	56533	0.168163	0.328251	0.0388973	0.0002473	-0.000196	-0.000082	0.000029	0.000033	0.0000142	0.0000093	0.000138	0.000172
2013	8	30	56534	0.167661	0.327082	0.0386768	0.0002367	-0.000168	-0.000096	0.000029	0.000033	0.0000058	0.0000095	0.000041	0.000051
2013	8	31	56535	0.166593	0.325700	0.0384634	0.0002152	-0.000155	-0.000089	0.000029	0.000033	0.0000122	0.0000095	0.000023	0.000028
2013	9	1	56536	0.165860	0.324084	0.0382068	0.0002970	-0.000152	-0.000074	0.000029	0.000033	0.0000084	0.0000093	0.000035	0.000041
2013	9	2	56537	0.165573	0.322684	0.0378617	0.0004198	-0.000142	-0.000047	0.000035	0.000036	0.0000102	0.0000109	0.000043	0.000053
2013	9	3	56538	0.165314	0.321419	0.0373927	0.0005024	-0.000149	-0.000031	0.000039	0.000036	0.0000127	0.0000114	0.000053	0.000066
2013	9	4	56539	0.164827	0.320456	0.0367879	0.0006379	-0.000156	-0.000014	0.000034	0.000034	0.0000049	0.0000106	0.000062	0.000077
2013	9	5	56540	0.164368	0.319491	0.0360450	0.0008060	-0.000259	-0.000088	0.000034	0.000034	0.0000114	0.0000104	0.000058	0.000072
2013	9	6	56541	0.164310	0.318349	0.0351748	0.0009072	-0.000380	-0.000180	0.000038	0.000034	0.0000046	0.0000104	0.000051	0.000064
2013	9	7	56542	0.163910	0.317351	0.0342240	0.0009627	-0.000400	-0.000187	0.000034	0.000034	0.0000118	0.0000101	0.000061	0.000083
2013	9	8	56543	0.163508	0.316383	0.0332626	0.0009316	-0.000371	-0.000155	0.000034	0.000031	0.0000085	0.0000098	0.000077	0.000112
2013	9	9	56544	0.162948	0.315306	0.0323533	0.0008653	-0.000327	-0.000098	0.000033	0.000031	0.0000085	0.0000101	0.000094	0.000145
2013	9	10	56545	0.162052	0.314146	0.0315245	0.0007584	-0.000269	-0.000045	0.000033	0.000035	0.0000075	0.0000101	0.000110	0.000176
2013	9	11	56546	0.161094	0.312773	0.0307834	0.0006948	-0.000268	0.000120	0.000031	0.000029	0.0000096	0.0000100	0.000092	0.000145
2013	9	12	56547	0.159937	0.311450	0.0301155	0.0006528	-0.000286	0.000308	0.000027	0.000026	0.0000070	0.0000100	0.000066	0.000100
2013	9	13	56548	0.158737	0.309930	0.0294762	0.0006294	-0.000305	0.000479	0.000027	0.000026	0.0000030	0.0000100	0.000039	0.000055
2013	9	14	56549	0.157790	0.308431	0.0288025	0.0007154	-0.000342	0.000490	0.000031	0.000029	0.0000144	0.0000103	0.000044	0.000057
2013	9	15	56550	0.157350	0.306944	0.0280242	0.0008645	-0.000383	0.000421	0.000031	0.000029	0.0000071	0.0000105	0.000060	0.000077
2013	9	16	56551	0.157106	0.305976	0.0270896	0.0010175	-0.000419	0.000334	0.000030	0.000030	0.0000068	0.0000099	0.000071	0.000091
2013	9	17	56552	0.156504	0.305514	0.0259668	0.0011926	-0.000437	0.000221	0.000030	0.000034	0.0000079	0.0000099	0.000085	0.000109
2013	9	18	56553	0.155377	0.305349	0.0246770	0.0013240	-0.000434	0.000094	0.000029	0.000032	0.0000056	0.0000102	0.000099	0.000127
2013	9	19	56554	0.153947	0.304766	0.0232973	0.0013738	-0.000357	0.000099	0.000043	0.000045	0.0000129	0.0000102	0.000074	0.000097
2013	9	20	56555	0.152824	0.303963	0.0219443	0.0012905	-0.000246	0.000155	0.000043	0.000045	0.0000038	0.0000102	0.000037	0.000054
2013	9	21	56556	0.151406	0.303196	0.0207179	0.0011330	-0.000223	0.000123	0.000048	0.000045	0.0000082	0.0000108	0.000028	0.000043
2013	9	22	56557	0.149281	0.302354	0.0196438	0.0010117	-0.000233	0.000067	0.000054	0.000050	0.0000083	0.0000111	0.000031	0.000045
2013	9	23	56558	0.146735	0.301442	0.0186897	0.0008985	-0.000242	0.000020	0.000033	0.000048	0.0000096	0.0000092	0.000033	0.000047
2013	9	24	56559	0.144871	0.300344	0.0178077	0.0008517	-0.000255	-0.000012	0.000033	0.000047	0.0000100	0.0000092	0.000035	0.000048
2013	9	25	56560	0.143566	0.299610	0.0169717	0.0008146	-0.000269	-0.000032	0.000033	0.000045	0.0000028	0.0000092	0.000035	0.000044
2013	9	26	56561	0.142079	0.298821	0.0161801	0.0007604	-0.000214	0.000000	0.000033	0.000045	0.0000090	0.0000089	0.000030	0.000037
2013	9	27	56562	0.140889	0.297939	0.0154371	0.0007188	-0.000141	0.000048	0.000033	0.000046	0.0000036	0.0000092	0.000023	0.000027
2013	9	28	56563	0.139500	0.297257	0.0147280	0.0007030	-0.000128	0.000090	0.000033	0.000046	0.0000080	0.0000095	0.000028	0.000036
2013	9	29	56564	0.137657	0.296237	0.0140048	0.0007466	-0.000136	0.000126	0.000033	0.000046	0.0000106	0.0000095	0.000037	0.000051
2013	9	30	56565	0.135490	0.295144	0.0131976	0.0008856	-0.000134	0.000152	0.000036	0.000048	0.0000104	0.0000103	0.000050	0.000080

11.3 Terrestrial to Celestial Transformation Matrices

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* Terrestrial-to-Celestial Transformation Matrices from the IERS Interactive Tool
* http://hpiers.obspm.fr/eop-pc/products/matrice/matrice.php
*
* Start date (UTC)
*  Y    M  D  h  m  s
 2002 12 01 23 59 57
* Step (seconds)
 3600
* End date (UTC)
*  Y    M  D  h  m  s
 2002 12 04 23 59 57
* Number of matrices
 73
* Elements of transformation matrices
*   (1,1)           (1,2)           (1,3)           (2,1)           (2,2)           (2,3)           (3,1)           (3,2)           (3,3)
*
  0.331883605827 -0.943320311334  0.000249813461  0.943320339439  0.331883619636  0.000014803982 -0.000096873893  0.000230740920  0.999999968687
  0.075711007140 -0.997129771395  0.000249789947  0.997129802120  0.075711013134  0.000014618127 -0.000033488020  0.000247966247  0.999999968696
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 -0.434288942083 -0.900773585505  0.000249881830  0.900773615082 -0.434288952391  0.000014247112  0.000095687496  0.000231274323  0.999999968678
 -0.653171165794 -0.757210251963  0.000249993005  0.757210277850 -0.653171183474  0.000014085700  0.000152622391  0.000198497646  0.999999968653
 -0.827298190689 -0.561762975918  0.000250139767  0.561762996326 -0.827298214530  0.000013954542  0.000199101037  0.000152063833  0.999999968618
 -0.944738856942 -0.327823778161  0.000250312956  0.327823791678 -0.944738885311  0.000013861838  0.000231936143  0.000095154359  0.999999968576
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  0.748720532936 -0.662885737435  0.000250329851  0.662885755354  0.748720558773  0.000014825653 -0.000197254820  0.000154839822  0.999999968558
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0.227722296590	0.973726086726	0.000252319898	-0.973726118431	0.227722300378	0.000013996531	-0.000043830081	-0.000248877797	0.999999968069
0.472613480141	0.881269785445	0.000252289168	-0.881269815092	0.472613491986	0.000014161687	-0.000106754998	-0.000229027832	0.999999968075
0.685121252944	0.728428998017	0.000252215238	-0.728429023583	0.685121272037	0.000014306944	-0.000162376431	-0.000193522891	0.999999968091
0.850684610870	0.525676354111	0.000252104897	-0.525676373854	0.850684635904	0.000014421618	-0.000206880659	-0.000144793837	0.999999968118
0.957959174666	0.286904437376	0.000251967604	-0.286904449953	0.957959203926	0.000014497212	-0.000237215371	-0.000086178364	0.999999968151
0.999594505519	0.028473867425	0.000251814743	-0.028473871981	0.999594537002	0.000014528106	-0.000251298970	-0.000021692355	0.999999968189
0.972737756259	-0.231907727807	0.000251658700	0.231907731573	0.972737787806	0.000014511958	-0.000248163362	0.000044245269	0.999999968229
0.879229148013	-0.476399036551	0.000251511884	0.476399048374	0.879229177461	0.000014449777	-0.000228020446	0.000107115357	0.999999968266
0.725475878316	-0.688247547607	0.000251385838	0.688247566666	0.725475903647	0.000014345696	-0.000192247758	0.000162608235	0.999999968300
0.522013100589	-0.852937430101	0.000251290520	0.852937455081	0.522013120063	0.000014206537	-0.000143294236	0.000206919098	0.999999968326
0.282782056716	-0.959184156083	0.000251233778	0.959184185262	0.282782068997	0.000014041276	-0.000084512577	0.000237008846	0.999999968342

11.4 Luni-Solar Nutation

```
* Luni-solar nutation
* Nutation model IAU2000A
*
* Fundamental arguments (arcseconds)
*      t**0              t**1        t**2      t**3       t**4
* F1 = l
  485868.249036 1717915923.2178  31.8792  0.051635 -0.00024470
* F2 = l'
 1287104.79305   129596581.0481  -0.5532  0.000136 -0.00001149
* F3 = F
  335779.526232 1739527262.8478 -12.7512 -0.001037  0.00000417
* F4 = D
 1072260.70369  1602961601.2090  -6.3706  0.006593 -0.00003169
* F5 = Omega
  450160.398036   -6962890.5431   7.4722  0.007702 -0.00005939
*
* Series of the luni-solar nutation
* Number of terms
 662
* Number of terms to be multiplied by t
  38
*   Argument multipliers                                Coefficients (microarcseconds)
*  F1   F2   F3   F4   F5          As            Ac         Bs          Bc          A's      A'c     B's      B'c
*
   0    0    0    0    1    -17206416.10   3338.60    1537.70   9205233.10  -17466.60    2.90    0.20   908.60
   0    0    2   -2    2     -1317090.60  -1369.60    -458.70    573033.60    -167.50    1.20   -0.30  -301.50
   0    0    2    0    2      -227641.70    279.60     137.40     97846.10     -23.40    0.20   -0.10   -48.50
   0    0    0    0    2       207455.40    -69.80     -29.10    -89749.20      20.70    0.00    0.00    47.00
   0    1    0    0    0       147587.70   1181.70    -192.40      7387.10    -363.30   -1.50    0.50   -18.40
   1    0    0    0    0        71115.90    -87.20      35.80      -675.00       7.30    0.00    0.00     0.00
   0    1    2   -2    2       -51682.10    -52.40     -17.40     22438.60     122.60    0.20    0.00   -67.70
   0    0    2    0    1       -38730.20     38.00      31.80     20073.00     -36.70    0.10    0.00     1.80
   1    0    2    0    2       -30146.40     81.60      36.70     12902.60      -3.60    0.00    0.00    -6.30
   0    1   -2    2   -2       -21582.90     11.10     -13.20     -9592.90      49.40    0.00    0.10    29.90
   1    0    0   -2    0       -15699.80    -16.80      -8.20      -123.50      -1.00    0.00    0.00     0.00
   0    0    2   -2    1        12822.70     18.10       3.90     -6898.20      13.70    0.00    0.00    -0.90
   1    0   -2    0   -2       -12345.70      1.90       0.40     -5331.10      -1.10    0.00    0.00     3.20
   0    0    0    2    0         6337.90    -15.00       2.90      -122.00       1.10    0.00    0.00     0.00
   1    0    0    0    1         6311.00      2.70      -0.90     -3322.80       6.30    0.00    0.00     0.00
   1    0   -2   -2   -2         5964.50     14.90      -6.60      2554.50       1.10    0.00    0.00    -1.10
   1    0    0    0   -1         5797.60    -18.90       7.50      3142.90       6.30    0.00    0.00     0.00
   1    0    2    0    1        -5161.30     12.90       7.80      2636.60      -4.20    0.00    0.00     0.00
   2    0   -2    0   -1        -4589.30      3.10      -2.00     -2423.60      -5.00    0.00    0.00    -1.00
   0    0    2    2    2        -3856.60     15.80       6.80      1645.00      -0.10    0.00    0.00    -1.10
   2    0    2    0    2        -3104.60     13.10       5.90      1323.80      -0.10    0.00    0.00    -1.10
   1    0    2   -2    2         2859.30     -0.10      -0.30     -1233.80       0.00    0.00    0.00     1.00
   1    0   -2    0   -1        -2044.10      1.00       0.30     -1075.80      -2.10    0.00    0.00     0.00
   0    2    0    0    0         1670.70     -1.00       1.00        16.80      -8.50    0.00    0.00    -0.10
   0    2    2   -2    2        -1579.40     -1.60      -0.50       685.00       7.20    0.00    0.00    -4.20
   1    0    0   -2   -1        -1516.40      1.10       0.10      -800.10      -1.00    0.00    0.00     0.00
   0    1    0    0    1        -1405.30      7.90      -4.50       855.10      -2.50    0.00    0.00    -0.20
   1    0    0   -2    1        -1287.30     -3.70      -1.40       695.30      -1.00    0.00    0.00     0.00
   0    1    0    0   -1         1265.40      6.30      -2.60       641.50      -1.10    0.00    0.00     0.00
   0    1    2    0    2          756.60     -1.10      -0.50      -325.00      -2.10    0.00    0.00     0.00
   0    1   -2    0   -2          714.10      0.80      -0.40       307.00      -2.10    0.00    0.00     0.00
   0    0    2    2    1         -663.70      2.50       1.40       335.30      -1.10    0.00    0.00     0.00
   0    0    0    2    1         -630.20      0.20       0.40       327.20      -1.10    0.00    0.00     0.00
   1    0    2   -2    1          580.00      0.20      -0.10      -304.50       1.00    0.00    0.00     0.00
   2    0    0   -2   -1          577.40     -1.50       0.50       304.10       1.10    0.00    0.00     0.00
   0    0    0    2   -1          494.00     -2.10       0.90       272.00       1.10    0.00    0.00     0.00
   0    1   -2    2   -1          475.20     -0.30       0.30       271.90       1.10    0.00    0.00     0.00
   1    0   -2   -2    0          -63.90     -0.20       0.00        -1.90       1.10    0.00    0.00     0.00
   2    0    0   -2    0         4772.20     -1.80       2.50        47.70
   0    2   -2    2   -2        -3248.10      0.00       0.00     -1387.00
   2    0    0    0    0         2924.30     -7.40       1.30       -60.90
   0    0    2    0    0         2588.70     -6.60       1.10       -55.00
   0    0    2   -2    0        -2178.30      1.30      -1.30       -16.70
   2    0   -2    0    0         1102.40     -1.40      -0.20        10.40
   1    0   -2   -2   -1         1020.40      2.50      -1.50       522.20
   1    0    2    2    2         -768.70      4.40       1.90       326.60
   1    1    0   -2    0         -735.00     -0.80      -0.40        -5.10
   1    0    0    2    0          657.50     -2.40       0.20       -19.90
   2    0    2   -2    2          644.30     -0.70      -0.40      -276.80
   2    0    2    0    1         -535.00      2.10       1.20       269.50
   1   -1    0    0    0          472.50     -0.60       0.30        -4.10
   1    0    0   -1    0         -402.60    -35.30      13.90       -55.30
   0    1    0   -2    0         -434.80     -1.00      -0.20        -8.10
```

0	0	0	1	0	-423.00	0.50	-0.20	-2.00
2	0	0	-2	1	406.50	0.60	0.10	-220.60
1	0	-2	0	0	405.60	0.50	0.20	4.00
0	1	2	-2	1	357.90	0.50	0.10	-190.00
1	1	0	0	0	-338.90	0.50	-0.20	3.50
1	0	2	0	0	333.90	-1.30	0.10	-10.70
1	-1	0	-1	0	-327.60	0.10	0.00	-0.90
2	0	-2	0	-2	307.10	-0.20	0.10	131.10
3	0	2	0	2	-290.10	1.50	0.70	123.20
1	-1	2	0	2	-287.80	0.80	0.40	123.20
1	1	-2	-2	-2	281.90	0.70	-0.30	120.70
0	1	-2	-2	-2	264.70	1.10	-0.50	112.90
1	1	2	0	2	248.10	-0.70	-0.30	-106.20
2	0	0	0	-1	229.40	-1.00	0.40	126.60
2	0	0	0	1	217.90	-0.20	-0.20	-112.90
1	0	-2	2	-1	198.70	-0.60	0.20	107.30
0	1	-1	1	-1	0.00	-198.80	167.90	0.00
1	0	0	0	2	-198.10	0.00	0.00	85.40
0	0	2	1	2	166.00	-0.50	-0.20	-71.00
3	0	0	0	0	157.50	-0.60	0.00	-5.00
1	0	-2	-4	-2	152.10	0.90	-0.40	64.70
1	0	0	0	-2	-140.50	0.40	-0.20	-61.00
2	0	-2	-2	-2	-137.80	-0.20	0.20	-59.20
1	0	0	-4	0	-133.80	-0.50	0.00	-3.90
1	0	2	2	1	-133.10	0.80	0.40	66.30
1	-1	0	-1	-1	-131.40	0.00	0.00	-70.00
1	1	2	-2	2	129.00	0.00	0.00	-55.60
2	0	0	-4	0	-128.20	-0.30	-0.10	-2.30
0	2	-2	2	-1	128.30	0.00	0.00	67.20
0	0	2	-2	3	124.80	0.00	0.10	-17.00
2	0	-2	-4	-2	121.40	0.50	-0.20	51.80
1	0	-4	0	-2	-114.60	-0.30	0.10	-49.00
2	0	2	2	2	-110.00	0.90	0.40	46.50
1	0	0	-1	-1	-102.00	-2.50	1.00	-49.50
1	0	-1	0	-1	0.00	-104.40	89.10	0.00
2	0	2	-2	1	101.90	-0.10	-0.10	-52.70
2	1	0	-2	0	101.40	-0.10	0.10	0.40
1	0	0	2	1	-97.00	0.20	0.10	49.60
1	-1	0	-2	0	94.90	0.10	0.10	0.80
3	0	2	-2	2	93.40	-0.30	-0.10	-39.90
0	0	4	-2	2	92.20	-0.10	-0.10	-39.50
0	1	-2	2	0	-87.50	0.10	0.00	2.90
0	0	2	-2	-1	-83.40	0.20	-0.10	-44.00
0	1	2	0	1	81.50	-0.10	-0.10	-42.20
1	0	2	-2	0	-76.60	0.10	0.00	0.90
1	1	0	-2	-1	-74.20	0.10	0.00	-39.10
0	1	0	0	2	71.50	-0.40	0.20	-32.60
2	0	-2	0	1	71.60	-0.20	-0.10	-38.90
0	0	2	-1	2	-70.40	0.00	0.00	30.40
0	0	2	4	2	-69.40	0.50	0.20	29.40
0	1	0	2	0	-67.30	0.20	0.00	1.40
0	0	2	0	-1	66.60	-0.30	0.10	36.90
0	1	-2	0	-1	66.70	0.10	-0.10	34.60
0	1	2	-2	0	-65.80	0.00	0.00	-0.20
1	-1	0	-1	-2	59.50	0.00	0.00	25.80
1	-1	2	2	2	-59.00	0.40	0.20	25.20
0	1	0	0	-2	-59.10	0.00	0.00	-25.30
2	0	0	2	0	58.80	-0.30	0.00	-2.40
1	1	0	-2	1	-58.50	-0.20	-0.10	31.60
1	0	-2	2	0	-57.80	0.10	0.00	0.50
1	-1	-2	-2	-2	-57.00	-0.20	0.10	-24.40
0	1	0	1	0	56.50	-0.10	0.00	-0.60
0	1	2	2	2	53.50	-0.20	-0.10	-22.80
1	-1	0	0	1	52.80	0.00	0.00	-27.90
3	0	2	0	1	-50.20	0.30	0.20	25.00
0	0	0	4	0	49.40	-0.20	0.00	-1.90
1	0	0	2	-1	49.20	-0.30	0.10	27.50
1	-1	0	2	0	49.30	-0.20	0.00	-1.50
2	-1	2	0	2	-48.80	0.20	0.10	20.70
1	1	-2	-2	-1	46.70	0.10	-0.10	24.00
0	0	0	2	2	-46.80	0.00	0.00	20.10
1	-1	-2	0	-2	-46.30	0.00	0.00	-20.00
1	0	2	-4	1	-45.30	-0.10	-0.10	24.40
0	1	-2	-2	-1	44.60	0.20	-0.10	22.50
0	3	2	-2	2	-43.80	0.00	0.00	18.10
1	-1	2	0	1	-42.10	0.10	0.10	21.60
0	0	2	2	0	41.60	-0.20	0.00	-1.70
2	1	2	0	2	41.20	-0.20	-0.10	-17.60
1	0	0	-2	-2	39.60	0.00	0.00	17.10
0	0	0	1	1	-39.00	0.00	0.00	20.50
2	-1	0	0	0	37.50	-0.10	0.00	-0.80
1	0	-1	0	-2	0.00	36.40	-17.60	0.00
1	1	2	0	1	36.00	-0.10	-0.10	-18.50

1	1	0	0	1	-36.10	0.00	0.00	18.90
1	0	-2	2	-2	-35.70	0.10	0.00	-15.40
1	0	2	1	2	33.70	-0.10	-0.10	-14.30
2	0	2	0	0	33.50	-0.20	0.00	-1.40
0	1	0	-2	1	-33.50	-0.10	-0.10	18.40
1	0	2	-1	2	-33.40	0.00	0.00	14.40
1	0	0	1	0	-32.50	0.10	0.00	0.70
0	0	0	1	-1	-32.10	0.10	0.00	-17.40
1	0	0	-2	2	30.90	0.10	0.00	-13.40
1	-1	0	0	-1	30.10	-0.10	0.00	16.20
2	1	0	0	0	-28.60	0.10	0.00	0.60
0	0	2	1	1	28.00	-0.10	0.00	-14.40
1	2	0	-2	0	-27.60	0.00	0.00	-0.20
0	3	0	0	0	27.60	0.00	0.00	0.20
1	0	-2	-4	-1	26.30	0.20	-0.10	13.10
4	0	2	0	2	-25.90	0.20	0.10	10.90
1	0	-2	0	1	25.30	0.10	0.00	-13.80
2	1	2	-2	2	25.20	0.00	0.00	-10.80
0	1	2	1	2	-24.50	0.10	0.00	10.40
1	1	2	-2	1	24.50	0.00	0.00	-12.80
1	0	4	-2	2	24.30	-0.10	0.00	-10.40
2	0	-2	-2	-1	-23.10	0.00	0.00	-12.00
1	0	-2	1	-1	22.90	0.00	0.00	12.80
2	-2	0	-2	0	22.80	0.00	0.00	0.10
0	0	0	0	3	-21.90	0.00	0.00	4.30
0	2	0	-2	0	-21.30	0.00	0.00	-0.40
2	0	-2	-4	-1	20.80	0.10	0.00	10.50
1	1	0	0	-1	-20.80	0.10	0.00	-11.20
0	1	0	2	1	19.90	0.00	0.00	-10.20
1	0	-4	0	-1	-19.70	-0.10	0.00	-10.00
2	0	2	2	1	-19.20	0.20	0.10	9.40
0	0	2	-3	2	-18.80	0.00	0.00	8.30
0	0	4	0	2	18.60	-0.10	0.00	-7.90
1	0	0	-1	1	15.90	-2.80	1.10	-5.40
1	0	0	-4	-1	18.70	0.00	0.00	9.60
2	0	0	-2	-2	-17.50	0.00	0.00	-7.50
1	1	-2	-4	-2	17.40	0.10	0.00	7.50
1	0	2	4	2	-16.30	0.20	0.10	6.90
0	0	1	0	1	0.00	-16.20	-13.80	0.00
3	0	0	-4	0	-16.10	0.00	0.00	-0.10
1	1	-2	0	-2	15.90	0.00	0.00	6.90
0	1	0	-2	-1	15.60	0.00	0.00	8.10
0	0	0	4	1	-15.40	0.10	0.00	7.80
0	0	2	-4	1	-15.30	-0.10	0.00	8.40
1	1	0	-4	0	-15.10	-0.10	0.00	-0.50
3	0	2	-2	1	14.70	0.00	0.00	-7.50
1	1	2	2	2	14.40	-0.10	0.00	-6.10
0	0	4	-2	1	14.10	0.00	0.00	-7.20
3	0	2	2	2	-13.40	0.10	0.10	5.60
2	1	0	-2	-1	13.20	0.00	0.00	6.90
0	2	-2	-2	-2	12.90	0.10	0.00	5.50
0	0	2	0	3	12.80	0.00	0.00	-0.10
2	0	0	-4	-1	-12.30	0.00	0.00	-6.40
0	0	2	4	1	-12.10	0.10	0.00	6.00
0	0	0	2	-2	-12.00	0.00	0.00	-5.20
3	0	0	0	-1	11.80	-0.10	0.00	6.60
2	1	0	-4	0	-11.50	0.00	0.00	-0.20
4	0	2	-2	2	11.30	-0.10	0.00	-4.90
2	0	0	2	1	-11.40	0.00	0.00	5.70
1	-1	0	-2	-1	11.30	0.00	0.00	5.90
2	1	-2	-4	-2	11.00	0.00	0.00	4.80
1	1	0	2	0	-10.30	-0.30	-0.10	0.30
0	0	2	-1	1	-10.60	0.00	0.00	6.10
1	-1	-2	2	-1	10.50	0.00	0.00	5.70
1	2	-2	-2	-2	10.40	0.00	0.00	4.40
1	0	0	-3	0	10.30	0.00	0.00	0.20
2	0	0	-2	2	-10.20	0.00	0.00	4.40
2	0	0	-4	1	-10.20	0.00	0.00	5.60
2	0	2	-4	1	10.10	0.00	0.00	-5.40
1	0	0	-4	1	-10.00	-0.10	0.00	5.60
1	-1	2	2	1	-10.00	0.10	0.00	5.00
2	-1	0	-2	0	-9.20	-0.50	0.20	1.20
1	-1	-2	0	-1	-9.60	0.00	0.00	-5.00
2	1	-2	0	-1	-9.10	-0.40	0.20	-5.40
4	0	0	0	0	9.40	0.00	0.00	-0.40
0	2	0	0	1	-9.40	0.00	0.00	5.10
0	1	-2	1	-2	-9.40	0.00	0.00	-4.00
1	0	-4	2	-2	9.30	0.00	0.00	4.00
0	2	-2	0	-2	8.30	1.00	0.20	4.00
2	-1	2	2	2	-9.20	0.10	0.00	3.90
0	1	-2	-4	-2	9.20	0.10	0.00	3.90
2	0	0	0	2	-9.10	0.00	0.00	3.90
1	0	-2	-3	-2	-9.10	0.00	0.00	-3.90

2	0	2	-2	0	-8.80	0.00	0.00	0.20
0	2	2	-2	1	8.70	0.00	0.00	-4.70
1	-1	-2	-2	-1	-8.40	0.00	0.00	-4.40
0	1	2	2	1	8.40	0.00	0.00	-4.30
3	0	0	0	1	8.30	0.00	0.00	-4.30
1	0	2	0	-1	8.30	0.00	0.00	4.70
1	0	-2	-1	-2	-8.30	0.00	0.00	-3.60
2	1	0	-2	1	8.20	0.00	0.00	-4.50
2	-1	-2	0	-1	-8.20	0.00	0.00	-4.50
1	0	2	2	0	8.10	-0.10	0.00	-0.40
1	0	0	4	0	8.20	0.00	0.00	-0.40
2	0	-4	0	-2	7.90	0.00	0.00	3.40
3	0	-2	0	-1	7.80	0.00	0.00	4.10
2	0	-2	2	-1	7.70	0.00	0.00	4.30
2	-1	2	0	1	-7.70	0.00	0.00	3.90
1	-2	0	-2	0	7.40	-0.30	0.10	-0.10
0	2	2	0	2	7.40	0.00	0.00	-3.20
1	-1	2	-2	2	-7.30	0.00	0.00	3.20
1	0	2	-4	2	7.10	0.00	0.00	-3.10
2	0	2	-1	2	-6.90	0.00	0.00	3.00
1	1	-2	1	-1	-6.80	0.00	0.00	-3.60
0	1	0	-4	0	-6.50	0.00	0.00	-0.20
2	1	2	0	1	6.40	0.00	0.00	-3.30
3	-1	2	0	2	-6.30	0.00	0.00	2.60
2	1	-2	-2	-2	-6.30	0.00	0.00	-2.80
1	1	-2	0	-1	6.30	0.00	0.00	3.30
1	0	-1	0	-3	0.00	-6.30	2.70	0.00
1	-1	0	-2	1	6.20	0.00	0.00	-3.40
1	0	-2	1	0	-6.10	0.00	0.00	0.10
0	2	0	0	-1	6.10	0.00	0.00	3.20
2	0	-2	-2	0	6.00	0.00	0.00	0.20
1	0	2	1	1	5.70	0.00	0.00	-2.90
2	0	0	0	-2	-5.60	0.00	0.00	-2.50
3	1	2	0	2	5.30	0.00	0.00	-2.30
1	1	2	1	2	-5.30	0.00	0.00	2.20
2	-1	2	-2	2	5.10	0.00	0.00	-2.20
1	-2	2	0	2	-5.10	0.00	0.00	2.20
3	0	0	2	0	4.90	0.00	0.00	-0.20
0	1	0	1	1	4.90	0.00	0.00	-2.60
0	1	2	-2	3	4.80	0.00	0.00	-1.00
0	1	0	1	-1	4.80	0.00	0.00	2.50
2	0	2	1	2	4.70	0.00	0.00	-1.90
2	-1	0	2	0	4.70	0.00	0.00	-0.10
1	1	0	1	0	4.70	0.00	0.00	-0.10
1	1	-2	2	-1	-4.70	0.00	0.00	-2.40
2	0	-4	-2	-2	-4.60	0.00	0.00	-1.80
4	0	2	0	1	-4.50	0.00	0.00	2.20
1	2	2	-2	2	4.50	0.00	0.00	-2.00
1	1	2	-4	1	-4.50	0.00	0.00	2.30
0	1	0	2	-1	-4.50	0.00	0.00	-2.60
0	0	4	-4	4	4.50	0.00	0.00	-0.80
3	0	-2	-2	-2	-4.40	0.00	0.00	-1.90
2	1	-2	0	0	4.40	0.00	0.00	-0.20
0	0	4	-4	2	-4.40	0.00	0.00	1.90
2	0	-2	-6	-2	4.30	0.00	0.00	1.80
1	0	2	-3	1	-4.30	0.00	0.00	2.40
2	0	0	2	-1	4.20	0.00	0.00	2.40
0	1	2	1	1	-4.20	0.00	0.00	2.20
2	1	2	-2	1	4.10	0.00	0.00	-2.10
1	0	2	-1	1	-4.00	0.00	0.00	2.10
1	0	4	-2	1	3.90	0.00	0.00	-2.10
1	-1	2	-2	1	-3.90	0.00	0.00	2.10
2	-1	0	-2	1	-3.80	0.00	0.00	1.90
2	-2	0	-2	-1	3.80	0.00	0.00	2.00
1	0	2	-2	-1	-3.80	0.00	0.00	-2.00
2	0	4	-2	2	3.70	0.00	0.00	-1.60
1	-1	0	2	1	-3.70	0.00	0.00	1.90
0	0	2	3	2	3.70	0.00	0.00	-1.60
1	0	-2	2	1	-3.60	0.00	0.00	2.00
1	-1	0	2	-1	3.60	0.00	0.00	2.00
0	1	4	-2	2	3.60	0.00	0.00	-1.50
2	-1	0	0	1	3.50	0.00	0.00	-1.80
1	-2	-2	-2	-2	-3.50	0.00	0.00	-1.40
0	0	0	4	-1	3.50	0.00	0.00	1.90
1	0	0	-1	-2	3.40	0.00	0.00	1.50
1	0	-2	1	-2	3.30	0.00	0.00	2.10
0	1	-2	2	1	-3.30	0.00	0.00	1.60
3	1	2	-2	2	3.20	0.00	0.00	-1.30
2	0	2	-4	2	-3.20	0.00	0.00	1.50
1	1	0	2	1	3.20	0.00	0.00	-1.60
1	0	0	4	1	-3.20	0.00	0.00	1.60
1	0	-2	-6	-2	3.20	0.00	0.00	1.40
1	0	-4	-2	-2	-3.20	0.00	0.00	-1.30

0	0	4	0	1	3.20	0.00	0.00	-1.60
1	-1	-2	-4	-2	-3.10	0.00	0.00	-1.30
1	-2	2	2	2	-3.10	0.00	0.00	1.30
0	0	2	-4	2	3.10	0.00	0.00	-1.30
3	0	2	0	0	3.00	0.00	0.00	-0.20
1	1	-2	-4	-1	3.00	0.00	0.00	1.50
0	0	1	0	2	0.00	3.00	1.40	0.00
3	-1	0	0	0	2.90	0.00	0.00	-0.10
2	-1	0	0	-1	2.90	0.00	0.00	1.50
2	-1	-2	0	0	2.90	0.00	0.00	-0.10
1	0	2	4	1	-2.90	0.00	0.00	1.40
2	0	2	-4	0	-2.80	0.00	0.20	0.00
1	2	0	-2	-1	-2.80	0.00	0.00	-1.50
1	1	-2	-2	0	-2.80	0.00	0.00	-0.10
1	0	0	1	-1	-2.80	0.00	0.00	-1.50
0	1	2	-2	-1	-2.80	0.00	0.00	-1.50
2	0	2	4	2	-2.70	0.00	0.00	1.20
2	-1	-2	-2	-2	2.70	0.00	0.00	1.10
0	1	-2	-2	0	-2.70	0.00	0.00	-0.10
0	0	2	-3	1	2.70	0.00	0.00	-1.40
3	0	2	-4	2	-2.60	0.00	0.00	1.10
3	0	-2	-2	-1	-2.60	0.00	0.00	-1.40
2	1	2	2	2	2.60	0.00	0.00	-1.10
0	0	3	0	3	0.00	-2.60	-1.10	0.00
2	0	0	1	0	-2.50	0.00	0.00	0.10
3	0	2	2	1	-2.40	0.00	0.00	1.10
1	0	4	0	2	2.40	0.00	0.00	-1.00
1	-1	2	4	2	-2.40	0.00	0.00	1.00
1	-1	-2	2	-2	-2.40	0.00	0.00	-1.10
5	0	2	0	2	-2.30	0.00	0.00	0.90
3	0	-2	-6	-2	2.30	0.00	0.00	0.90
2	0	0	-6	0	-2.30	0.00	0.00	-0.10
1	1	2	2	1	2.30	0.00	0.00	-1.20
1	0	0	2	2	2.30	0.00	0.00	-1.00
1	-2	2	-2	1	1.00	1.30	-0.50	0.60
2	1	0	0	-1	-2.20	0.00	0.00	-1.20
1	2	0	-2	1	-2.20	0.00	0.00	1.20
1	-1	2	-1	2	2.20	0.00	0.00	-0.90
0	2	-2	-2	-1	2.20	0.00	0.00	1.00
2	0	-2	0	2	-2.10	0.00	0.00	1.00
1	2	2	0	2	2.10	0.00	0.00	-0.90
0	1	0	-2	-2	2.10	0.00	0.00	0.90
0	1	-2	2	-3	2.10	0.00	0.00	0.50
2	1	0	0	1	-2.00	0.00	0.00	1.10
1	1	0	-2	-2	2.00	0.00	0.00	0.80
3	0	0	-4	-1	-1.90	0.00	0.00	-1.00
2	1	-2	-4	-1	1.90	0.00	0.00	0.90
2	-1	-2	-4	-2	-1.90	0.00	0.00	-0.80
1	0	0	1	1	-1.90	0.00	0.00	1.00
1	0	-4	2	-1	1.90	0.00	0.00	1.00
4	0	2	-2	1	1.80	0.00	0.00	-0.90
3	0	-2	0	-2	-1.80	0.00	0.00	-0.80
1	-1	0	0	2	-1.80	0.00	0.00	0.70
0	1	2	-4	1	-1.80	0.00	0.00	1.00
1	0	-2	4	-1	1.70	0.00	0.00	0.90
1	0	-2	-2	1	-1.70	0.00	0.00	0.90
0	2	0	-2	1	-1.70	0.00	0.00	1.00
0	1	2	4	2	1.70	0.00	0.00	-0.70
0	1	-4	2	-2	1.70	0.00	0.00	0.70
3	0	0	-2	-1	1.60	0.00	0.00	0.80
2	0	-2	2	-2	-1.60	0.00	0.00	-0.60
2	-1	2	2	1	-1.60	0.00	0.00	0.70
1	0	0	-6	0	-1.60	0.00	0.00	-0.10
1	0	-2	-3	-1	-1.60	0.00	0.00	-0.80
1	0	-2	-4	0	-1.60	0.00	0.00	-0.10
0	1	0	-4	-1	1.60	0.00	0.00	0.80
0	1	-2	-4	-1	1.60	0.00	0.00	0.70
4	0	2	2	2	-1.50	0.00	0.00	0.70
2	0	-2	-3	-2	-1.50	0.00	0.00	-0.70
1	0	2	0	3	1.50	0.00	0.00	0.30
0	1	-2	1	-1	-1.50	0.00	0.00	-0.80
0	0	4	-2	4	1.50	0.00	0.00	-0.30
0	0	2	-2	4	-1.50	0.00	0.00	0.30
3	0	0	-4	1	-1.40	0.00	0.00	0.70
1	2	-2	-2	-1	1.40	0.00	0.00	0.80
1	1	0	-2	2	1.40	0.00	0.00	-0.60
0	0	4	-4	1	-1.40	0.00	0.00	0.80
1	1	0	0	2	1.30	0.00	0.00	-0.50
1	1	0	-4	1	-1.30	0.00	0.00	0.60
1	0	1	0	1	0.00	-1.30	-1.10	0.00
1	0	0	2	-2	-1.30	0.00	0.00	-0.50
1	0	0	-4	-2	1.30	0.00	0.00	0.60
0	0	2	6	2	-1.30	0.00	0.00	0.50

0	0	0	1	2	1.30	0.00	0.00	-0.60
3	0	0	2	1	-1.20	0.00	0.00	0.60
3	-1	2	2	2	-1.20	0.00	0.00	0.50
3	-1	2	-2	2	1.20	0.00	0.00	-0.50
1	1	0	-4	-1	1.20	0.00	0.00	0.60
1	0	1	-2	1	0.00	-1.20	-1.00	0.00
1	0	0	-1	2	-1.20	0.00	0.00	0.50
1	-2	2	-2	2	-1.20	0.00	0.00	0.50
0	1	0	2	2	1.20	0.00	0.00	-0.50
0	1	-2	-1	-2	-1.20	0.00	0.00	-0.50
0	0	2	2	-1	1.20	0.00	0.00	0.60
3	-1	-2	-1	-2	1.10	0.00	0.00	0.50
1	0	-2	0	-3	1.10	0.00	0.00	0.30
1	-1	2	-4	1	1.10	0.00	0.00	-0.60
5	0	2	-2	2	1.00	0.00	0.00	-0.40
4	0	-2	-2	-1	1.00	0.00	0.00	0.60
2	1	0	-4	1	-1.00	0.00	0.00	0.50
2	1	0	-4	-1	-1.00	0.00	0.00	-0.60
2	0	2	0	-1	1.00	0.00	0.00	0.50
2	0	-4	0	-1	1.00	0.00	0.00	0.50
1	2	-2	-4	-2	1.00	0.00	0.00	0.40
1	0	4	-4	2	-1.00	0.00	0.00	0.40
0	0	4	-1	2	-1.00	0.00	0.00	0.40
0	0	3	0	2	0.00	-1.00	-0.50	0.00
0	0	0	3	1	1.00	0.00	0.00	-0.60
2	1	-2	-2	-1	-0.90	0.00	0.00	-0.50
2	0	0	2	2	0.90	0.00	0.00	-0.40
2	-2	2	0	2	-0.90	0.00	0.00	0.40
1	0	0	-3	1	0.90	0.00	0.00	-0.40
1	-1	-2	-3	-2	0.90	0.00	0.00	0.40
1	-2	0	0	1	0.90	0.00	0.00	-0.50
1	-2	-2	0	-2	-0.90	0.00	0.00	-0.40
0	1	0	-2	2	0.90	0.00	0.00	-0.30
0	0	2	0	-2	-0.90	0.00	0.00	-0.30
0	0	2	-2	-2	0.90	0.00	0.00	0.40
0	2	-2	0	-1	0.60	-0.30	-0.10	0.30
4	0	0	0	-1	0.80	0.00	0.00	0.40
3	0	2	-1	2	-0.80	0.00	0.00	0.40
3	-1	2	0	1	-0.80	0.00	0.00	0.40
2	2	2	-2	2	0.80	0.00	0.00	-0.30
2	0	2	-1	1	-0.80	0.00	0.00	0.40
1	2	2	-2	1	0.80	0.00	0.00	-0.40
1	1	0	2	-1	-0.80	0.00	0.00	-0.40
0	2	2	0	1	0.80	0.00	0.00	-0.40
0	0	0	1	-2	0.80	0.00	0.00	0.30
4	0	2	-4	2	-0.70	0.00	0.00	0.30
3	1	2	0	1	0.70	0.00	0.00	-0.40
2	0	-4	2	-2	0.70	0.00	0.00	0.30
2	-1	-2	0	-2	0.70	0.00	0.00	0.30
1	1	4	-2	2	0.70	0.00	0.00	-0.30
1	1	2	1	1	-0.70	0.00	0.00	0.40
1	1	2	-4	2	0.70	0.00	0.00	-0.30
1	1	0	-1	1	0.70	0.00	0.00	-0.40
1	0	2	3	2	0.70	0.00	0.00	-0.30
1	0	0	4	-1	0.70	0.00	0.00	0.30
1	-2	0	-2	-1	0.70	0.00	0.00	0.40
0	0	0	4	2	-0.70	0.00	0.00	0.30
4	-1	2	0	2	-0.60	0.00	0.00	0.20
2	2	-2	-4	-2	0.60	0.00	0.00	0.20
2	1	2	1	2	-0.60	0.00	0.00	0.30
2	1	2	-4	1	0.60	0.00	0.00	-0.30
2	0	2	1	1	0.60	0.00	0.00	-0.30
2	0	-2	-6	-1	0.60	0.00	0.00	0.30
2	0	-4	-2	-1	-0.60	0.00	0.00	-0.30
2	-1	2	-1	2	0.60	0.00	0.00	-0.30
1	0	-2	-2	-3	-0.60	0.00	0.00	-0.10
1	-1	0	-4	-1	-0.60	0.00	0.00	-0.30
1	-2	2	0	1	-0.60	0.00	0.00	0.30
1	-2	0	-2	1	0.60	0.00	0.00	-0.30
0	2	2	2	2	0.60	0.00	0.00	-0.30
0	2	-2	-4	-2	0.60	0.00	0.00	0.30
0	1	2	3	2	-0.60	0.00	0.00	0.30
0	1	0	-4	1	-0.60	0.00	0.00	0.30
4	1	2	0	2	0.50	0.00	0.00	-0.20
4	-1	-2	-2	-2	-0.50	0.00	0.00	-0.20
3	0	0	-2	1	0.50	0.00	0.00	-0.30
2	1	0	-2	-2	-0.50	0.00	0.00	-0.20
2	1	-2	0	1	0.50	0.00	0.00	-0.30
2	1	-2	-6	-2	0.50	0.00	0.00	0.20
2	0	4	-2	1	0.50	0.00	0.00	-0.30
2	0	0	-1	1	0.50	0.00	0.00	-0.20
2	0	0	-3	-1	0.50	0.00	0.00	0.30
2	-1	2	-2	1	0.50	0.00	0.00	-0.30

2	-1	-2	2	-1	0.50	0.00	0.00	0.20
2	-2	0	-2	1	0.50	0.00	0.00	-0.30
1	1	-2	2	-2	0.50	0.00	0.00	0.20
1	1	-2	-3	-2	-0.50	0.00	0.00	-0.20
1	0	3	0	3	0.00	-0.50	-0.20	0.00
1	0	0	-6	-1	0.50	0.00	0.00	0.30
1	0	-1	0	1	0.00	0.50	0.40	0.00
1	0	-2	1	1	-0.50	0.00	0.00	0.20
1	0	-2	0	2	-0.50	0.00	0.00	0.20
1	-1	2	1	2	0.50	0.00	0.00	-0.20
1	-1	0	0	-2	-0.50	0.00	0.00	-0.20
1	-1	0	-2	-2	-0.50	0.00	0.00	5.30
1	-1	-4	2	-2	0.50	0.00	0.00	0.20
1	-2	0	0	-1	0.50	0.00	0.00	0.30
1	-2	-2	-2	-1	-0.50	0.00	0.00	-0.30
0	3	-2	-2	-2	0.50	0.00	0.00	0.20
0	1	4	-2	1	0.50	0.00	0.00	-0.30
0	1	0	4	1	0.50	0.00	0.00	-0.20
0	0	4	2	2	0.50	0.00	0.00	-0.20
0	0	2	3	1	0.50	0.00	0.00	-0.30
3	1	2	-2	1	0.40	0.00	0.00	-0.20
3	0	4	-2	2	0.40	0.00	0.00	-0.20
3	0	2	1	2	0.40	0.00	0.00	-0.20
3	0	0	2	-1	0.40	0.00	0.00	0.20
3	0	0	0	2	-0.40	0.00	0.00	0.20
3	0	-2	2	-1	0.40	0.00	0.00	0.20
2	0	4	-4	2	-0.40	0.00	0.00	0.20
2	0	2	-3	2	-0.40	0.00	0.00	0.20
2	0	0	4	1	-0.40	0.00	0.00	0.20
2	0	0	-3	1	0.40	0.00	0.00	-0.20
2	0	-2	-2	1	0.40	0.00	0.00	-0.20
2	0	-4	2	-1	0.40	0.00	0.00	0.20
2	-1	0	2	1	-0.40	0.00	0.00	0.20
2	-1	0	2	-1	0.40	0.00	0.00	0.20
2	-2	2	2	2	-0.40	0.00	0.00	0.20
2	-2	2	-2	2	-0.10	0.30	-0.10	0.30
2	-2	0	-2	-2	-0.40	0.00	0.00	-0.20
1	1	2	4	2	0.40	0.00	0.00	-0.20
1	1	0	1	1	0.40	0.00	0.00	-0.20
1	1	0	1	-1	0.40	0.00	0.00	0.20
1	1	-2	-6	-2	0.40	0.00	0.00	0.20
1	0	0	-3	-1	0.40	0.00	0.00	0.20
1	0	-2	-6	-1	0.40	0.00	0.00	0.20
1	0	-4	-2	-1	-0.40	0.00	0.00	-0.20
1	-1	-2	-4	-1	-0.40	0.00	0.00	-0.20
1	-2	2	2	1	-0.40	0.00	0.00	0.20
1	-2	-2	2	-1	0.40	0.00	0.00	0.20
0	2	0	0	2	0.40	0.00	0.00	-0.20
0	2	0	0	-2	-0.40	0.00	0.00	-0.10
0	1	2	-4	2	0.40	0.00	0.00	-0.20
0	1	-2	4	-1	-0.40	0.00	0.00	-0.20
5	0	2	0	1	-0.30	0.00	0.00	0.10
4	1	2	-2	2	0.30	0.00	0.00	-0.10
4	0	-2	0	-1	0.30	0.00	0.00	0.20
3	1	2	2	2	0.30	0.00	0.00	-0.10
3	1	-2	-6	-2	0.30	0.00	0.00	0.10
3	0	0	0	-2	-0.30	0.00	0.00	-0.10
3	0	-2	-1	-1	-0.30	0.00	0.00	-0.20
3	0	-2	-4	-2	-0.30	0.00	0.00	-0.10
3	0	-2	-6	-1	0.30	0.00	0.00	0.20
2	2	0	-2	-1	0.30	0.00	0.00	0.10
2	1	2	2	1	0.30	0.00	0.00	-0.20
2	1	2	-4	2	-0.30	0.00	0.00	0.10
2	1	0	2	1	0.30	0.00	0.00	-0.20
2	1	-2	0	-2	0.30	0.00	0.00	0.10
2	0	2	4	1	-0.30	0.00	0.00	0.20
2	0	2	-2	-1	-0.30	0.00	0.00	-0.20
2	0	2	-6	1	-0.30	0.00	0.00	0.20
2	0	0	-4	2	0.30	0.00	0.00	-0.10
2	0	0	-4	-2	0.30	0.00	0.00	0.10
2	0	0	-6	-1	0.30	0.00	0.00	0.20
2	0	-2	-5	-2	-0.30	0.00	0.00	-0.10
2	-1	2	4	2	-0.30	0.00	0.00	0.10
2	-1	0	-2	2	0.30	0.00	0.00	-0.10
2	-1	-2	0	1	0.30	0.00	0.00	-0.10
2	-1	-2	-2	-1	0.30	0.00	0.00	0.20
1	3	-2	-2	-2	0.30	0.00	0.00	0.10
1	2	2	0	1	0.30	0.00	0.00	-0.20
1	2	2	-4	1	-0.30	0.00	0.00	0.10
1	2	0	0	1	-0.30	0.00	0.00	0.20
1	1	0	0	-2	0.30	0.00	0.00	0.10
1	1	-2	1	-2	0.30	0.00	0.00	0.10
1	1	-2	-1	-2	-0.30	0.00	0.00	-0.10

1	0	4	0	1	0.30	0.00	0.00	-0.20
1	0	2	-4	-1	0.30	0.00	0.00	0.20
1	0	2	-6	1	-0.30	0.00	0.00	0.20
1	0	0	-4	2	0.30	0.00	0.00	-0.10
1	0	-1	-2	-1	0.00	-0.30	0.20	0.00
1	0	-2	4	-2	-0.30	0.00	0.00	-0.10
1	-1	2	4	1	-0.30	0.00	0.00	0.20
1	-1	2	-3	1	0.30	0.00	0.00	-0.20
1	-1	0	4	1	-0.30	0.00	0.00	0.20
1	-1	-2	1	-1	0.30	0.00	0.00	0.20
0	1	4	-4	2	-0.30	0.00	0.00	0.10
0	1	-4	2	-1	0.30	0.00	0.00	0.10
0	0	0	3	2	0.30	0.00	0.00	-0.10
1	0	-1	0	0	0.00	33.00	0.00	0.00
0	2	-2	2	0	-9.40	0.00	0.00	0.00
1	-2	0	0	0	8.50	0.00	0.00	0.00
1	0	2	-4	0	7.50	0.00	0.00	0.00
0	0	1	0	0	0.00	7.50	0.00	0.00
1	0	2	-3	2	-6.00	0.00	0.00	0.00
2	0	0	-3	0	5.10	0.00	0.00	0.00
2	0	0	-1	0	3.80	0.00	0.00	0.00
1	1	0	-1	0	3.60	0.00	0.00	0.00
1	2	0	0	0	-3.50	0.00	0.00	0.00
1	-1	-2	2	0	-3.40	0.00	0.00	0.00
0	0	2	-1	0	3.10	0.00	0.00	0.00
1	1	-2	1	0	3.00	0.00	0.00	0.00
2	0	-2	2	0	-2.90	0.00	0.00	0.00
1	1	2	-2	0	-2.90	0.00	0.00	0.00
1	-2	0	2	0	2.50	0.00	0.00	0.00
3	0	-2	0	0	-2.40	0.00	0.00	0.00
3	1	0	0	0	-2.30	0.00	0.00	0.00
1	-1	2	0	0	2.20	0.00	0.00	0.00
1	-1	0	-4	0	2.20	0.00	0.00	0.00
4	0	0	-2	0	-2.00	0.00	0.00	0.00
2	2	0	-2	0	2.00	0.00	0.00	0.00
0	1	2	0	0	-2.00	0.00	0.00	0.00
1	1	2	0	0	-1.90	0.00	0.00	0.00
1	-1	-2	0	0	1.80	0.00	0.00	0.00
0	0	2	1	0	-1.80	0.00	0.00	0.00
1	1	-2	0	0	-1.70	0.00	0.00	0.00
0	2	2	-2	0	-1.70	0.00	0.00	0.00
2	-1	0	-4	0	1.50	0.00	0.00	0.00
0	0	0	3	0	-1.50	0.00	0.00	0.00
3	1	0	-4	0	-1.40	0.00	0.00	0.00
3	0	0	-6	0	-1.40	0.00	0.00	0.00
2	0	-2	-4	0	-1.30	0.00	0.00	0.00
1	0	-4	0	0	1.30	0.00	0.00	0.00
0	1	0	-1	0	1.30	0.00	0.00	0.00
4	0	0	-4	0	1.20	0.00	0.00	0.00
2	1	0	2	0	-1.20	0.00	0.00	0.00
1	-1	0	4	0	1.20	0.00	0.00	0.00
3	0	2	-2	0	-1.10	0.00	0.00	0.00
2	0	2	2	0	1.10	0.00	0.00	0.00
1	2	0	-4	0	-1.10	0.00	0.00	0.00
1	-1	0	-3	0	-1.10	0.00	0.00	0.00
0	1	0	4	0	-1.10	0.00	0.00	0.00
0	1	-2	0	0	-1.10	0.00	0.00	0.00
2	0	0	4	0	1.00	0.00	0.00	0.00
1	1	-2	2	0	1.00	0.00	0.00	0.00
2	-1	0	-1	0	-0.90	0.00	0.00	0.00
1	3	0	-2	0	-0.90	0.00	0.00	0.00
0	3	0	-2	0	-0.90	0.00	0.00	0.00
1	0	1	0	0	0.30	0.60	0.00	0.00
0	0	4	-2	0	-0.80	0.00	0.00	0.00
3	0	-2	-2	0	0.70	0.00	0.00	0.00
2	-2	0	0	0	0.70	0.00	0.00	0.00
1	1	2	-4	0	0.70	0.00	0.00	0.00
1	1	0	-3	0	0.70	0.00	0.00	0.00
1	0	2	-3	0	0.70	0.00	0.00	0.00
1	-1	2	-2	0	0.70	0.00	0.00	0.00
0	2	0	2	0	-0.70	0.00	0.00	0.00
0	0	2	4	0	0.70	0.00	0.00	0.00
5	0	0	0	0	0.60	0.00	0.00	0.00
3	0	0	-3	0	-0.60	0.00	0.00	0.00
2	2	0	-4	0	-0.60	0.00	0.00	0.00
1	-1	2	2	0	0.60	0.00	0.00	0.00
0	1	0	3	0	0.60	0.00	0.00	0.00
3	0	0	-2	0	-0.50	0.00	0.00	0.00
1	0	1	-2	0	0.00	0.50	0.00	0.00
0	2	0	-4	0	-0.50	0.00	0.00	0.00
0	0	2	-4	0	-0.50	0.00	0.00	0.00
0	0	1	-1	0	-0.50	0.00	0.00	0.00
0	0	0	6	0	0.50	0.00	0.00	0.00

4	0	0	2	0	0.40	0.00	0.00	0.00
3	0	0	-1	0	0.40	0.00	0.00	0.00
3	-1	0	2	0	0.40	0.00	0.00	0.00
2	1	0	1	0	0.40	0.00	0.00	0.00
2	1	0	-6	0	-0.40	0.00	0.00	0.00
2	-1	2	0	0	0.40	0.00	0.00	0.00
1	0	2	-1	0	0.40	0.00	0.00	0.00
1	-1	0	1	0	-0.40	0.00	0.00	0.00
1	-1	-2	-2	0	0.40	0.00	0.00	0.00
0	2	-2	2	-3	0.40	0.00	0.00	0.00
0	1	2	2	0	-0.40	0.00	0.00	0.00
0	0	2	2	3	0.40	0.00	0.00	0.00
0	0	2	-3	0	0.40	0.00	0.00	0.00
4	0	-2	-2	0	-0.30	0.00	0.00	0.00
3	1	0	-2	0	-0.30	0.00	0.00	0.00
3	-1	0	-2	0	-0.30	0.00	0.00	0.00
3	-1	0	-3	0	-0.30	0.00	0.00	0.00
2	1	2	0	0	-0.30	0.00	0.00	0.00
2	1	2	-2	0	-0.30	0.00	0.00	0.00
2	1	0	-3	0	0.30	0.00	0.00	0.00
2	0	2	0	3	0.30	0.00	0.00	0.00
1	1	0	-6	0	-0.30	0.00	0.00	0.00
1	0	2	1	0	-0.30	0.00	0.00	0.00
1	0	2	-2	3	-0.30	0.00	0.00	0.00
1	0	0	3	0	-0.30	0.00	0.00	0.00
1	-2	0	-1	0	-0.30	0.00	0.00	0.00
0	1	4	-4	4	0.30	0.00	0.00	0.00
0	0	4	-2	3	0.30	0.00	0.00	0.00

11.5 Planetary Nutation

```
* Planetary nutation
* Nutation model IAU2000A
*
* Fundamental arguments (radians)
*      t**0              t**1        t**2
* f1 = l
   2.355555980  8328.6914269554   0.0
* f2 = l'
   6.240060130   628.3019550000   0.0
* f3 = F
   1.627905234  8433.4661581310   0.0
* f4 = D
   5.198466741  7771.3771468121   0.0
* f5 = Omega
   2.182439200   -33.7570450000   0.0
* f6 = lMe
   4.402608842  2608.7903141574   0.0
* f7 = lVe
   3.176146697  1021.3285546211   0.0
* f8 = lE
   1.753470314   628.3075849991   0.0
* f9 = lMa
   6.203480913   334.0612426700   0.0
* f10 = lJu
   0.599546497    52.9690962641   0.0
* f11 = lSa
   0.874016757    21.3299104960   0.0
* f12 = lUr
   5.481293871     7.4781598567   0.0
* f13 = lNe
   5.321159000     3.8127774000   0.0
* f14 = pa
   0.0             0.0243817500   0.00000538691
*
* Series of the luni-solar nutation
* Number of terms
 658
*                Argument multipliers                      Coefficients (microarcseconds)
*  f1  f2  f3  f4  f5  f6  f7  f8  f9 f10 f11 f12 f13 f14     Cs       Cc       Ds       Dc
*
    0   0   1  -1   1   0   0  -1   0  -2   5   0   0   0  -308.40   512.30   273.50   164.70
    0   0   0   0   0   0   0   0   0   2  -5   0   0  -1   144.40   240.90   128.60   -77.10
    0   0   0   0   0   0   3  -5   0   0   0   0   0  -2   206.50     0.00     0.00    89.50
    0   0   1  -1   1   0  -8  12   0   0   0   0   0   0   120.00    59.80    31.90   -64.10
    0   0   0   0   0   0   0   0   0   2   0   0   0   2  -116.60     0.00     0.00    50.50
    0   0   0   0   1   0   0  -1   2   0   0   0   0   0   -46.00   -43.50   -23.20    24.60
    0   0   0   0   0   0   8 -13   0   0   0   0   0  -1   -42.50    21.20    13.30    26.90
    0   0   0   0   0   0   0   2  -8   3   0   0   0  -2    12.30   -41.60    19.90     5.90
    0   0   0   0   0   0   0   6  -8   3   0   0   0   2    12.30   -41.50   -18.00    -5.30
    0   0   0   0   0   0   0   3   0  -1   0   0   0   2    51.70     1.60     0.70   -20.10
    0   0   1  -1   1   0   0  -1   0   2  -5   0   0   0     3.10   -48.10   -25.70    -1.70
    0   0   0   0   0   0   4  -6   0   0   0   0   0  -2   -49.00     0.00     0.00   -21.30
    0   0   0   0   0   0   2  -4   0   0   0   0   0  -2    45.80     0.00     0.00    19.80
    0   0   2  -2   1   0  -5   6   0   0   0   0   0   0    -1.80   -43.60   -23.30     0.90
    0   0   0   0   1   0   0  -4   8  -3   0   0   0   0     8.40    29.80    15.90    -4.50
    0   0   0   0   0   0   2   0   0   0   0   0   0   2    37.00    -0.80     0.00   -16.00
    0   0   0   0   1   0   0   4  -8   3   0   0   0   0    -8.20    29.20    15.60     4.40
    0   0   1  -1   1   0   0   0  -2   0   0   0   0   0    27.30     8.00     4.30   -14.60
    0   0   0   0   0   0   1   1   0   0   0   0   0   2   -33.90     0.00     0.00    14.70
    0   0   0   0   0   0   0   0   0   2   0   0   0   1     5.10    27.20    14.50    -2.70
    2   0   0  -2  -1   0   0  -2   0   2   0   0   0   0   -28.40     0.00     0.00   -15.10
    0   0   0   0   0   0   5  -8   0   0   0   0   0  -2     1.10   -26.10    11.30     0.50
    0   0   0   0   0   0   0   1   0   1   0   0   0   2   -26.20     0.00     0.00    11.40
    0   0   1  -1   1   0   0  -1   0   0  -1   0   0   0    17.40     8.40     4.50    -9.30
    0   0   1  -1   1   0   0  -1   0  -1   0   0   0   0    -5.00    19.40    10.30     2.70
    0   0   0   0   0   0   0   0   0   2  -5   0   0   1     1.40   -21.80    11.70     0.80
    0   0   0   0   0   0   8 -13   0   0   0   0   0  -2     4.10    17.50    -7.60     1.70
    0   0   0   0   0   0   5  -7   0   0   0   0   0  -2   -20.20     0.00     0.00    -8.70
    1   0   2   0   2   0   0   1   0   0   0   0   0   0    13.10    -6.30    -2.60    -5.70
    1   0  -2   0  -2   0   0   4  -8   3   0   0   0   0    12.60    -6.30     2.70     5.50
    0   0   0   0   0   0   0   4   0  -2   0   0   0   2   -18.40    -0.30    -0.10     8.00
    0   0   0   0   0   0   0   2   0  -1   0   0   0   2   -15.40    -3.00    -1.30     6.70
    0   0   0   0   0   0   2  -1   0   0   0   0   0   2     0.50   -17.30    -7.50    -0.20
    0   0   0   0   0   0   0   2   0   1   0   0   0   2    16.30    -1.20    -0.50    -7.20
    0   0   0   0   0   0   8 -11   0   0   0   0   0  -2     6.20   -11.20     4.90     2.70
    0   0   0   0   0   0   0   8 -16   4   5   0   0  -2    -5.60   -11.70     4.20    -4.00
    0   0   1  -1   1   0   0  -1   0   2   0   0   0   0    -2.70   -14.30    -7.70     1.40
```

0	0	0	0	0	0	0	8	-16	4	5	0	0	2	12.50	-4.30	0.00	-5.40
0	0	1	-1	1	0	-5	7	0	0	0	0	0	0	14.00	2.70	1.40	-7.50
0	0	0	0	0	0	0	0	0	0	2	0	0	1	5.10	11.40	6.10	-2.70
0	0	1	-1	1	0	0	-1	0	0	2	0	0	0	-4.80	-11.00	-5.90	2.60
0	0	0	0	0	0	0	3	0	-2	0	0	0	2	6.70	-9.10	-3.90	-2.90
0	0	0	0	0	0	8	-15	0	0	0	0	0	-2	-6.10	-9.60	4.20	-2.70
0	0	0	0	0	0	0	1	2	0	0	0	0	2	-8.50	-7.00	-3.10	3.70
0	0	0	0	0	0	0	3	-2	0	0	0	0	2	8.00	-7.10	-3.10	-3.50
0	0	0	0	0	0	0	0	0	3	0	0	0	2	-12.70	2.10	0.90	5.50
0	0	0	0	0	0	0	4	-2	0	0	0	0	2	14.30	-0.30	-0.10	-6.20
0	0	0	0	0	0	0	0	0	0	2	0	0	2	-13.30	0.00	0.00	5.70
0	0	0	0	0	0	4	-6	0	0	0	0	0	-1	2.50	10.60	-5.60	1.40
0	0	0	0	0	0	1	-1	0	0	0	0	0	-1	-2.50	10.60	-5.70	-1.30
0	0	0	0	0	0	0	1	0	-3	0	0	0	-2	-11.80	0.00	0.00	-5.20
0	0	2	-2	1	0	-3	3	0	0	0	0	0	0	11.70	0.00	0.00	-6.30
0	0	0	0	0	0	6	-8	0	0	0	0	0	-2	-11.70	0.00	0.00	-5.10
0	0	1	-1	1	0	0	3	-8	3	0	0	0	0	-11.40	0.00	0.00	6.10
0	0	0	0	0	0	3	-2	0	0	0	0	0	2	0.00	-11.40	-5.00	0.00
0	0	0	0	0	0	2	-5	0	0	0	0	0	-2	0.00	-11.40	4.90	0.00
0	0	0	0	0	0	1	-3	0	0	0	0	0	-2	-11.30	0.00	0.00	-4.90
0	0	0	0	1	0	8	-13	0	0	0	0	0	0	4.60	6.60	3.50	-2.50
2	0	0	-2	1	0	0	-2	0	3	0	0	0	0	8.90	-1.60	-0.90	-4.80
0	0	0	0	0	0	5	-8	0	0	0	0	0	-1	-8.80	1.70	-0.90	-4.70
1	0	0	0	-1	0	-18	16	0	0	0	0	0	0	6.80	-3.40	1.80	3.60
0	0	1	-1	1	0	0	-5	8	-3	0	0	0	0	9.90	0.00	0.00	-5.30
0	0	0	0	1	0	-8	13	0	0	0	0	0	0	-4.00	5.70	3.00	2.10
0	0	0	0	1	0	0	0	0	-2	5	0	0	0	7.60	1.70	0.90	-4.10
0	0	0	0	1	0	0	0	0	2	-5	0	0	0	-7.30	1.70	0.90	3.90
0	0	0	0	1	0	0	0	0	1	0	0	0	0	2.00	-7.00	-3.70	-1.10
0	0	0	0	0	0	0	2	0	0	0	0	0	2	-8.90	0.00	0.00	3.80
0	0	0	0	0	0	0	6	-16	4	5	0	0	-2	0.00	-8.60	1.90	-0.60
1	0	0	0	1	0	-18	16	0	0	0	0	0	0	5.70	-2.80	-1.50	-3.00
0	0	0	0	0	0	0	1	0	2	0	0	0	2	-3.50	-4.80	-2.10	1.50
0	0	0	0	0	0	3	-7	0	0	0	0	0	-2	6.30	-1.60	0.70	2.80
0	0	1	-1	1	0	0	-1	0	0	1	0	0	0	-6.60	-1.20	-0.60	3.50
0	0	0	0	0	0	0	0	0	1	0	0	0	2	5.20	2.30	1.00	-2.30
0	0	0	0	0	0	7	-9	0	0	0	0	0	-2	-7.40	0.00	0.00	-3.20
0	0	0	0	0	0	0	0	2	0	0	0	0	2	-7.40	0.00	0.00	3.20
0	0	0	0	0	0	2	-4	0	0	0	0	0	-1	-1.40	-5.90	3.10	-0.80
0	0	0	0	1	0	0	1	-2	0	0	0	0	0	-3.70	3.50	1.90	2.00
0	0	0	0	0	0	3	-3	0	0	0	0	0	2	5.40	-1.50	-0.70	-2.40
0	0	0	0	0	0	4	-7	0	0	0	0	0	-2	-0.30	6.60	-2.90	-0.10
0	0	0	0	0	0	2	-2	0	0	0	0	0	-1	-1.20	5.50	-2.90	-0.60
0	0	0	0	0	0	0	0	0	1	0	0	0	-1	1.30	5.20	-2.80	0.70
2	0	0	-2	-1	0	0	-2	0	3	0	0	0	0	5.30	-0.90	0.50	2.80
0	0	0	0	0	0	3	-5	0	0	0	0	0	-1	-1.10	-4.90	2.60	-0.70
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.60	5.40	2.90	-0.30
1	0	0	-1	1	0	0	-1	0	2	0	0	0	0	-2.60	-2.90	-1.60	1.40
0	0	1	-1	1	0	0	-2	2	0	0	0	0	0	-0.80	-4.70	-2.50	0.40
0	0	0	0	0	0	0	0	0	0	1	0	0	1	4.70	0.80	0.40	-2.50
2	0	0	-2	1	0	0	-2	0	2	0	0	0	0	5.40	0.00	0.00	-2.90
0	0	0	0	0	0	0	0	4	0	0	0	0	2	-2.10	-3.20	-1.40	0.90
0	0	1	-1	1	0	0	-1	0	1	0	0	0	0	-0.60	-4.70	-2.50	0.30
0	0	0	0	0	0	8	-10	0	0	0	0	0	-2	-5.00	0.30	-0.10	-2.20
0	0	0	0	0	0	0	1	-2	0	0	0	0	-1	-0.60	4.70	-2.50	-0.30
0	0	0	0	0	0	0	2	-4	0	0	0	0	-2	5.10	0.00	0.00	2.20
0	0	2	-2	1	0	0	-2	0	2	0	0	0	0	5.00	0.00	0.00	-2.70
0	0	1	-1	1	0	-3	4	0	0	0	0	0	0	-1.00	4.00	2.10	0.50
0	0	0	0	0	0	0	5	-4	0	0	0	0	2	3.00	-1.80	-0.80	-1.30
0	0	0	0	0	0	0	4	-4	0	0	0	0	2	1.80	-2.90	-1.30	-0.80
0	0	0	0	0	0	0	0	0	0	1	0	0	-1	-3.20	1.50	0.80	1.70
0	0	0	0	0	0	6	-9	0	0	0	0	0	-2	0.00	-4.50	2.00	0.00
0	0	0	0	0	0	0	4	0	-3	0	0	0	2	-3.70	-0.70	-0.30	1.60
0	0	0	0	0	0	5	-7	0	0	0	0	0	-1	0.80	3.50	-1.90	0.50
0	0	0	0	0	0	0	2	0	0	0	0	0	1	0.70	-3.60	-1.50	-0.40
0	0	0	0	0	0	3	-3	0	0	0	0	0	-1	-0.80	3.40	-1.80	-0.40
0	0	0	0	0	0	2	1	0	0	0	0	0	2	1.90	-2.30	-1.00	0.20
0	0	0	0	0	0	0	4	-3	0	0	0	0	2	2.60	-1.40	-0.60	-1.10
0	0	0	0	0	0	1	-1	0	0	0	0	0	1	-0.70	-3.20	-1.70	0.40
0	0	0	0	0	0	1	-3	0	0	0	0	0	-1	-0.80	-3.10	1.60	-0.40
0	0	0	0	0	0	3	-1	0	0	0	0	0	2	3.10	-0.60	0.00	-1.30
0	0	0	0	0	0	0	3	-6	0	0	0	0	-2	2.40	-1.30	0.60	1.00
0	0	1	-1	1	0	0	-1	0	-4	10	0	0	0	0.90	-2.70	-1.40	-0.50
0	0	0	0	0	0	0	1	0	-4	0	0	0	-2	-3.00	-0.60	0.20	-1.30
2	0	2	0	2	0	0	2	0	-3	0	0	0	0	2.40	-1.20	-0.50	-1.10
0	0	2	0	2	0	0	1	0	0	0	0	0	0	-2.40	-1.20	-0.50	1.00
0	0	1	-1	1	0	0	-1	0	0	0	0	2	0	-1.70	-1.90	-1.00	0.90
0	0	1	-1	2	0	0	-1	0	0	2	0	0	0	1.10	2.40	1.10	-0.50
0	0	1	-1	1	0	-4	5	0	0	0	0	0	0	-0.70	2.80	1.50	0.40
0	0	0	0	0	0	0	4	0	-1	0	0	0	2	-0.30	-3.20	-1.40	0.10
0	0	0	0	0	0	0	2	-4	0	0	0	0	-1	1.40	2.10	-1.10	0.70
0	0	0	0	0	0	0	0	0	2	-5	0	0	-2	-1.10	-2.40	1.10	-0.90
0	0	0	0	0	0	0	1	-8	3	0	0	0	-2	2.20	1.20	-0.50	1.00

0	0	0	0	0	0	9	-11	0	0	0	0	0	-2	-3.40	0.00	0.00	-1.50
0	0	0	0	0	0	2	-3	0	0	0	0	0	-1	-3.00	-0.30	0.20	-1.60
1	0	2	0	1	0	0	-2	0	3	0	0	0	0	2.10	-1.10	-0.60	-1.10
1	0	-2	0	-1	0	0	-1	0	0	0	0	0	0	2.10	-1.10	0.60	1.10
0	0	2	-2	1	0	0	-9	13	0	0	0	0	0	1.00	-2.20	-1.20	-0.50
0	0	0	0	1	0	2	-3	0	0	0	0	0	0	0.00	-3.20	-1.70	0.00
0	0	0	0	1	0	0	-2	4	0	0	0	0	0	-1.10	-2.10	-1.10	0.60
0	0	1	1	1	0	0	1	0	0	0	0	0	0	-0.30	2.80	1.50	0.20
0	0	0	0	0	0	4	-4	0	0	0	0	0	-1	-0.60	2.40	-1.30	-0.30
0	0	0	0	0	0	0	1	-2	0	0	0	0	1	2.30	0.70	0.30	-1.30
1	0	0	-1	1	0	-3	4	0	0	0	0	0	0	0.00	2.90	1.50	0.00
0	0	0	0	0	0	6	-10	0	0	0	0	0	-2	-2.40	0.50	-0.20	-1.10
0	0	0	0	0	0	0	3	0	0	-1	0	0	2	2.90	0.00	0.00	-1.30
0	0	0	0	0	0	0	0	0	3	0	0	0	1	0.60	2.30	1.20	-0.40
0	0	0	0	1	0	1	-1	0	0	0	0	0	0	-2.80	0.00	0.00	1.50
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0.40	2.40	1.30	-0.20
0	0	0	0	0	0	1	1	0	0	0	0	0	1	0.50	-2.30	-1.20	-0.30
0	0	0	0	0	0	0	0	3	0	0	0	0	2	-1.80	-1.00	-0.40	0.80
0	0	2	-2	1	0	-4	4	0	0	0	0	0	0	2.70	0.00	0.00	-1.40
0	0	0	0	1	0	-3	5	0	0	0	0	0	0	-2.10	-0.60	-0.30	1.10
0	0	0	0	0	0	3	-6	0	0	0	0	0	-2	0.00	-2.70	1.20	0.00
0	0	0	0	0	0	0	1	-4	0	0	0	0	-2	1.90	-0.80	0.40	0.80
0	0	1	-1	1	0	-1	0	0	0	0	0	0	0	0.50	2.10	1.10	-0.30
0	0	0	0	0	0	0	7	-8	3	0	0	0	2	-2.50	0.00	0.00	1.10
0	0	0	0	0	0	0	4	-7	0	0	0	0	-2	-1.60	0.90	-0.40	-0.70
0	0	0	0	0	0	0	2	0	-2	0	0	0	1	-0.40	2.10	1.10	0.20
0	0	0	0	0	0	7	-10	0	0	0	0	0	-2	0.00	-2.40	1.00	0.00
0	0	0	0	0	0	6	-8	0	0	0	0	0	-1	0.50	1.90	-1.00	0.20
1	0	0	-1	-1	0	-3	4	0	0	0	0	0	0	0.00	2.30	-1.30	0.00
0	0	1	-1	1	0	8	-14	0	0	0	0	0	0	1.10	-1.20	-0.70	-0.60
0	0	1	-1	1	0	3	-6	0	0	0	0	0	0	-0.90	-1.40	-0.80	0.50
0	0	0	0	0	0	3	-9	4	0	0	0	0	-2	-1.40	0.90	-0.40	-0.60
0	0	1	-1	1	0	0	-3	4	0	0	0	0	0	0.90	-1.30	-0.70	-0.50
0	0	0	0	1	0	0	8	-15	0	0	0	0	0	1.50	-0.70	-0.40	-0.80
0	0	0	0	0	0	3	-5	4	0	0	0	0	2	-1.30	0.90	0.40	0.60
0	0	0	0	0	0	0	8	-15	0	0	0	0	-2	1.40	0.80	-0.30	0.60
0	0	0	0	0	0	0	6	0	0	0	0	0	2	1.30	0.90	0.40	-0.20
2	0	0	-2	1	0	-6	8	0	0	0	0	0	0	-1.70	-0.40	-0.20	0.90
0	0	0	0	0	0	5	-5	0	0	0	0	0	-1	-0.40	1.70	-0.90	-0.20
0	0	0	0	0	0	1	2	0	0	0	0	0	2	0.40	1.70	0.70	-0.20
0	0	0	0	0	0	3	0	0	0	0	0	0	2	1.70	-0.30	-0.10	0.00
0	0	0	0	0	0	0	5	-9	0	0	0	0	-2	-0.80	1.20	-0.50	-0.30
0	0	0	0	0	0	0	3	0	-3	0	0	0	2	0.90	-1.10	-0.50	-0.40
0	0	0	0	0	0	0	2	0	0	-1	0	0	2	0.00	-2.00	-0.90	0.00
0	0	0	0	0	0	0	0	0	0	0	0	2	1	-0.90	-1.10	0.60	-0.50
0	0	0	0	0	0	7	-11	0	0	0	0	0	-2	1.60	-0.30	0.10	0.70
0	0	1	-1	1	0	0	-9	15	0	0	0	0	0	0.00	1.90	1.00	0.00
0	0	0	0	1	0	0	0	0	-1	0	0	0	0	0.40	1.50	0.80	-0.20
0	0	0	0	1	0	-1	1	0	0	0	0	0	0	-1.90	0.00	0.00	1.00
0	0	0	0	1	0	-2	3	0	0	0	0	0	0	0.00	1.90	1.00	0.00
0	0	0	0	0	0	2	0	0	0	0	0	0	1	0.40	-1.50	-0.80	-0.20
0	0	0	0	0	0	0	5	-5	0	0	0	0	2	0.70	-1.20	-0.50	-0.30
0	0	0	0	0	0	0	3	-1	0	0	0	0	2	1.90	0.00	0.00	-0.80
0	0	0	0	0	0	0	2	0	0	1	0	0	2	0.00	-1.90	-0.80	0.00
0	0	1	-1	1	0	-2	2	0	0	0	0	0	0	1.80	0.00	0.00	-0.90
0	0	0	0	0	0	0	2	0	-2	5	0	0	2	1.20	-0.60	-0.30	-0.50
0	0	0	0	0	0	0	2	0	2	-5	0	0	2	-1.10	-0.60	-0.30	0.50
0	0	0	0	0	0	5	-3	0	0	0	0	0	2	1.40	-0.30	0.00	-0.10
0	0	0	0	0	0	0	3	0	2	-5	0	0	2	0.50	1.20	0.50	-0.20
0	0	0	0	0	0	0	3	-5	0	0	0	0	-2	-1.70	0.00	0.00	-0.70
0	0	0	0	0	0	0	2	0	-4	0	0	0	-2	-1.70	0.00	0.00	-0.70
2	0	0	-2	1	0	-3	3	0	0	0	0	0	0	1.60	0.00	0.00	-0.90
0	0	0	0	1	0	3	-7	4	0	0	0	0	0	1.00	-0.60	-0.30	-0.50
0	0	0	0	0	0	6	-6	0	0	0	0	0	-1	-0.30	1.30	-0.70	-0.20
0	0	0	0	0	0	2	-2	0	0	0	0	0	1	-0.30	-1.30	-0.70	0.10
0	0	0	0	0	0	2	-3	0	0	0	0	0	-2	-0.50	-1.10	0.50	-0.20
0	0	0	0	0	0	0	11	0	0	0	0	0	2	-1.10	0.50	0.20	0.50
0	0	0	0	0	0	0	6	-15	0	0	0	0	-2	-1.10	0.50	-0.20	-0.50
0	0	0	0	0	0	0	4	-8	0	0	0	0	-2	0.60	-1.00	0.40	0.30
0	0	0	0	0	0	0	3	0	1	0	0	0	2	-0.50	-1.10	-0.50	0.20
0	0	2	-2	2	0	-8	11	0	0	0	0	0	0	0.00	1.50	0.60	0.00
0	0	1	-1	2	0	0	-2	2	0	0	0	0	0	0.00	1.50	0.70	0.00
0	0	0	0	1	0	0	1	0	-1	0	0	0	0	1.50	0.00	0.00	-0.80
0	0	0	0	0	0	7	-9	0	0	0	0	0	-1	0.30	1.20	-0.60	0.20
0	0	0	0	0	0	4	-7	0	0	0	0	0	-1	1.20	-0.30	0.20	0.60
0	0	0	0	0	0	3	-3	0	0	0	0	0	1	0.30	1.20	0.60	-0.10
0	0	0	0	0	0	0	6	-6	0	0	0	0	2	0.60	-0.90	-0.40	-0.20
0	0	0	0	0	0	0	5	0	-2	0	0	0	2	0.30	1.20	0.50	-0.10
0	0	0	0	0	0	0	0	0	0	3	0	0	2	0.00	1.50	0.70	0.00
2	0	0	-2	-1	0	-6	8	0	0	0	0	0	0	-1.10	-0.30	0.10	-0.60
0	0	0	0	0	0	4	-4	0	0	0	0	0	2	1.10	-0.30	-0.10	-0.50
0	0	1	-1	1	0	0	-1	0	-1	1	0	0	0	0.00	1.40	0.70	0.00
0	0	0	0	1	0	-3	7	-4	0	0	0	0	0	-0.90	-0.50	-0.30	0.50

0	0	0	0	0	1	0	-4	0	0	0	0	0	-2	0.40	1.00	-0.40	0.20
0	0	0	0	0	0	0	6	0	0	0	0	0	0	1.40	0.00	0.00	-0.40
0	0	0	0	0	0	0	1	0	0	1	0	0	2	-1.40	0.00	0.00	0.60
0	0	0	0	0	0	0	1	-5	0	0	0	0	-2	0.50	-0.90	0.40	0.20
1	0	-2	-2	-2	0	0	-2	0	2	0	0	0	0	-1.30	0.00	0.00	-0.60
0	0	1	-1	1	0	2	-4	0	-3	0	0	0	0	0.00	-1.30	-0.70	0.00
0	0	0	0	1	0	3	-5	0	2	0	0	0	0	1.30	0.00	0.00	-0.70
0	0	0	0	0	0	5	-6	0	0	0	0	0	2	0.30	1.00	0.40	-0.10
0	0	0	0	0	0	0	1	1	0	0	0	0	2	-1.30	0.00	0.00	0.60
0	0	1	-1	1	0	0	-1	0	0	3	0	0	0	-0.80	0.40	0.20	0.40
0	0	0	0	1	0	0	2	-4	0	0	0	0	0	-0.40	0.80	0.40	0.20
0	0	0	0	0	0	4	-2	0	0	0	0	0	2	0.80	-0.40	0.00	-0.40
0	0	0	0	0	0	0	7	-13	0	0	0	0	-2	0.40	0.80	-0.30	0.20
0	0	0	0	0	0	0	0	0	0	3	0	0	1	0.80	-0.40	-0.20	-0.40
2	0	0	-2	-1	0	0	-2	0	0	5	0	0	0	-1.20	0.00	0.00	-0.60
0	0	2	-2	2	0	-3	3	0	0	0	0	0	0	-1.20	0.00	0.00	0.50
0	0	2	-2	2	0	-5	6	0	0	0	0	0	0	0.00	1.20	0.50	0.00
0	0	1	-1	1	0	0	-1	0	3	0	0	0	0	-0.30	-0.90	-0.50	0.20
0	0	0	0	0	0	3	-5	0	0	0	0	0	1	-0.30	-0.90	-0.50	0.30
0	0	0	0	0	0	0	1	0	3	0	0	0	2	-0.50	-0.70	-0.30	0.20
0	0	0	0	0	0	0	0	0	4	0	0	0	2	-0.90	0.30	0.10	0.40
0	0	2	-2	1	0	-2	2	0	0	0	0	0	0	1.10	0.00	0.00	-0.60
0	0	1	-1	-1	0	0	0	-2	0	0	0	0	0	-0.80	-0.30	0.10	-0.50
0	0	0	0	1	0	0	-1	0	1	0	0	0	0	1.10	0.00	0.00	-0.60
0	0	0	0	0	0	8	-13	0	0	0	0	0	1	0.50	-0.60	0.30	0.30
0	0	0	0	0	0	5	-10	0	0	0	0	0	-2	0.30	0.80	-0.40	0.10
0	0	0	0	0	0	1	0	0	0	0	0	0	2	-0.50	0.60	0.30	0.20
0	0	0	0	0	0	0	6	-11	0	0	0	0	-2	0.00	1.10	-0.50	0.00
0	0	0	0	0	0	0	1	-3	0	0	0	0	-2	1.10	0.00	0.00	0.50
2	0	0	-2	-1	0	0	-5	6	0	0	0	0	0	0.60	0.40	-0.20	0.30
2	0	-1	-1	-1	0	0	-1	0	3	0	0	0	0	0.30	0.70	-0.40	0.20
0	0	1	-1	2	0	0	-1	0	2	0	0	0	0	0.00	1.00	0.40	0.00
0	0	0	0	0	0	9	-12	0	0	0	0	0	-2	0.00	-1.00	0.50	0.00
0	0	0	0	0	0	5	-9	0	0	0	0	0	-2	-1.00	0.00	0.00	-0.40
0	0	0	0	0	0	4	-4	0	0	0	0	0	1	0.00	-1.00	-0.50	0.00
0	0	0	0	0	0	3	-1	0	0	0	0	0	1	0.00	-1.00	-0.60	-0.10
0	0	0	0	0	0	1	-2	0	0	0	0	0	1	-1.00	0.00	0.10	0.50
0	0	0	0	0	0	0	5	-3	0	0	0	0	2	-1.00	0.00	0.00	0.40
0	0	0	0	0	0	0	4	-8	1	5	0	0	-2	-0.30	-0.70	0.30	0.00
2	0	-1	-1	-1	0	0	3	-7	0	0	0	0	0	0.50	-0.40	0.20	0.30
0	0	2	0	2	0	0	4	-8	3	0	0	0	0	0.00	0.90	0.40	0.10
0	0	2	0	2	0	0	-4	8	-3	0	0	0	0	0.00	0.90	0.40	-0.10
0	0	1	-1	1	0	0	1	0	0	0	0	0	0	0.00	-0.90	-0.50	0.00
0	0	1	-1	1	0	-2	3	0	0	0	0	0	0	0.00	0.90	0.50	0.10
0	0	0	0	2	0	0	-1	2	0	0	0	0	0	-0.50	-0.40	-0.20	0.20
0	0	0	0	0	0	7	-7	0	0	0	0	0	-1	0.00	0.90	-0.50	-0.10
0	0	0	0	0	0	6	-9	0	0	0	0	0	-1	-0.90	0.00	0.00	-0.50
0	0	0	0	0	0	4	-3	0	0	0	0	0	2	0.00	0.90	0.40	0.00
0	0	0	0	0	0	0	5	0	-3	0	0	0	2	-0.90	0.00	0.10	0.40
0	0	0	0	0	0	0	3	-6	0	0	0	0	-1	0.90	0.00	-0.10	0.50
0	0	0	0	0	0	1	-2	0	0	0	0	0	-2	0.30	-0.60	0.20	0.10
0	0	0	0	0	0	0	6	-5	0	0	0	0	2	-0.60	0.30	0.10	0.30
0	0	0	0	0	0	0	2	-5	0	0	0	0	-2	0.60	-0.30	0.20	0.30
2	0	0	-2	1	0	0	-6	8	0	0	0	0	0	0.30	0.50	0.30	-0.20
2	0	-1	-1	-2	0	0	-1	0	2	0	0	0	0	0.00	-0.80	0.20	0.00
0	0	2	0	2	0	1	-1	0	0	0	0	0	0	0.80	0.00	0.00	-0.40
0	0	2	0	2	0	-1	1	0	0	0	0	0	0	-0.80	0.00	0.00	0.30
0	0	2	-2	1	0	0	-2	0	0	2	0	0	0	0.80	0.00	0.00	-0.40
0	0	2	-2	1	0	0	-8	11	0	0	0	0	0	0.00	0.80	0.40	0.00
0	0	2	-2	1	-1	0	2	0	0	0	0	0	0	0.00	0.80	0.40	0.10
0	0	1	-1	2	0	0	-1	0	-2	5	0	0	0	-0.30	0.50	0.20	0.10
0	0	1	-1	1	0	0	-1	0	0	0	2	0	0	0.00	-0.80	-0.40	-0.10
0	0	1	-1	1	0	0	-1	0	-1	2	0	0	0	0.00	-0.80	-0.40	0.00
0	0	1	-1	1	0	0	-1	0	-2	4	0	0	0	0.50	0.30	0.20	-0.20
0	0	0	0	1	0	3	-5	0	0	0	0	0	0	-0.80	0.00	0.10	0.40
0	0	0	0	1	0	0	-8	15	0	0	0	0	0	-0.50	-0.30	-0.10	0.30
0	0	0	0	0	0	5	-5	0	0	0	0	0	2	-0.80	0.00	0.00	0.40
0	0	0	0	0	0	2	-6	0	0	0	0	0	-2	0.80	0.00	0.00	0.40
0	0	0	0	0	0	0	8	-15	0	0	0	0	-1	0.00	0.80	0.40	0.00
0	0	0	0	0	0	0	5	-2	0	0	0	0	2	0.00	-0.80	-0.40	0.00
0	0	0	0	0	0	0	5	-8	0	0	0	0	-2	-0.50	0.30	-0.10	-0.20
0	0	0	0	0	0	0	2	2	0	0	0	0	2	-0.40	0.40	0.20	0.20
0	0	0	0	0	0	0	2	-6	0	0	0	0	-2	0.30	-0.50	0.20	0.10
0	0	0	0	0	0	0	0	0	0	1	0	0	2	0.00	0.80	0.40	0.00
1	0	0	-1	1	0	0	-3	4	0	0	0	0	0	0.40	0.30	0.10	-0.20
1	0	-2	-2	-2	0	-3	3	0	0	0	0	0	0	-0.70	0.00	0.00	-0.30
0	0	2	-2	1	0	0	-2	0	3	0	0	0	0	0.70	0.00	0.00	-0.40
0	0	1	-1	2	0	0	0	-2	0	0	0	0	0	-0.70	0.00	0.00	0.30
0	0	1	-1	1	0	0	-1	0	0	-2	0	0	0	0.30	-0.40	-0.20	-0.20
0	0	0	0	2	0	0	4	-8	3	0	0	0	0	0.00	-0.70	-0.30	0.00
0	0	0	0	2	0	0	-4	8	-3	0	0	0	0	0.00	-0.70	-0.30	0.00
0	0	0	0	1	0	0	-9	17	0	0	0	0	0	-0.30	-0.40	-0.20	0.10
0	0	0	0	0	0	8	-8	0	0	0	0	0	-1	0.00	0.70	-0.40	0.00

0	0	0	0	0	0	8	-10	0	0	0	0	0	-1	0.00	0.70	-0.40	0.00
0	0	0	0	0	0	4	-2	0	0	0	0	0	1	0.00	-0.70	-0.40	0.00
0	0	0	0	0	0	3	-4	0	0	0	0	0	-1	-0.70	0.00	0.00	-0.40
0	0	0	0	0	0	3	-6	0	0	0	0	0	-1	0.70	0.00	0.00	0.40
0	0	0	0	0	0	1	-4	0	0	0	0	0	-2	-0.30	-0.40	0.20	-0.10
0	0	0	0	0	0	0	6	0	0	0	0	0	1	0.00	0.70	0.30	0.00
0	0	0	0	0	0	0	6	-7	0	0	0	0	2	0.00	-0.70	-0.30	0.00
0	0	0	0	0	0	0	4	0	0	-2	0	0	2	-0.70	0.00	0.00	0.30
0	0	0	0	0	0	0	3	0	0	-2	0	0	2	0.00	-0.70	-0.30	0.00
0	0	0	0	0	0	0	1	0	-1	0	0	0	1	0.00	0.70	0.30	0.00
0	0	0	0	0	0	0	1	-6	0	0	0	0	-2	0.00	-0.70	0.30	0.00
0	0	0	0	0	0	0	0	0	4	-5	0	0	2	0.70	0.00	0.00	-0.30
0	0	0	0	0	0	0	0	0	0	0	2	0	2	-0.70	0.00	0.00	0.30
2	0	0	-2	-2	0	-3	3	0	0	0	0	0	0	-0.60	0.00	0.00	-0.30
2	0	-1	-1	-1	0	0	-1	0	2	0	0	0	0	0.00	-0.60	0.30	0.00
1	0	2	-2	2	0	0	-2	0	2	0	0	0	0	-0.60	0.00	0.00	0.30
1	0	-1	1	-1	0	-18	17	0	0	0	0	0	0	0.00	-0.60	0.30	0.00
0	0	2	0	2	0	0	1	0	-1	0	0	0	0	-0.60	0.00	0.00	0.30
0	0	2	0	2	0	0	-1	0	1	0	0	0	0	0.60	0.00	0.00	-0.30
0	0	2	-2	-1	0	-5	6	0	0	0	0	0	0	0.00	0.60	-0.30	0.00
0	0	1	-1	2	0	0	-1	0	1	0	0	0	0	0.00	0.60	0.30	0.00
0	0	1	-1	2	0	0	-1	0	-1	0	0	0	0	0.00	-0.60	-0.20	0.00
0	0	0	0	1	0	2	-2	0	0	0	0	0	0	0.60	0.00	0.00	-0.30
0	0	0	0	0	0	8	-12	0	0	0	0	0	-2	0.60	0.00	0.00	0.20
0	0	0	0	0	0	8	-16	0	0	0	0	0	-2	0.60	0.00	0.00	0.30
0	0	0	0	0	0	2	-3	0	0	0	0	0	1	0.30	-0.30	-0.10	-0.20
0	0	0	0	0	0	0	5	-6	0	0	0	0	2	0.00	-0.60	-0.20	0.00
0	0	0	0	0	0	0	4	-6	0	0	0	0	-2	-0.60	0.00	0.00	-0.20
0	0	0	0	0	0	0	4	-8	1	5	0	0	2	0.00	0.60	0.20	0.00
0	0	0	0	0	0	0	2	0	-2	0	0	0	2	-0.60	0.00	-0.10	0.30
0	0	0	0	0	0	0	2	-7	0	0	0	0	-2	0.00	-0.60	0.20	0.00
0	0	0	0	0	0	0	0	0	0	5	0	0	2	-0.60	0.00	0.00	0.30
0	0	0	0	0	0	0	0	0	0	0	0	2	2	-0.60	0.00	0.00	0.30
2	0	0	-2	-1	0	0	-2	0	4	-5	0	0	0	0.50	0.00	0.00	0.30
2	0	0	-2	-1	0	-3	3	0	0	0	0	0	0	0.50	0.00	0.00	0.30
2	0	-1	-1	-1	0	0	-1	0	0	0	0	0	0	0.00	-0.50	0.30	0.00
1	0	1	-1	1	0	0	-1	0	0	0	0	0	0	0.00	0.50	0.30	0.00
1	0	0	-1	-1	0	0	-2	2	0	0	0	0	0	-0.50	0.00	0.00	-0.30
1	0	-1	1	-1	0	0	1	0	0	0	0	0	0	0.00	-0.50	0.20	0.00
1	0	-1	-1	-1	0	20	-20	0	0	0	0	0	0	-0.50	0.00	0.00	-0.30
1	0	-2	0	-2	0	-10	3	0	0	0	0	0	0	0.50	0.00	-0.10	0.20
1	0	-2	-2	-2	0	0	-2	0	3	0	0	0	0	0.50	0.00	0.00	0.20
0	0	2	-2	2	0	0	-2	0	2	0	0	0	0	-0.50	0.00	0.00	0.20
0	0	2	-2	1	0	0	-1	0	1	0	0	0	0	0.50	0.00	0.00	-0.30
0	0	1	-1	2	0	0	-1	0	0	1	0	0	0	-0.50	0.00	0.00	0.20
0	0	1	-1	2	0	-5	7	0	0	0	0	0	0	-0.50	0.00	0.00	0.20
0	0	1	-1	1	0	1	-2	0	0	0	0	0	0	0.00	0.50	0.30	0.00
0	0	1	-1	1	0	-2	1	0	0	0	0	0	0	0.00	0.50	0.30	0.00
0	0	0	0	1	0	5	-8	0	0	0	0	0	0	0.00	0.50	0.30	0.00
0	0	0	0	1	0	0	2	-2	0	0	0	0	0	0.50	0.00	0.00	-0.20
0	0	0	0	1	0	0	0	0	0	-1	0	0	0	0.00	0.50	0.30	0.00
0	0	0	0	0	0	9	-9	0	0	0	0	0	-1	0.00	0.50	-0.20	-0.50
0	0	0	0	0	0	9	-11	0	0	0	0	0	-1	0.00	0.50	-0.30	0.00
0	0	0	0	0	0	6	-10	0	0	0	0	0	-1	0.00	0.50	-0.30	0.10
0	0	0	0	0	0	5	-3	0	0	0	0	0	1	0.00	-0.50	-0.30	0.00
0	0	0	0	0	0	4	-5	0	0	0	0	0	-1	-0.50	0.00	0.00	-0.20
0	0	0	0	0	0	3	-4	0	0	0	0	0	-2	0.00	-0.50	0.20	0.00
0	0	0	0	0	0	0	5	-10	0	0	0	0	-2	0.00	-0.50	0.20	0.00
0	0	0	0	0	0	0	4	0	-4	0	0	0	2	-0.50	0.00	0.00	0.20
0	0	0	0	0	0	0	2	0	0	0	0	0	0	-0.50	0.00	0.00	-3.50
0	0	0	0	0	0	0	2	0	-5	0	0	0	-2	-0.50	0.00	0.00	-0.20
0	0	0	0	0	0	0	1	0	-2	5	0	0	2	0.00	0.50	0.20	0.00
0	0	0	0	0	0	0	1	0	-2	0	0	0	-2	0.50	0.00	0.00	0.20
0	0	0	0	0	0	0	1	0	-3	0	0	0	-1	0.00	-0.50	0.30	0.00
0	0	0	0	0	0	0	1	0	-5	0	0	0	-2	-0.50	0.00	0.00	-0.20
0	0	0	0	0	0	0	0	0	0	0	2	0	1	0.00	-0.50	0.30	0.00
2	0	2	0	1	0	0	1	0	0	0	0	0	0	0.40	0.00	-0.10	-0.20
1	0	0	-1	1	0	0	-1	0	1	0	0	0	0	0.40	0.00	0.00	-0.20
0	0	2	-2	1	0	0	4	-8	3	0	0	0	0	0.00	0.40	0.20	0.00
0	0	2	-2	1	0	0	1	0	-1	0	0	0	0	-0.40	0.00	0.00	0.20
0	0	2	-2	1	0	0	-3	0	3	0	0	0	0	0.40	0.00	0.00	-0.20
0	0	2	-2	1	0	0	-4	8	-3	0	0	0	0	0.00	0.40	0.20	0.00
0	0	2	-2	1	0	-5	5	0	0	0	0	0	0	0.40	0.00	0.00	-0.20
0	0	1	-1	2	0	-8	12	0	0	0	0	0	0	-0.40	0.00	0.00	0.20
0	0	1	-1	1	0	1	-3	0	0	0	0	0	0	-0.40	0.00	0.00	0.20
0	0	1	-1	1	0	0	-1	0	0	0	-1	0	0	0.00	0.40	0.20	0.00
0	0	1	-1	1	0	0	-4	6	0	0	0	0	0	0.40	0.00	0.00	-0.20
0	0	1	-1	1	0	-5	6	0	0	0	0	0	0	0.00	0.40	0.20	0.00
0	0	1	-1	-1	0	0	-1	0	-1	0	0	0	0	0.00	-0.40	0.20	0.10
0	0	0	0	1	0	3	-4	0	0	0	0	0	0	0.00	-0.40	-0.20	0.00
0	0	0	0	1	0	0	1	0	-2	0	0	0	0	0.00	-0.40	-0.20	-0.10
0	0	0	0	1	0	-2	2	0	0	0	0	0	0	0.40	0.00	0.00	-0.20
0	0	0	0	0	0	7	-10	0	0	0	0	0	-1	-0.40	0.00	0.00	-0.20

0	0	0	0	0	0	5	-5	0	0	0	0	0	1	0.00	-0.40	-0.20	0.00
0	0	0	0	0	0	4	-5	0	0	0	0	0	-2	0.00	-0.40	0.20	0.00
0	0	0	0	0	0	3	-8	0	0	0	0	0	-2	0.00	0.40	-0.20	0.00
0	0	0	0	0	0	2	-5	0	0	0	0	0	-1	0.40	0.00	0.00	0.20
0	0	0	0	0	0	1	-2	0	0	0	0	0	-1	0.40	0.00	0.00	0.20
0	0	0	0	0	0	0	7	-8	0	0	0	0	2	0.00	-0.40	-0.20	0.00
0	0	0	0	0	0	0	7	-9	0	0	0	0	2	0.00	-0.40	-0.20	0.00
0	0	0	0	0	0	0	6	-10	0	0	0	0	-2	0.00	0.40	-0.20	-0.10
0	0	0	0	0	0	0	3	0	0	0	0	0	2	0.00	0.40	0.20	0.00
0	0	0	0	0	0	0	3	-8	3	0	0	0	-2	0.40	0.00	0.00	0.20
0	0	0	0	0	0	0	2	0	0	-2	0	0	1	0.00	0.40	0.20	0.00
0	0	0	0	0	0	0	2	-4	0	0	0	0	1	0.40	0.00	0.00	-0.20
0	0	0	0	0	0	0	1	0	0	0	0	0	-1	0.40	0.00	0.00	0.20
0	0	0	0	0	0	0	1	0	-1	0	0	0	-1	0.00	-0.40	0.20	0.00
2	0	2	-2	2	0	0	-2	0	3	0	0	0	0	0.30	0.00	0.00	-0.10
2	0	1	-3	1	0	-6	7	0	0	0	0	0	0	0.00	0.30	0.10	0.00
2	0	0	-2	1	0	0	-5	6	0	0	0	0	0	0.30	0.00	0.00	-0.20
2	0	0	-2	-1	0	0	-2	0	3	-1	0	0	0	-0.30	0.00	0.00	-0.20
2	0	0	-2	-1	0	0	-6	8	0	0	0	0	0	0.00	0.30	-0.20	0.10
2	0	-1	-1	1	0	0	3	-7	0	0	0	0	0	0.30	0.00	-0.10	-0.20
2	0	-2	-2	-2	0	0	-2	0	2	0	0	0	0	0.30	0.00	0.00	0.10
1	0	2	0	2	0	1	-1	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
1	0	2	0	2	0	0	4	-8	3	0	0	0	0	0.00	0.30	0.10	0.00
1	0	2	0	2	0	0	-4	8	-3	0	0	0	0	0.00	0.30	0.10	0.00
1	0	2	0	2	0	-1	1	0	0	0	0	0	0	-0.30	0.00	0.00	0.10
1	0	2	-2	2	0	-3	3	0	0	0	0	0	0	-0.30	0.00	0.00	0.10
1	0	1	1	1	0	0	1	0	0	0	0	0	0	0.00	0.30	0.20	0.00
1	0	0	0	1	0	-10	3	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
1	0	0	0	-1	0	-10	3	0	0	0	0	0	0	0.30	0.00	0.00	0.10
1	0	0	-1	-1	0	0	-3	4	0	0	0	0	0	0.30	0.00	0.00	0.20
1	0	0	-2	1	0	0	-2	0	2	0	0	0	0	0.30	0.00	0.00	-0.20
1	0	0	-2	-1	0	0	-2	0	2	0	0	0	0	0.30	0.00	0.00	0.20
1	0	-1	0	-1	0	-3	5	0	0	0	0	0	0	0.30	0.00	0.00	0.20
1	0	-2	-2	-2	0	0	1	0	-1	0	0	0	0	-0.30	0.00	0.00	-0.10
0	0	2	2	2	0	0	2	0	-2	0	0	0	0	0.30	0.00	0.00	-0.10
0	0	2	0	2	0	2	-2	0	0	0	0	0	0	-0.30	0.00	0.00	0.10
0	0	2	0	2	0	2	-3	0	0	0	0	0	0	0.00	0.30	0.10	0.00
0	0	2	0	2	0	-2	3	0	0	0	0	0	0	0.00	0.30	0.10	0.00
0	0	2	0	2	0	-2	2	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
0	0	2	-2	1	0	1	-1	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
0	0	2	-2	1	0	0	-2	0	1	0	0	0	0	-0.30	0.00	0.00	0.10
0	0	2	-2	1	0	0	-2	0	0	0	0	0	0	-0.30	0.00	0.00	0.20
0	0	2	-2	1	0	0	-4	4	0	0	0	0	0	0.30	0.00	0.00	-0.20
0	0	2	-2	1	0	0	-7	9	0	0	0	0	0	0.00	0.30	0.20	-0.10
0	0	2	-2	1	0	0	-10	15	0	0	0	0	0	-0.30	0.00	0.00	0.10
0	0	2	-2	1	0	-8	11	0	0	0	0	0	0	0.00	0.30	0.20	0.00
0	0	1	1	2	0	0	1	0	0	0	0	0	0	0.00	-0.30	-0.20	0.00
0	0	1	-1	2	0	0	-1	0	0	-1	0	0	0	-0.30	0.00	0.00	0.10
0	0	1	-1	2	0	-3	4	0	0	0	0	0	0	0.00	-0.30	-0.10	0.00
0	0	1	-1	1	0	0	1	-4	0	0	0	0	0	0.30	0.00	0.00	-0.20
0	0	1	-1	1	0	0	-1	0	1	-3	0	0	0	0.00	0.30	0.20	0.00
0	0	1	-1	1	0	-1	2	0	0	0	0	0	0	0.00	0.30	0.10	0.00
0	0	1	-1	1	0	-4	6	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
0	0	1	-1	-1	0	-5	7	0	0	0	0	0	0	0.30	0.00	0.00	0.10
0	0	0	0	2	0	0	0	0	1	0	0	0	0	0.00	-0.30	-0.10	0.00
0	0	0	0	2	0	-3	5	0	0	0	0	0	0	0.30	0.00	0.00	-0.10
0	0	0	0	1	0	0	7	-13	0	0	0	0	0	-0.30	0.00	0.00	0.20
0	0	0	0	1	0	0	2	0	-2	0	0	0	0	-0.30	0.00	0.00	0.20
0	0	0	0	1	0	0	-1	0	2	0	0	0	0	0.00	0.30	0.10	0.00
0	0	0	0	1	0	0	-2	2	0	0	0	0	0	0.30	0.00	0.00	-0.20
0	0	0	0	1	0	-1	2	0	0	0	0	0	0	0.00	0.30	0.10	0.00
0	0	0	0	1	0	-3	4	0	0	0	0	0	0	0.00	0.30	0.20	0.00
0	0	0	0	0	0	9	-13	0	0	0	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	8	-11	0	0	0	0	0	-1	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	8	-14	0	0	0	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	7	-11	0	0	0	0	0	-1	0.00	-0.30	0.20	0.00
0	0	0	0	0	0	6	-4	0	0	0	0	0	1	0.00	-0.30	-0.20	0.00
0	0	0	0	0	0	6	-6	0	0	0	0	0	1	0.00	-0.30	-0.20	0.00
0	0	0	0	0	0	6	-7	0	0	0	0	0	-1	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	5	-4	0	0	0	0	0	2	0.00	0.30	0.10	0.00
0	0	0	0	0	0	5	-6	0	0	0	0	0	-1	-0.30	0.00	0.00	-0.20
0	0	0	0	0	0	5	-6	0	0	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	4	-2	0	0	0	0	0	0	0.00	0.30	-0.20	0.00
0	0	0	0	0	0	4	-8	0	0	0	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	3	-3	0	2	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	3	-4	0	0	0	0	0	1	0.30	0.00	0.00	-0.20
0	0	0	0	0	0	2	1	0	0	0	0	0	1	0.00	0.30	0.20	-1.00
0	0	0	0	0	0	1	-1	0	0	0	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	1	-4	0	0	0	0	0	-1	0.30	0.00	0.00	0.20
0	0	0	0	0	0	0	9	-17	0	0	0	0	-2	-0.30	0.00	0.00	-0.20
0	0	0	0	0	0	0	7	-7	0	0	0	0	2	0.00	0.30	-0.20	0.00
0	0	0	0	0	0	0	7	-12	0	0	0	0	-2	0.00	0.30	-0.10	0.00
0	0	0	0	0	0	0	6	-4	0	0	0	0	2	-0.30	0.00	0.00	0.10

0	0	0	0	0	0	0	6	-8	1	5	0	0	2	0.00	-0.30	-0.10	0.00
0	0	0	0	0	0	0	6	-9	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	5	0	-4	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	0	5	-7	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	5	-8	3	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	0	5	-9	0	0	0	0	-1	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	5	-13	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	5	-16	4	5	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	0	4	-7	0	0	0	0	-1	-0.30	0.00	0.00	-0.20
0	0	0	0	0	0	0	4	-8	3	0	0	0	1	0.30	0.00	0.00	-0.20
0	0	0	0	0	0	0	4	-8	3	0	0	0	-1	0.30	0.00	0.00	0.20
0	0	0	0	0	0	0	3	0	-5	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	3	-5	0	0	0	0	-1	0.00	-0.30	0.20	-0.10
0	0	0	0	0	0	0	3	-7	0	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	0	3	-9	0	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	0	2	1	0	0	0	0	2	0.30	0.00	0.10	-0.10
0	0	0	0	0	0	0	2	0	2	0	0	0	2	0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	2	-8	1	5	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	0	1	0	1	0	0	0	1	0.00	0.30	0.20	0.00
0	0	0	0	0	0	0	1	0	0	2	0	0	2	0.00	-0.30	-0.10	0.00
0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.30	0.00	0.00	-0.10
0	0	0	0	0	0	0	4	-8	3	0	0	0	0	-46.20	160.40	0.00	0.00
0	0	0	0	0	0	1	-1	0	0	0	0	0	0	148.50	0.00	0.00	0.00
0	0	0	0	0	0	0	8	-16	4	5	0	0	0	144.00	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	-1	0	0	0	0	-122.30	-2.90	0.00	0.00
0	0	0	0	0	0	0	1	-2	0	0	0	0	0	-44.90	43.00	0.00	0.00
0	0	0	0	0	0	2	-3	0	0	0	0	0	0	0.80	61.40	0.00	0.00
0	0	0	0	0	0	0	0	0	2	-5	0	0	0	-49.10	12.80	0.00	0.00
0	0	0	0	0	0	2	-2	0	0	0	0	0	0	-59.80	0.00	0.00	0.00
0	0	0	0	0	0	8	-13	0	0	0	0	0	0	23.50	33.40	0.00	0.00
2	0	0	-2	0	0	0	-2	0	2	0	0	0	0	43.90	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	-2	0	0	0	0	-16.60	26.90	0.00	0.00
0	0	0	0	0	0	0	2	0	-2	0	0	0	0	41.30	1.30	0.00	0.00
2	0	0	-2	0	0	0	-2	0	3	0	0	0	0	34.90	-6.20	0.00	0.00
0	0	0	0	0	0	0	2	-2	0	0	0	0	0	-36.80	0.00	0.00	0.00
0	0	1	-1	0	0	0	0	-2	0	0	0	0	0	-26.60	-7.80	0.00	0.00
0	0	0	0	0	0	0	0	0	1	0	0	0	0	-9.10	24.80	0.00	0.00
0	0	0	0	0	0	3	-4	0	0	0	0	0	0	-0.50	32.80	0.00	0.00
1	0	0	0	0	0	-18	16	0	0	0	0	0	0	-22.60	10.10	0.00	0.00
1	0	0	0	0	0	-10	3	0	0	0	0	0	0	21.90	8.90	0.00	0.00
0	0	2	-2	0	0	-5	6	0	0	0	0	0	0	1.00	23.30	0.00	0.00
0	0	0	0	0	0	0	2	-4	0	0	0	0	0	-8.60	15.30	0.00	0.00
0	0	0	0	0	0	3	-5	0	0	0	0	0	0	-14.50	4.70	0.00	0.00
1	0	0	-2	0	0	19	-21	3	0	0	0	0	0	10.30	-6.00	0.00	0.00
2	0	0	-2	0	0	-3	3	0	0	0	0	0	0	13.80	0.00	0.00	0.00
1	0	0	-1	0	0	-3	4	0	0	0	0	0	0	0.00	13.10	0.00	0.00
0	0	0	0	0	0	0	3	-4	0	0	0	0	0	-7.80	4.50	0.00	0.00
0	0	0	0	0	0	1	-2	0	0	0	0	0	0	2.20	-8.70	0.00	0.00
0	0	0	0	0	0	0	2	-3	0	0	0	0	0	-6.80	3.90	0.00	0.00
0	0	1	-1	0	0	0	-1	0	-1	0	0	0	0	2.10	-7.80	0.00	0.00
0	0	0	0	0	0	0	2	0	-3	0	0	0	0	8.30	1.50	0.00	0.00
2	0	0	-2	0	0	-6	8	0	0	0	0	0	0	-7.80	-1.80	0.00	0.00
0	0	0	0	0	0	3	-3	0	0	0	0	0	0	8.90	0.00	0.00	0.00
0	0	0	0	0	0	4	-4	0	0	0	0	0	0	8.30	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	0	-1	0	0	0	-7.50	0.00	0.00	0.00
0	0	0	0	0	0	0	8	-15	0	0	0	0	0	4.50	-2.20	0.00	0.00
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1.10	5.60	0.00	0.00
0	0	0	0	0	0	0	1	0	-3	0	0	0	0	-2.80	3.60	0.00	0.00
0	0	1	-1	0	0	0	-1	0	0	-1	0	0	0	4.20	2.00	0.00	0.00
0	0	0	0	0	0	4	-6	0	0	0	0	0	0	-4.60	1.40	0.00	0.00
0	0	0	0	0	0	5	-5	0	0	0	0	0	0	5.90	0.00	0.00	0.00
0	0	0	0	0	0	0	3	-5	0	0	0	0	0	-2.00	3.40	0.00	0.00
1	0	0	-1	0	0	0	-1	0	1	0	0	0	0	5.30	0.00	0.00	0.00
0	0	0	0	0	0	5	-8	0	0	0	0	0	0	-1.40	-3.90	0.00	0.00
0	0	0	0	0	0	0	0	0	2	0	0	0	0	-2.50	2.20	0.00	0.00
0	0	0	0	0	0	0	1	0	2	-5	0	0	0	-1.30	-3.00	0.00	0.00
0	0	1	-1	0	0	-5	7	0	0	0	0	0	0	-3.50	-0.70	0.00	0.00
0	0	0	0	0	0	6	-6	0	0	0	0	0	0	4.00	0.00	0.00	0.00
0	0	0	0	0	0	0	4	-6	0	0	0	0	0	-1.60	2.30	0.00	0.00
2	0	0	-2	0	0	0	-6	8	0	0	0	0	0	1.50	2.20	0.00	0.00
2	0	0	-2	0	0	0	-5	6	0	0	0	0	0	2.40	1.20	0.00	0.00
2	0	-1	-1	0	0	0	3	-7	0	0	0	0	0	2.60	-0.90	0.00	0.00
0	0	0	0	0	0	0	2	0	-1	0	0	0	0	0.00	3.50	0.00	0.00
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0.80	-2.70	0.00	0.00
1	0	0	-2	0	0	0	-2	0	2	0	0	0	0	3.40	0.00	0.00	0.00
2	0	0	0	0	0	0	-2	0	3	0	0	0	0	-2.10	1.10	0.00	0.00
0	0	0	0	0	0	1	0	0	0	0	0	0	0	-0.40	-2.80	0.00	0.00
0	0	0	0	0	0	0	3	-6	0	0	0	0	0	0.00	3.10	0.00	0.00
0	0	0	0	0	0	0	3	-8	3	0	0	0	0	-1.90	-1.10	0.00	0.00
0	0	0	0	0	0	7	-7	0	0	0	0	0	0	2.80	0.00	0.00	0.00
0	0	0	0	0	0	0	3	-3	0	0	0	0	0	2.70	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	0	-2	0	0	0	-0.60	2.00	0.00	0.00
0	0	1	-1	0	0	0	-1	0	-2	5	0	0	0	0.90	-1.60	0.00	0.00

0	0	0	0	0	0	2	-1	0	0	0	0	0	0	0.60	1.90	0.00	0.00
0	0	0	0	0	0	0	1	-1	0	0	0	0	0	-2.50	0.00	0.00	0.00
1	0	0	-1	0	0	0	-3	4	0	0	0	0	0	1.60	0.80	0.00	0.00
0	0	1	-1	0	0	0	-1	0	-1	1	0	0	0	0.00	2.40	0.00	0.00
0	0	0	0	0	0	0	5	-8	3	0	0	0	0	2.10	0.30	0.00	0.00
0	0	0	0	0	0	0	4	-5	0	0	0	0	0	1.60	-0.60	0.00	0.00
0	0	0	0	0	0	0	4	-7	0	0	0	0	0	0.00	2.20	0.00	0.00
0	0	0	0	0	0	5	-7	0	0	0	0	0	0	1.60	-0.50	0.00	0.00
0	0	0	0	0	0	0	3	0	-3	0	0	0	0	1.80	-0.30	0.00	0.00
0	0	1	-1	0	0	-8	12	0	0	0	0	0	0	1.40	0.70	0.00	0.00
0	0	0	0	0	0	0	5	-9	0	0	0	0	0	0.70	1.30	0.00	0.00
0	0	1	-1	0	0	0	-1	0	2	0	0	0	0	0.30	1.60	0.00	0.00
0	0	0	0	0	0	0	1	0	1	0	0	0	0	0.80	1.10	0.00	0.00
1	0	0	-2	0	0	-3	3	0	0	0	0	0	0	1.90	0.00	0.00	0.00
0	0	0	0	0	0	8	-8	0	0	0	0	0	0	1.90	0.00	0.00	0.00
0	0	0	0	0	0	0	3	0	-2	0	0	0	0	-0.40	-1.20	0.00	0.00
2	0	0	-2	0	0	0	-2	0	4	-3	0	0	0	0.60	-0.90	0.00	0.00
2	0	0	-2	0	0	0	-2	0	3	-1	0	0	0	-1.50	0.00	0.00	0.00
0	0	0	0	0	0	0	6	-11	0	0	0	0	0	0.90	0.60	0.00	0.00
0	0	0	0	0	0	0	2	0	0	-2	0	0	0	1.50	0.00	0.00	0.00
0	0	0	0	0	0	0	2	0	-4	0	0	0	0	1.10	0.40	0.00	0.00
1	0	0	-2	0	0	0	-2	0	3	0	0	0	0	-1.30	0.00	0.00	0.00
0	0	2	-2	0	0	-3	3	0	0	0	0	0	0	-1.30	0.00	0.00	0.00
0	0	1	-1	0	0	0	-1	0	0	2	0	0	0	0.40	0.90	0.00	0.00
0	0	0	0	0	0	9	-9	0	0	0	0	0	0	1.30	0.00	0.00	0.00
0	0	0	0	0	0	0	5	-7	0	0	0	0	0	0.50	-0.70	0.00	0.00
0	0	0	0	0	0	0	0	0	2	-5	0	0	2	-1.20	0.00	0.00	0.00
0	0	0	0	0	0	1	-3	0	0	0	0	0	0	0.80	-0.30	0.00	0.00
0	0	0	0	0	0	0	9	-17	0	0	0	0	0	0.50	-0.60	0.00	0.00
0	0	0	0	0	0	0	5	-8	0	0	0	0	0	0.00	1.10	0.00	0.00
0	0	0	0	0	0	3	-5	0	2	0	0	0	0	1.00	0.00	0.00	0.00
0	0	0	0	0	0	2	-4	0	0	0	0	0	0	0.50	-0.50	0.00	0.00
0	0	0	0	0	0	0	7	-13	0	0	0	0	0	1.00	0.00	0.00	0.00
0	0	0	0	0	0	6	-7	0	0	0	0	0	0	0.00	0.90	0.00	0.00
0	0	0	0	0	0	0	3	-2	0	0	0	0	0	0.00	0.90	0.00	0.00
1	0	0	-2	0	0	20	-21	0	0	0	0	0	0	0.00	-0.80	0.00	0.00
0	0	2	-2	0	0	0	-9	13	0	0	0	0	0	0.30	-0.50	0.00	0.00
0	0	0	0	0	1	0	-4	0	0	0	0	0	0	0.50	0.30	0.00	0.00
0	0	0	0	0	0	8	-12	0	0	0	0	0	0	0.80	0.00	0.00	0.00
0	0	0	0	0	0	5	-6	0	0	0	0	0	0	0.00	0.80	0.00	0.00
0	0	0	0	0	0	0	4	-4	0	0	0	0	0	0.80	0.00	0.00	0.00
0	0	0	0	0	0	0	4	-8	0	0	0	0	0	0.30	0.50	0.00	0.00
0	0	0	0	0	0	0	1	0	-4	0	0	0	0	-0.40	0.40	0.00	0.00
1	0	0	-2	0	0	0	1	0	-1	0	0	0	0	0.70	0.00	0.00	0.00
0	0	0	0	0	0	3	-7	4	0	0	0	0	0	-0.70	0.00	0.00	0.00
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0.30	-0.40	0.00	0.00
1	0	0	0	0	0	0	-2	0	2	0	0	0	0	-0.60	0.00	0.00	0.00
1	0	0	-2	0	0	2	-2	0	0	0	0	0	0	0.60	0.00	0.00	0.00
0	0	0	0	0	0	7	-8	0	0	0	0	0	0	0.00	0.60	0.00	0.00
0	0	0	0	0	0	0	0	2	0	0	0	0	0	0.60	0.00	0.00	0.00
2	0	0	-2	0	0	0	-4	8	-3	0	0	0	0	-0.50	0.00	0.00	0.00
2	0	0	-2	0	0	-2	2	0	0	0	0	0	0	0.50	0.00	0.00	0.00
1	0	0	0	0	0	0	4	-8	3	0	0	0	0	0.00	-0.50	0.00	0.00
1	0	0	0	0	0	0	-4	8	-3	0	0	0	0	0.00	-0.50	0.00	0.00
1	0	0	0	0	0	-1	1	0	0	0	0	0	0	0.50	0.00	0.00	0.00
1	0	0	-1	0	0	0	-2	2	0	0	0	0	0	0.50	0.00	0.00	0.00
1	0	0	-2	0	0	17	-16	0	-2	0	0	0	0	0.00	0.50	0.00	0.00
0	0	2	-2	0	0	0	-2	0	2	0	0	0	0	-0.50	0.00	0.00	0.00
0	0	0	0	0	0	0	6	-9	0	0	0	0	0	0.00	-0.50	0.00	0.00
0	0	0	0	0	0	0	3	0	-4	0	0	0	0	0.50	0.00	0.00	0.00
0	0	0	0	0	0	0	0	0	0	0	1	-2	-2	0.00	0.50	0.00	0.00
2	0	0	-2	0	0	0	-2	0	2	2	0	0	0	-0.40	0.00	0.00	0.00
2	0	0	-2	0	0	0	-4	4	0	0	0	0	0	0.40	0.00	0.00	0.00
1	0	0	0	0	0	1	-1	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
1	0	0	0	0	0	0	-1	0	1	0	0	0	0	-0.40	0.00	0.00	0.00
1	0	0	0	0	0	-3	3	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
1	0	0	-2	0	0	1	-1	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
1	0	0	-2	0	0	0	4	-8	3	0	0	0	0	0.00	-0.40	0.00	0.00
1	0	0	-2	0	0	0	-4	8	-3	0	0	0	0	0.00	-0.40	0.00	0.00
1	0	0	-2	0	0	-2	2	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
0	0	2	-2	0	0	-4	4	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
0	0	1	1	0	0	0	1	0	0	0	0	0	0	0.00	-0.40	0.00	0.00
0	0	1	-1	0	0	3	-6	0	0	0	0	0	0	0.00	0.40	0.00	0.00
0	0	1	-1	0	0	0	-1	0	1	0	0	0	0	0.00	0.40	0.00	0.00
0	0	1	-1	0	0	0	-1	0	0	1	0	0	0	0.40	0.00	0.00	0.00
0	0	1	-1	0	0	0	-2	2	0	0	0	0	0	0.00	0.40	0.00	0.00
0	0	1	-1	0	0	-3	4	0	0	0	0	0	0	0.00	-0.40	0.00	0.00
0	0	1	-1	0	0	-4	5	0	0	0	0	0	0	0.00	-0.40	0.00	0.00
0	0	0	2	0	0	0	-1	0	1	0	0	0	0	-0.40	0.00	0.00	0.00
0	0	0	0	0	0	8	-9	0	0	0	0	0	0	0.00	0.40	0.00	0.00
0	0	0	0	0	0	3	-6	0	0	0	0	0	0	0.00	-0.40	0.00	0.00
0	0	0	0	0	0	1	1	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
0	0	0	0	0	0	0	0	0	3	-5	0	0	0	0.00	-0.40	0.00	0.00

0	0	0	0	0	0	0	0	0	2	-2	0	0	0	-0.40	0.00	0.00	0.00
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.20	0.10	0.00	0.00
2	0	0	-2	0	0	2	-5	0	0	0	0	0	0	0.00	-0.30	0.00	0.00
2	0	0	-2	0	0	0	-2	0	5	-5	0	0	0	0.00	0.30	0.00	0.00
2	0	0	-2	0	0	0	-2	0	1	5	0	0	0	0.30	0.00	0.00	0.00
2	0	0	-2	0	0	0	-2	0	0	5	0	0	0	0.30	0.00	0.00	0.00
2	0	0	-2	0	0	0	-2	0	0	2	0	0	0	0.30	0.00	0.00	0.00
2	0	0	-2	0	0	-4	4	0	0	0	0	0	0	0.30	0.00	0.00	0.00
2	0	-1	-1	0	0	0	-1	0	3	0	0	0	0	0.00	0.30	0.00	0.00
2	0	-2	0	-2	0	0	5	-9	0	0	0	0	0	0.00	0.30	0.00	0.00
1	0	0	0	0	0	0	1	0	-1	0	0	0	0	0.30	0.00	0.00	0.00
1	0	0	0	0	0	0	-2	0	3	0	0	0	0	0.30	0.00	0.00	0.00
1	0	0	-2	0	0	0	2	0	-2	0	0	0	0	-0.30	0.00	0.00	0.00
1	0	-1	1	0	0	0	1	0	0	0	0	0	0	0.00	0.30	0.00	0.00
1	0	-1	-1	0	0	0	8	-15	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	2	-2	0	-1	0	2	0	0	0	0	0	0	0.00	-0.30	0.00	0.00
0	0	1	-1	0	0	0	1	0	0	0	0	0	0	0.00	0.30	0.00	0.00
0	0	1	-1	0	0	0	-1	0	0	-2	0	0	0	0.00	0.30	0.00	0.00
0	0	1	-1	0	0	-1	0	0	0	0	0	0	0	0.00	-0.30	0.00	0.00
0	0	1	-1	0	0	-2	2	0	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	2	0	0	0	2	0	-2	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	2	0	0	-2	2	0	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	6	-8	0	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	6	-9	0	0	0	0	0	0	0.00	-0.30	0.00	0.00
0	0	0	0	0	0	5	-6	-4	0	0	0	0	-2	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	4	-5	0	0	0	0	0	0	0.00	-0.30	0.00	0.00
0	0	0	0	0	0	3	-1	0	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	2	0	0	0	0	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	6	-10	0	0	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	0	0	5	-6	0	0	0	0	0	0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	2	0	0	-3	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	0	0	1	0	1	-5	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	0	-3	0	0	0	-0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	-3	5	0	0	0	0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	1	-3	0	0	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	0	0	0	0	2	-6	3	0	-2	0.30	0.00	0.00	0.00
0	0	0	0	0	0	0	0	0	1	-2	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	1	0	-3	0	0	0	0	0	-2	-0.10	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	1	-2	0	0	0	-0.10	0.00	0.00	0.00

11.6 Nutational Corrections of Pole Coordinates

```
* Nutational corrections of pole coordinates (IERS Conventions 2003)
*
* Trigonometric series
* Number of terms
  10
*     Argument multipliers  Coefficients (microarcseconds)
*  F1  F2  F3  F4  F5  chi    Xns     Xnc      Yns    Ync
*
   -1   0  -2   0  -1   1   -0.44   0.25   -0.25  -0.44
   -1   0  -2   0  -2   1   -2.31   1.32   -1.32  -2.31
    1   0  -2  -2  -2   1   -0.44   0.25   -0.25  -0.44
    0   0  -2   0  -1   1   -2.14   1.23   -1.23  -2.14
    0   0  -2   0  -2   1  -11.36   6.52   -6.52 -11.36
   -1   0   0   0   0   1    0.84  -0.48    0.48   0.84
    0   0  -2   2  -2   1   -4.76   2.73   -2.73  -4.76
    0   0   0   0   0   1   14.27  -8.19    8.19  14.27
    0   0   0   0  -1   1    1.93  -1.11    1.11   1.93
    1   0   0   0   0   1    0.76  -0.43    0.43   0.76
```

11.7 Precession Model

```
* Precession model IAU2000A
*
* Frame biases (arcseconds)
* dalpha0
  -0.01460
* dpsi0
  -0.0417750
* depsilon0
  -0.0068192
*
* Precession parameters (arcseconds)
*      t**0       t**1     t**2     t**3
* psiA
        0.0   5038.47875 -1.07259 -0.001147
* omegaA
    84381.448   -0.02524  0.05127 -0.007726
* chiA
        0.0     10.55260 -2.38064 -0.001125
* epsilonA
    84381.448  -46.84024 -0.00059  0.001813
* epsilon0
    84381.448
```

11.8 Greenwich Mean Sidereal Time

```
* Greenwich Sidereal Time (IERS Conventions 2003)
*
* Earth Rotation Angle (cycles)
*    Tu**0              Tu**1
  0.7790572732640   0.00273781191135448
*
* Polynomial part of GST (arcseconds)
*    t**0           t**1         t**2          t**3         t**4
  0.01450600  4612.15739966  1.39667721  -0.00009344  0.00001882
*
* Trigonometric series in the non-polynomial part of GST
* Number of terms
  33
* Number of terms to be multiplied by t
   1
*                     Argument multipliers                Coefficients (microarcseconds)
* F1  F2  F3  F4  F5  f6  f7  f8  f9 f10 f11 f12 f13 f14     Es      Ec    E's    E'c
*
   0   0   0   0   1   0   0   0   0   0   0   0   0   0  2640.96  -0.39  -0.87   0.00
   0   0   0   0   2   0   0   0   0   0   0   0   0   0    63.52  -0.02
   0   0   2  -2   3   0   0   0   0   0   0   0   0   0    11.75   0.01
   0   0   2  -2   1   0   0   0   0   0   0   0   0   0    11.21   0.01
   0   0   2  -2   2   0   0   0   0   0   0   0   0   0    -4.55   0.00
   0   0   2   0   3   0   0   0   0   0   0   0   0   0     2.02   0.00
   0   0   2   0   1   0   0   0   0   0   0   0   0   0     1.98   0.00
   0   0   0   0   3   0   0   0   0   0   0   0   0   0    -1.72   0.00
   0   1   0   0   1   0   0   0   0   0   0   0   0   0    -1.41  -0.01
   0   1   0   0  -1   0   0   0   0   0   0   0   0   0    -1.26  -0.01
   1   0   0   0  -1   0   0   0   0   0   0   0   0   0    -0.63   0.00
   1   0   0   0   1   0   0   0   0   0   0   0   0   0    -0.63   0.00
   0   1   2  -2   3   0   0   0   0   0   0   0   0   0     0.46   0.00
   0   1   2  -2   1   0   0   0   0   0   0   0   0   0     0.45   0.00
   0   0   4  -4   4   0   0   0   0   0   0   0   0   0     0.36   0.00
   0   0   1  -1   1   0  -8  12   0   0   0   0   0   0    -0.24  -0.12
   0   0   2   0   0   0   0   0   0   0   0   0   0   0     0.32   0.00
   0   0   2   0   2   0   0   0   0   0   0   0   0   0     0.28   0.00
   1   0   2   0   3   0   0   0   0   0   0   0   0   0     0.27   0.00
   1   0   2   0   1   0   0   0   0   0   0   0   0   0     0.26   0.00
   0   0   2  -2   0   0   0   0   0   0   0   0   0   0    -0.21   0.00
   0   1  -2   2  -3   0   0   0   0   0   0   0   0   0     0.19   0.00
   0   1  -2   2  -1   0   0   0   0   0   0   0   0   0     0.18   0.00
   0   0   0   0   0   0   8 -13   0   0   0   0   0  -1    -0.10   0.05
   0   0   0   2   0   0   0   0   0   0   0   0   0   0     0.15   0.00
   2   0  -2   0  -1   0   0   0   0   0   0   0   0   0    -0.14   0.00
   1   0   0  -2   1   0   0   0   0   0   0   0   0   0     0.14   0.00
   0   1   2  -2   2   0   0   0   0   0   0   0   0   0    -0.14   0.00
   1   0   0  -2  -1   0   0   0   0   0   0   0   0   0     0.14   0.00
   0   0   4  -2   4   0   0   0   0   0   0   0   0   0     0.13   0.00
   0   0   2  -2   4   0   0   0   0   0   0   0   0   0    -0.11   0.00
   1   0  -2   0  -3   0   0   0   0   0   0   0   0   0     0.11   0.00
   1   0  -2   0  -1   0   0   0   0   0   0   0   0   0     0.11   0.00
*
* TEO position rate (arcseconds/cy)
* ds'/dt
  -0.000047
```

11.9 Variations of UT1 due to zonal tides

```
* Variations of UT1 due to zonal tides (IERS Conventions 2003)
*
* Trigonometric series
* Number of terms
  62
* Argument multipliers      Coefficients
*                          (microseconds)
*  F1  F2  F3  F4  F5        Uzs      Uzc
*
    1   0   2   2   2       -2.0      0.0
    2   0   2   0   1       -4.0      0.0
    2   0   2   0   2      -10.0      0.0
    0   0   2   2   1       -5.0      0.0
    0   0   2   2   2      -12.0      0.0
    1   0   2   0   0       -4.0      0.0
    1   0   2   0   1      -41.0      0.0
    1   0   2   0   2       -1.0      1.0
    3   0   0   0   0       -2.0      0.0
   -1   0   2   2   1       -8.0      0.0
   -1   0   2   2   2      -20.0      0.0
    1   0   0   2   0       -8.0      0.0
    2   0   2  -2   2        2.0      0.0
    0   1   2   0   2        3.0      0.0
    0   0   2   0   0      -30.0      0.0
    0   0   2   0   1     -322.0      2.0
    0   0   2   0   2     -779.0      5.0
    2   0   0   0  -1        2.0      0.0
    2   0   0   0   0      -34.0      0.0
    2   0   0   0   1        2.0      0.0
    0  -1   2   0   2       -2.0      0.0
    0   0   0   2  -1        5.0      0.0
    0   0   0   2   0      -74.0      0.0
    0   0   0   2   1       -5.0      0.0
    0  -1   0   2   0       -5.0      0.0
    1   0   2  -2   1        5.0      0.0
    1   0   2  -2   2       10.0      0.0
    1   1   0   0   0        4.0      0.0
   -1   0   2   0   0        5.0      0.0
   -1   0   2   0   1       18.0      0.0
   -1   0   2   0   2       44.0      0.0
    1   0   0   0  -1       54.0      0.0
    1   0   0   0   0     -833.0      6.0
    1   0   0   0   1       55.0      0.0
    0   0   0   1   0        5.0      0.0
    1  -1   0   0   0       -6.0      0.0
   -1   0   0   2  -1       12.0      0.0
   -1   0   0   2   0     -184.0      1.0
   -1   0   0   2   1       13.0      0.0
    1   0  -2   2  -1        2.0      0.0
   -1  -1   0   2   0       -9.0      0.0
    0   2   2  -2   2       -6.0      0.0
    0   1   2  -2   1        3.0      0.0
    0   1   2  -2   2     -191.0      2.0
    0   0   2  -2   0       26.0      0.0
    0   0   2  -2   1      118.0     -1.0
    0   0   2  -2   2    -4906.0     43.0
    0   2   0   0   0      -20.0      0.0
    2   0   0  -2  -1        5.0      0.0
    2   0   0  -2   0      -56.0      1.0
    2   0   0  -2   1        4.0      0.0
    0  -1   2  -2   1       -5.0      0.0
    0   1   0   0  -1        9.0      0.0
    0  -1   2  -2   2       82.0     -1.0
    0   1   0   0   0    -1565.0     15.0
    0   1   0   0   1      -14.0      0.0
    1   0   0  -1   0        3.0      0.0
    2   0  -2   0   0      -14.0      0.0
   -2   0   2   0   1       43.0     -1.0
   -1   1   0   1   0       -4.0      0.0
    0   0   0   0   2      820.0     11.0
    0   0   0   0   1 -168954.0  -2504.0
```