



GOCE Standards

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GOCE High Level Processing Facility

GOCE Standards

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				<p>updated. Chapter 6.1: Editorial update; Solid Earth pole tides: Complete update and typo in formula for m_2 removed; Table 6-3: Value for C_{20} variation due to permanent tide changed to IERS2003 conventions; Solid Earth Pole Tide Equation clarified. Chapter 7.1: GRS80 removed from general description of height systems. Chapter 7.2: GRS80 removed from general description of gravity systems. Chapter 7.3: Definition of geoid updated. Chapter 7.3: Value for C_{20} variation due to permanent tide changed to IERS2003 conventions. Chapter 8.2: Term gravity gradient tensor replaced by gravity gradients; Editorial update. Chapter 8.3: Term gravity gradient tensor replaced by gravity gradients; Editorial update. Chapter 9: References list updated. Chapter 10: Glossary updated.</p>
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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]

Parameter	Value	Unit
Speed of Light	299792458	$\frac{\text{m}}{\text{s}}$
Constant of Gravitation	$6.673 \cdot 10^{-11}$	$\frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}$
GM _{Sun} : Heliocentric Gravitational Constant	$1.32712442076 \cdot 10^{20}$	$\frac{\text{m}^3}{\text{s}^2}$
Astronomical Unit	499.0047838061	s
Astronomical Unit	149597870691	m
Moon-Earth Mass Ratio	0.0123000383	-
GM _{Earth} : Geocentric Gravitational Constant when working with TT (EGM96 Value)	$3.986004415 \cdot 10^{14}$	$\frac{\text{m}^3}{\text{s}^2}$
Earth Equatorial Radius in Tide-free System (EGM96 Value)	6378136.3	m
Flattening Factor of the Earth 1/f in Tide-free system	298.257222101 (according to IERS, GRS80 is used)	-
Nominal Mean Angular Velocity of the Earth	$7.292115 \cdot 10^{-5}$	$\frac{\text{rad}}{\text{s}}$
Mass of Planets	[same as for DE405, see chapter 4.1.3]	-

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3. Time Systems and Relations

TCB: Barycentric Coordinate Time.

TDB: Barycentric Dynamical Time.

TT: 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.

TGPS: Time realized by the GPS system. GPS time has a constant offset to TAI of -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: January 2006).

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.

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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.

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.

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]
Speed of light	299792.458	[km/s]
Obliquity of the ecliptic	23°26'21.409''	
Earth-Moon mass ratio	81.30056	
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	

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 CTRS is a set of physical points with precisely determined coordinates in a specific coordinate system attached to the TRF.

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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.

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 ITRF2000, where 2000 indicates that observations up to the year 2000 have been included.

For GOCE data processing the most recent consolidated ITRF solution (very likely ITRF2005) will be used.

At this point the following description is based on ITRF2000. It shall be updated as soon as the ITRF2004 description will be available.

The ITRF2000 is characterized by the following properties:

- The scale is realized by setting to zero the scale excess and the scale rate parameters between ITRF2000 and a weighted average of VLBI and most consistent SLR solutions. The scale is expressed in the TT-scale.
- The origin is realized by setting to zero the translation components and their rates between ITRF2000 and a weighted average of most consistent SLR solutions. In order to obtain a truly geocentric position one must apply the geocenter motion correction.
- The orientation is aligned to that of the ITRF97 at 1997.0 and its rate is aligned to that of the geological model NNR-NUVEL-1A. This is an implicit application of the no-net rotation condition in agreement with the CTRS definition. The ITRF2000 orientation and its rate were established using a selection of ITRF sites with high geodetic quality. For some stations the velocity values given in ITRF2000 are not accurate enough. In this case the plate motion model NNR-NUVEL-1A shall be used.
- All analysis centers use a conventional tide-free correction. Therefore the ITRF2000 is a tide-free frame.
- ITRF solutions are specified by Cartesian equatorial coordinates X, Y and Z.

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- The orientation of ITRF is given by the IERS reference pole (~ CIO) and reference meridian (~ BTS).

The ITRF2000 point positions can be expressed in several ways:

- Direct use of ITRF2000 station positions (see <http://www.iers.org/iers/products/itrf>).
- Use of IGS products (e.g. orbits and clocks) which are nominally all referred to the ITRF. Users should be aware of the ITRF version used in the generation of the IGS products (see <http://igs.cb.jpl.nasa.gov>).
- Use of transformation formulas between a particular TRF and ITRF2000.

4.2 Transformation between Celestial and Terrestrial Systems

This chapter describes the sequence of computations needed for the transformation from the International Terrestrial Reference System (ITRS) to the Geocentric Celestial Reference System (GCRS) based on [1], Chapter 5.

Two equivalent ways to compute the transformation from ITRS to GCRS 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 that can lead to confusions. 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 ITRS to the GCRS is described in details in the subsequent sections 4.2.2 to 4.2.7. This description is a certain 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]. Brief description of the comparison results 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.

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The classical, based on the equinox and Greenwich Sidereal Time, transformation from the Terrestrial Reference Frame (ITRF) to the Celestial Reference Frame (ICRF) is defined in the form

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

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 details.

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

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

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

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

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 rotation by angle α around X -axis. The matrix $\mathbf{R}_2(\beta)$ describes rotation by angle β around Y -axis. The matrix $\mathbf{R}_3(\gamma)$ describes rotation by angle γ around 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, $(X,Y,Z)_j$:

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

Figure 4-1 illustrates these rotations.

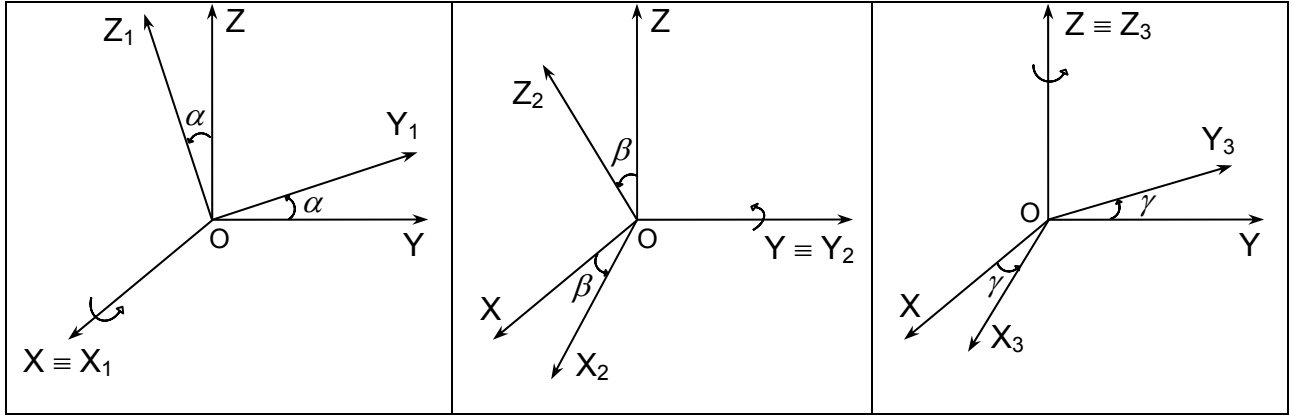


Figure 4-1: Frame Rotations around Coordinate Axes

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:

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

where

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

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

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

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

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

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

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

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 EOPC04 series (see example file in attachment 11.2). They must be interpolated to the date of computation.

4.2.3 The Precession Matrix

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

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

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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

$$\psi_A = 5038.47875'' \cdot t - 1.07259'' \cdot t^2 - 0.001147'' \cdot t^3, \quad (12)$$

$$\omega_A = 84381.448'' - 0.02524'' \cdot t + 0.05127'' \cdot t^2 - 0.007726'' \cdot t^3, \quad (13)$$

$$\chi_A = 10.55260'' \cdot t - 2.38064'' \cdot t^2 - 0.001125'' \cdot t^3. \quad (14)$$

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):

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

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

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

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

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

ε_A is mean obliquity of date

$$\varepsilon_A = 84381.448'' - 46.84024'' \cdot t - 0.00059'' \cdot t^2 + 0.001813'' \cdot t^3, \quad (18)$$

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).

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4.2.4.1 Luni-Solar Nutation

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

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

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

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 **nutatation_luso.txt** (see attachment 11.4).

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

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

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

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

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

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

The argument t in formulas (19), (20), (22) – (26) is given by expression (15). Numerical values of coefficients of these polynomials are stored also in the attached file **nutatation_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

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

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

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

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

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 **nutatation_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 same multipliers of fundamental arguments into a single term.)

First five arguments in 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.

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

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

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

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

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$$f_5(t) \equiv \Omega = 2.182439200 - 33.7570450000 \cdot t, \quad (34)$$

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

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

$$f_8(t) \equiv l_E = 1.753470314 + 628.3075849991 \cdot t, \quad (37)$$

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

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

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

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

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

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

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 `nutatation_plan.txt` (see attachment 11.5).

4.2.5 The Earth Rotation Matrix

The Earth rotation matrix is

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

GST is Greenwich Sidereal Time given by the expression

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

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, sum of first two terms in the right-hand side of formula (45) can be considered as Mean Greenwich Sidereal Time (GMST):

$$GMST = \theta(T_U) + p(t), \quad (46)$$

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

$$GST = GMST + \Delta\psi \cos \varepsilon_A + q(t). \quad (47)$$

4.2.5.1 The Earth Rotation Angle

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

$$\theta(T_U) = 2\pi(0.7790572732640 + 1.00273781191135448 \cdot T_U). \quad (48)$$

The coefficients in brackets 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 polynomial (48) is defined in days elapsed since the basic epoch J2000.0 in time scale UTI :

$$T_U = JD(UTI) - 2451545.0. \quad (49)$$

Here

$$\begin{aligned} UTI &= UTC + (UTI - UTC) \\ &= TAI + (UTC - TAI) + (UTI - UTC) \\ &= TT + (TAI - TT) + (UTC - TAI) + (UTI - UTC). \end{aligned} \quad (50)$$

The difference $(TAI - TT)$ is defined as

$$TAI - TT = -32.184^s. \quad (51)$$

Information on the difference $(UTC - TAI)$ is published by the IERS in the Bulletin C. From 2006 January 1, 0h UTC up to now the difference is

$$UTC - TAI = -33^s, \quad (52)$$

The instantaneous value of the difference $(UTI - UTC)$ can be obtained, after interpolation of the daily EOPC04 series published by the IERS, by applying the additional component to account for the effect of ocean tides with periods less than two days:

$$(UTI - UTC)_t = (UTI - UTC)_t^{IERS} + \Delta UTI_{tidal}(t). \quad (53)$$

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

$$T_U = T'_U + \frac{\Delta UTI_{tidal}(t)}{86400}, \quad (54)$$

where

$$T'_U = JD(TT) - 2451545.0 + \frac{(UTI - UTC)_t^{IERS} + (UTC - TAI) + (TAI - TT)}{86400}. \quad (55)$$

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

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

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

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

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 8.2 in [1] or 16)).

The fundamental arguments $F_j(t)$ of luni-solar nutation are given by expressions (22) – (26). The last function in (57), $\chi(t_u)$, is GMST + π as it is used traditionally in tidal expansions. In regret, we cannot apply formula (46) during the computation of $\chi(t_u)$ because the numerical values of the coefficients in (56) are determined with the expression for GMST coming from the IERS Conventions 1996. Therefore

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

where

$$t_u = \frac{T'_U}{36525}, \quad (59)$$

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 :

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

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

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

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

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

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 $f_j(t)$ ($j = \overline{6,14}$) 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 ($UTI-UTC$) in the formula (53) requires an interpolation of the daily EOPC04 series published by the IERS. 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 $(UTI-UTC)_{node}^{IERS}$ at interpolation nodes:

$$(UTI_{Red} - UTC)_{node}^{IERS} = (UTI - UTC)_{node}^{IERS} - \delta UTI_{zonal}(t_{node}) \quad (63)$$

and then added to the interpolated values $(UTI_{Red} - UTC)_t^{IERS}$:

$$(UTI - UTC)_t^{IERS} = (UTI_{Red} - UTC)_t^{IERS} + \delta UTI_{zonal}(t) \quad (64)$$

In this view, expression (53) becomes

$$(UTI - UTC)_t = (UTI_{Red} - UTC)_t^{IERS} + \delta UTI_{zonal}(t) + \Delta UTI_{tidal}(t) \quad (65)$$

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

$$\delta UTI_{zonal}(t) = \sum_{k=1}^{62} (U_{Sk}^{zonal} \sin \eta_k(t) + U_{Ck}^{zonal} \cos \eta_k(t)) \quad (66)$$

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

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

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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

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

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

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

with t given by expression (15). Numerical value of the coefficient in 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 EOPC04 published by the IERS, 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:

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

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:

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

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

The tidal constituents are exactly the same as for the correction of UTI (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 8.3 in [1] or [16]).

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4.2.7.2 Nutational Corrections of Pole Coordinates

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

$$\Delta x_{\text{nutational}}(t) = \sum_{k=1}^{10} \left(X_{S_k}^{\text{nutational}} \sin \zeta_k(t) + X_{C_k}^{\text{nutational}} \cos \zeta_k(t) \right), \quad (73)$$

$$\Delta y_{\text{nutational}}(t) = \sum_{k=1}^{10} \left(Y_{S_k}^{\text{nutational}} \sin \zeta_k(t) + Y_{C_k}^{\text{nutational}} \cos \zeta_k(t) \right). \quad (74)$$

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

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

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 $X_{S_k}^{\text{nutational}}$, $X_{C_k}^{\text{nutational}}$, $Y_{S_k}^{\text{nutational}}$, $Y_{C_k}^{\text{nutational}}$ 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 Bulletin C04 series 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 two times a week. Values are given in daily intervals and are slightly smoothed.

With each new input data set included by the IERS the Bulletin C04 EOP series is 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 C04 EOP series available within HPF the following procedure is applied to construct the internal product:

1. The C04 EOP 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 C04 EOP file.

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 mas in x and y pole, of 10 msec in UT1-UTC, and of 40 mas in dX and dY pole offsets. The typical scatter for the last entries in the IERS C04 series is of the order of 100 mas, 40 msec, and 600 mas, respectively.

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Because the C04 EOP series provides daily values interpolation to the actual epoch is required for celestial pole offsets dX and dY (section 4.2.2), UT1-UTC (section 4.2.5) and pole coordinates x and y (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) since interpolation errors are of the order of $50\mu\text{s}$ for pole coordinates, $140\mu\text{s}$ for $UT1_{\text{red}}$ and $20\mu\text{s}$ for celestial pole offsets and below the measurement 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 GCRS is implemented in the HPF software. At different stage 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 the 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 at the interval from 2002 December 1, 23h 59m 57s UTC to 2002 December 4, 23h 59m 57s UTC with the step 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 is the approach (CEO-based or equinox-based) implemented in the interactive tool. Therefore, in our computations performed for the comparison

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

EOP (IERS) C 04 daily series of the Earth Orientation Parameters were taken from the file `eopc04_IAU2000.62-now`, available at the IERS Web site (http://hpiers.obspm.fr/eoppc/eop/eopc04/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

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

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

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

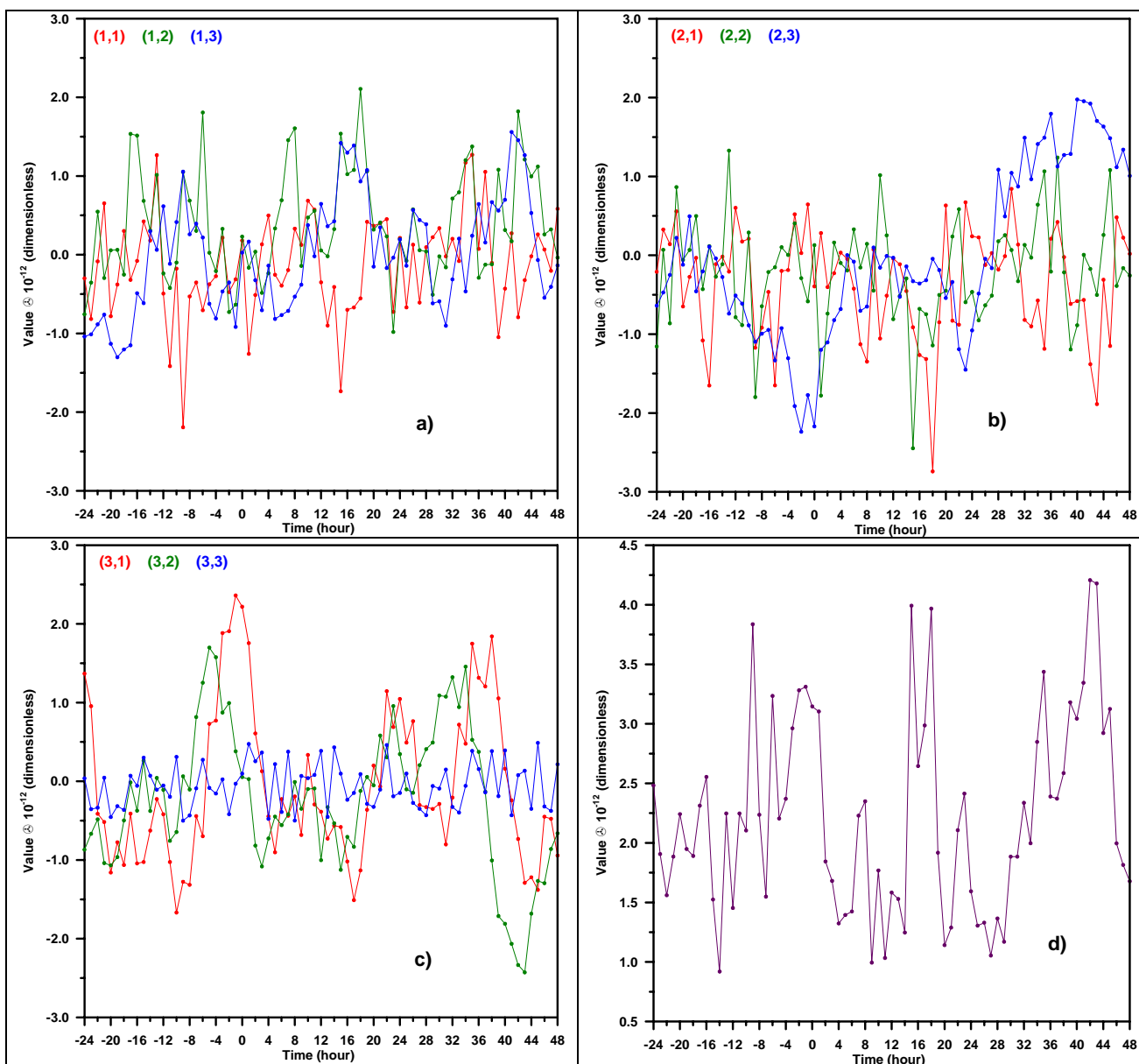


Figure 4-2: Comparison of the transformation matrix with that provided by the IERS Interactive tool:
a), b), c) – elements of the difference matrix (76);
d) – Euclidean norm (77) of the non-orthogonality;
Time is counted from 2002 December 2, 23h 59m 57s UTC.

Maximal deviations from the IERS results do not exceed 4.5×10^{-12} (Figure 4-2d). This estimation corresponds to the 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 an overall precision of the models used for the transformation.

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



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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.

Neill mapping for GPS with estimation of zenith delay is adopted. The 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 effect removed by analysis of the ionosphere-free linear combination of the two frequencies of GPS observations. Higher order effects 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 [27].

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

Taken from ITRF2000 (ITRF2005 when available).

Ocean Loading

The site displacement due to ocean loading shall be computed according to [1], chapter 7.1.1. The tide model selected for ocean loading site displacements must not necessarily correspond to the tide model used for GOCE dynamic modelling (see chapter 6.1). The most recent altimetric and hydrodynamic tide models are available in the automatic loading service (see

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[1], Table 7.2). The tide model for computing ocean loading site displacements applied for GOCE is to be determined before launch.

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:

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

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

Not 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. Measured attitude information is used to orient the antenna.
- For GPS ground stations and GPS satellites the antenna characteristics are taken from the IGS.

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	<ul style="list-style-type: none"> • Marini & Murray for SLR. • Neill mapping for GPS.
Ionospheric Refraction	<ul style="list-style-type: none"> • GPS dual frequency. • Second order ignored.
Relativistic Corrections	<ul style="list-style-type: none"> • SLR: IERS Conventions 2003 • GPS observations and clock corrections: IERS Conventions 2003
Phase Windup	<ul style="list-style-type: none"> • According to [27]
Station Positions	<ul style="list-style-type: none"> • ITRF2000 (ITRF2004)
Station Velocities	<ul style="list-style-type: none"> • ITRF2000 (ITRF2004)
Ocean Loading	<ul style="list-style-type: none"> • According to IERS Conventions 2003. • Tide Model TBD by WP3000
Solid Earth Tides	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • IERS2003, linear model of mean pole
Atmospheric Loading	<ul style="list-style-type: none"> • Not applied
Postglacial Rebound	<ul style="list-style-type: none"> • Implicitly considered with ITRF velocities.
Geocenter Variations	<ul style="list-style-type: none"> • Not applied
Geometric GPS Correction	<p>For GOCE SSTI, GPS satellites and GPS ground stations:</p> <ul style="list-style-type: none"> • Antenna Phase Center Offset Correction • Zenith/Nadir and Azimuth Dependency of Phase Center Corrections

6. Dynamic Models

6.1 Gravitational Forces

Mean Geopotential

IERS Conventions 2003 [1] recommend at this time the EGM96 model to be applied as conventional model. In the meantime CHAMP and GRACE based combined gravity field models have been released showing significantly increased accuracies for the low frequency spectrum of the gravity field. These models still show some uncertainties in the degree 1 and degree 2 terms of the spherical harmonic series. For this reason as of today no consolidated CHAMP and GRACE based gravity field model can be recommended to be applied as standard model. At the time when GOCE flies it can be expected that a consistent GRACE based model will be available, which fully can replace the EGM96 model. For this reason the final decision on the static gravity field model to be used in the GOCE level 2 data processing as reference model will be done shortly before begin of the mission.

Values for the C_{21} and S_{21} coefficients are included in the EGM96 model. The two coefficients describe the position of the Earth's figure axis. When averaged over many years, the figure axis should closely coincide with the observed position of the rotation pole averaged over the same time period. For the mean gravity field that will be selected the coefficients C_{21} and S_{21} as well as their time derivatives have to be consistent with the mean pole and its linear motion as defined in section 7.1.4 of [1] (to which pole tide corrections refer), as it is the case for EGM96..

Table 6-1 gives a summary for the parameters of the mean geopotential field to be applied for GOCE data processing.

Table 6-1: Summary of Parameters of mean Geopotential

Parameter	Value	Remark
GM_{Earth}	TBD	TBD before launch
a_e	TBD	in Tide-free System; TBD before launch
$\bar{C}_{n,m}, \bar{S}_{n,m}$	TBD	Spherical Harmonic Coefficients up to Degree N; TBD before launch
$\dot{\bar{C}}_{n,m}, \dot{\bar{S}}_{n,m}$	TBD	Time Variable Spherical Harmonic Coefficients; TBD before launch

Direct Tides of Sun, Moon and Planets

The perturbations due to Sun, Moon and all the 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.

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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:

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

where \bar{C}_{20} is 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 by the mass of j -th body; (x_j, y_j, z_j) are Earth-centered coordinates if 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)	<ul style="list-style-type: none"> • For SSTI: Direct & indirect Terms of Point-mass 3rd Body Perturbations. • For SGG: Correction of Gravity Gradients
Indirect J_2 Effect	<ul style="list-style-type: none"> • Sun and Moon only.
Planetary Ephemerides	<ul style="list-style-type: none"> • JPL DE405 and LE405

Solid Earth Tides

The changes induced by the solid Earth tides in the free space potential are modelled as variations in the geopotential coefficients. The contributions of these variations in 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 in the free space potential by tides of spherical harmonic degree (nm). For degree 2 only two parameters are needed due to mass conservation. The effect of the anelasticity of the Earth is included.

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.

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 33 of 72</p>
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Table 6-3: Solid Earth Tide Geopotential to be used in dynamic Model

Effect	Model
Solid Earth Tide Perturbation	<ul style="list-style-type: none"> • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Planetary Ephemerides	<ul style="list-style-type: none"> • JPL DE405 and LE405
Frequency Independent Terms	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 $C_{2,0}$	<ul style="list-style-type: none"> • -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).

Permanent Tide

The degree 2 zonal tide generating potential has a mean value that is nonzero. This time independent potential produces a permanent deformation and a consequent time independent contribution to the geopotential coefficient $C_{2,0}$. When the time independent contribution is included in the adopted value of the mean geopotential field then the value is termed “zero-tide” (e.g. for JGM-3 geopotential model). If the time independent contribution is not included then the value is termed “conventional tide-free” (e.g. for the EGM96 geopotential model).

When using a “conventional tide-free” model the effect of the permanent tides is implicitly removed when applying the solid Earth tide correction following IERS Conventions 2003 [1] (see above). In case of a “zero-tide” geopotential model, the model of tidal effects to be added should not once again contain a time independent part. Its permanent part must first be restored before the procedure described in [1] can be applied. Final choice of the procedure for permanent tide will be made after the final choice of the conventional gravity model.

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

In the Earth-fixed frame the pole tide potential becomes $(1+k_2)U_c$ (where U_c is the centrifugal potential) since the Earth fixed observer does sense the centrifugal potential including the effect caused by elastic deformation.

$$\left(\Delta\bar{C}_{21} - i\Delta\bar{S}_{21}\right) = -(1+k_2) \frac{R^3\Omega^2}{\sqrt{15} \cdot GM} \cdot \frac{\pi}{648000} (m_1 - im_2) \quad (80)$$

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where k_2 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 by the Earth's mass. The value of Love number k_2 in accordance with [1] is

$$k_2 = 0.3077 + i \cdot 0.0036 \quad (81)$$

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

$$\begin{aligned} m_1 &= x_p - \bar{x}_p \\ m_2 &= -(y_p - \bar{y}_p) \end{aligned} \quad (82)$$

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 constiuens in the right-hand side of (82) are expressed in arcseconds.

Inserting (81) in (80) yields:

$$\begin{aligned} \Delta \bar{C}_{21} - i \Delta \bar{S}_{21} &= -\frac{R^3 \Omega^2}{\sqrt{15} \cdot GM} \cdot \frac{\pi}{648000} (m_1 - i m_2) (1.3077 + i 0.0036) = \\ &= -\frac{R^3 \Omega^2}{\sqrt{15} \cdot GM} \cdot \frac{\pi}{648000} ([1.3077 m_1 + 0.0036 m_2] - i [1.3077 m_2 - 0.0036 m_1]) \end{aligned} \quad (83)$$

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

$$\begin{cases} \Delta \bar{C}_{21} \\ \Delta \bar{S}_{21} \end{cases} = -5.6662 \cdot 10^{-9} \begin{cases} m_1 + 0.00275 m_2 \\ m_2 - 0.00275 m_1 \end{cases} \quad (84)$$

Pole Tide in an inertial Reference Frame

In the inertial reference frame we assume that the observer is not attached to the Earth fixed frame, a consequence is that the centrifugal potential is not sensed by the inertial observer. The pole tide spherical harmonic coefficients are therefore:

$$(\Delta \bar{C}_{21} - i \Delta \bar{S}_{21}) = -k_2 \frac{R^3 \Omega^2}{\sqrt{15} \cdot GM} \cdot \frac{\pi}{648000} (m_1 - i m_2) \quad (85)$$

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

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$$\begin{Bmatrix} \Delta\bar{C}_{21} \\ \Delta\bar{S}_{21} \end{Bmatrix} = -1.333 \cdot 10^{-9} \begin{Bmatrix} m_1 + 0.0115m_2 \\ m_2 - 0.0115m_1 \end{Bmatrix} \quad (86)$$

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

Effect	Model
Anelastic Earth Model Contribution to $C_{2,1}$ and $S_{2,1}$	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • IERS Standard Product: Daily Earth Rotation Parameters C04
Constant Parameters	<ul style="list-style-type: none"> • Love Number: $k_2=0.3077+0.0036i$; 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 for the ocean tide model to be selected for GOCE. The tide model is selected in WP3000. The ocean tide model to be applied for GOCE is TBD. Within this work package the coefficients for the selected tide model are computed.

Table 6-5: Ocean Tide Model for dynamic Model

Effect	Model
Ocean Tide Model	<ul style="list-style-type: none"> • TBD • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Tidal Amplitudes and Phase Convention	<ul style="list-style-type: none"> • Doodson • Schwiderski
Tidal Harmonics Selection	<ul style="list-style-type: none"> • TBD

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 estimate 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.

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

Effect	Model
Atmosphere and Ocean De-Aliasing	<ul style="list-style-type: none"> • 6 hourly Spherical Harmonic Coefficients as Corrections to the mean Geopotential. • Interpolation to Observation Epochs by linear Interpolation between 6 hourly Epochs of Correction Coefficients. • For SSTI: Correction of Mean Geopotential • For SGG: Correction of Gravity Gradients
Atmosphere	<ul style="list-style-type: none"> • Based on ECMWF Operational Analysis Output • Referenced to Multi Year Mean Atmosphere • Vertical Integration • Correction for Atmosphere Tides: TBD
Ocean Model	<ul style="list-style-type: none"> • Baroclinic Ocean Model OMCT • Referenced to Multi Year Mean Ocean Bottom Pressure • Driven by ECMWF operational Analysis and Forecast Fields.
Inverse Barometer	<ul style="list-style-type: none"> • Taken Care in Ocean Model

Monthly Geopotential Field Variability

It shall be considered if the GRACE monthly fields can be used as additional information to eliminate seasonal variations in the geopotential field. TBD

6.2 Non-Gravitational Forces

For GOCE the non-gravitational forces are accounted for by the drag-free control system of the satellite. This system is based on the common mode accelerations from the six accelerometers forming the gravity gradiometer instrument. As the drag-free compensation will not fully be free of systematic effects, which are caused by the closed-loop control system itself, by variations of the centre of mass of the satellite due to fuel consumption and by 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 provided by the instrument.

For GOCE level 2 processing the common-mode accelerations shall be applied for the two 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 analysis of these observations.
- For the SSTI data analysis targeting on the long wavelength gravity field determination by continuously analyzing the orbit perturbations, 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 non-gravitational signal already is compensated for by the drag-free control system, i.e. the orbit will be almost gravitational and that only the residual signal observed by the common-mode accelerations has to be taken into account.

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 37 of 72</p>
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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).

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 38 of 72</p>
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7. Other System Definitions

7.1 Height System

Ellipsoidal Height

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

Physical Heights

(a) Potential difference (C) is the difference between the potential in a point at the surface of the Earth (including the centrifugal potential), W , minus the potential of the normal potential at the ellipsoid, (for GRS80: $U_0=62636860.850 \text{ m}^2/\text{s}^2$ [21]).
Units are $[\text{m}^2/\text{s}^2]$.

(b) Normal height, H^N , of a point at the surface of the Earth, is the potential difference divided by the mean value of the normal gravity along the plumb line of the normal gravity field, see [23, Eq. 3.107]. (An operational definition would be C divided by normal gravity in the same point). Units are $[\text{m}]$.

(c) Height anomaly, ζ is the difference $h - H^N$, see [23 Eq. 6.7]. Units are $[\text{m}]$.

7.2 Gravity System

Observed Quantities at or near the Surface of the Earth

(a) measured gravity g , must refer 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 and γ evaluated in a point (Q) with the same latitude φ and having the ellipsoidal height of the point Q equal to H^N .

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

Units are m/s^2

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Values calculated using a Spherical Harmonic Model

- (a) gravity, g , is the modulus of the gradient of the potential.
- (b) (free-air) gravity anomaly in a point (P) with geodetic latitude φ and normal height H^N is the difference between g and γ evaluated in a point (Q) with the same latitude φ and having the ellipsoidal height of the point Q equal to H^N (obtained from 7.1.2 (b)).
- (d) gravity disturbance is the difference between (calculated) gravity g and normal gravity evaluated at the same point.

Height Anomaly Slopes from a Spherical Harmonic Model

The differences between the East and North components of the gradients of the normal potential and the gradients of the spherical harmonic model potential. (Note the order in which the differences are taken – this is to be in agreement with deflections of the vertical).

Units are m/s^2 . (We have to make a choice between this and some angular units of the directions).

Mean Values from a Spherical Harmonic Model

Mean values (associated with the surface of the Earth) are computed using 5 x 5 point numerical integration scheme (TBD) over the points in a specific area where the points all have the same ellipsoidal height equal to the maximal altitude of the corresponding points at the surface of the Earth. (This definition is made in order to avoid problems with downward continuation through the masses).

7.3 Tide System

[see 19]. The definition of the geoid is complicated by the permanent deformation of the Earth caused by the presence of the Sun and the Moon. Nominally the geoid is the equipotential surface (of the tide-free potential) with potential equal to the U_0 value of normal potential of the reference ellipsoid used. Then the geoid height is the height of this surface above (or below) the reference ellipsoid evaluated along the ellipsoidal normal. Consideration of these permanent tidal effects has led to the definition of two types of geoids and two types of reference ellipsoids. The three geoids are described as follows:

- **Tide-free (or nontidal)**—This geoid would exist for a tide-free Earth with all (direct and indirect) effects of the Sun and Moon removed.
- **Zero**—This geoid would exist if the permanent direct effects of the Sun and Moon are removed, but the indirect effect component related to the elastic deformation of the Earth is retained.

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 40 of 72</p>
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In order to transfer a gravity field spherical harmonic series from one tide system to the other the following equation has to be applied to the C_{20} coefficient [1]:

$$C_{20}^{\text{tide-free}} = C_{20}^{\text{zero-tide}} + 4.201 \cdot 10^{-9} \quad (87)$$

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 41 of 72</p>
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8. GOCE Reference Frames and Time System

8.1 GOCE Spacecraft Parameters

TBD: Here a table shall be included providing information on the GOCE spacecraft parameters (e.g. CoM offsets, phase patterns, etc.).

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 later.

- Origin O_{GRF} located at the origin of the OAGRF₃
- X_{GRF} , Y_{GRF} , Z_{GRF} axes are parallel to the corresponding axes of OAGRF₃ 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 (see below) are 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} .

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

$$Z_{LNOF} = \begin{pmatrix} \cos \varphi \cos \lambda \\ \cos \varphi \sin \lambda \\ \sin \varphi \end{pmatrix}; Y_{LNOF} = \begin{pmatrix} \sin \lambda \\ -\cos \lambda \\ 0 \end{pmatrix}; X_{LNOF} = \begin{pmatrix} -\sin \varphi \cos \lambda \\ -\sin \varphi \sin \lambda \\ \cos \varphi \end{pmatrix} \quad (88)$$

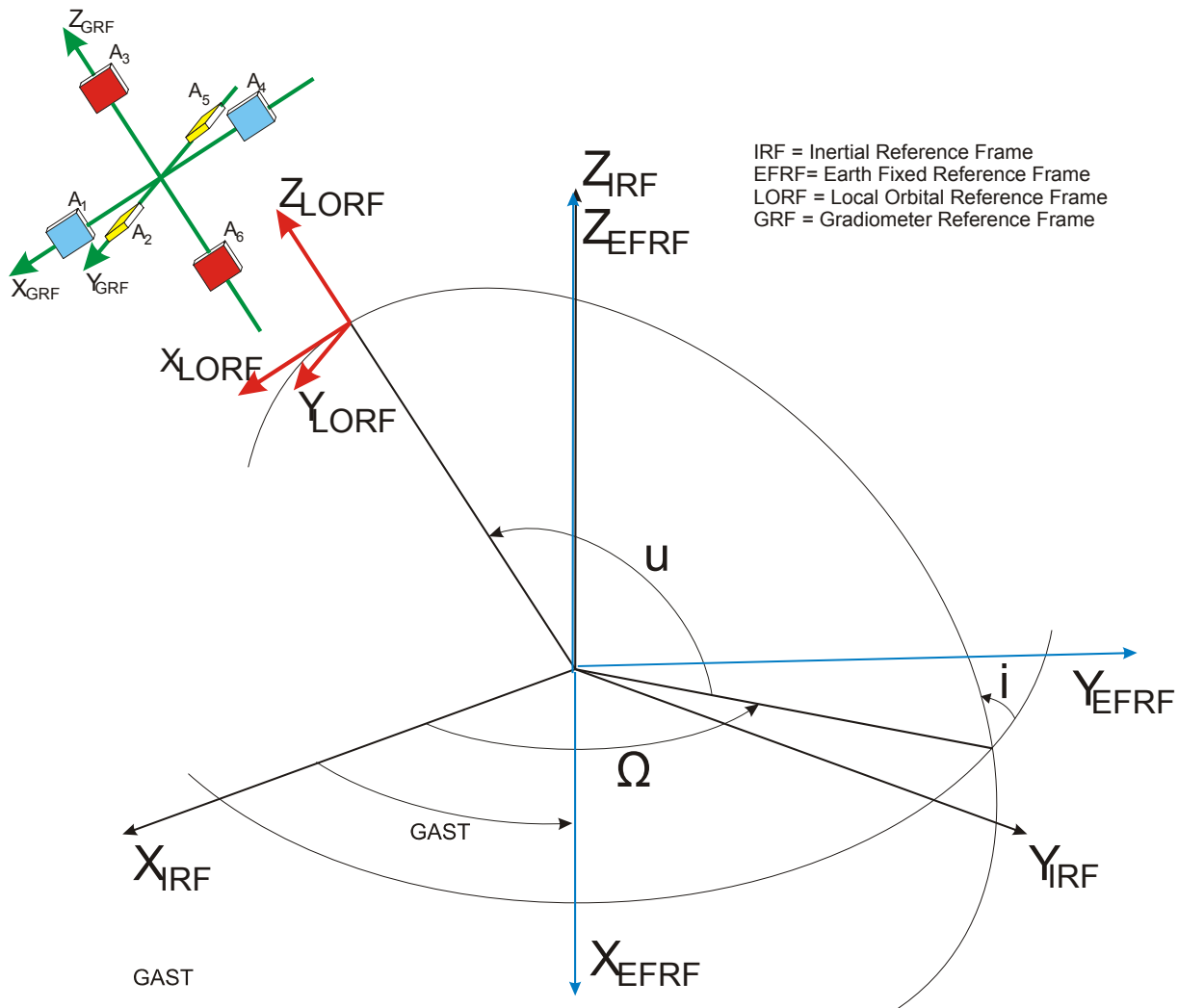


Figure 8-1: Definition of fundamental Reference Systems for GOCE: EFRF corresponds to an ITRF Frame; IRF corresponds to an ICRF Frame.

Figure 8-1 shows how the fundamental reference frames are oriented against each other. Because the satellite attitude is controlled with magnetotors, the GRF does not fully

coincide with the LORF. In science mode the satellite will operate in drag-free mode for the flight direction only with platform attitude controlled by the magnetorquers over the poles. Since the magnetorquers can only constrain close to the pole, the yaw steering mode allows roll to accumulate at the equator. A maximum value of yaw of 3.5° is also experienced at the equator due to lateral forces due to the Earth's rotation. Thus the satellite will be yaw steered to within $\pm 3.5^\circ$ (with respect to the LORF) in order to minimise lateral forces and torques.

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.

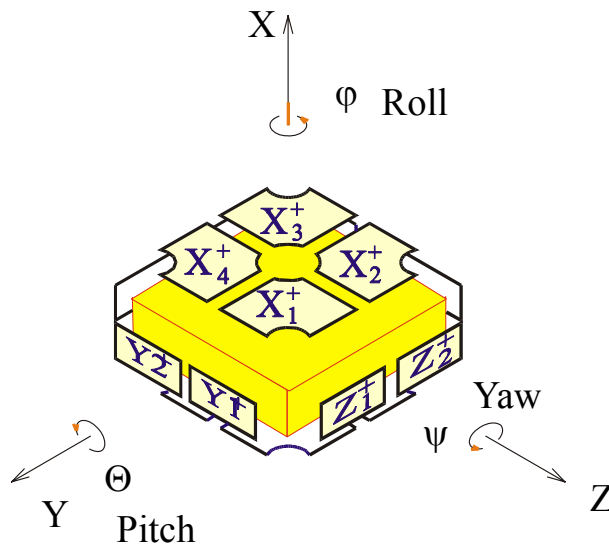


Figure 8-2: Accelerometer Electrode System Reference Frame and location of the 8 electrode pairs

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 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.

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- 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 .
 - $Z_{ARF1/4}$ axis is defined by $\underline{X}_{ARF1/4} \times \underline{L}_{ARF1/4}$, where $\underline{X}_{ARF1/4}$ is the unit vector of the $X_{ARF1/4}$ axis and $\underline{L}_{ARF1/4}$ is the unit vector normal to the internal wall of the lower electrode plate of the cage (the lower plate is placed on the same side of the sole plate), positive in the opposite direction of the sole plate. $Z_{ARF1/4}$ is nominally parallel to the second ultra-sensitive axis of the accelerometer (see Figure 8-4).
 - $Y_{ARF1/4}$ axis parallel to $\underline{Z}_{ARF1/4} \times \underline{X}_{ARF1/4}$ with the same sign of $\underline{Z}_{ARF1/4} \times \underline{X}_{ARF1/4}$. $Y_{ARF1/4}$ is nominally parallel to the less sensitive axis of the accelerometer.
- 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 .
 - $X_{ARF2/5}$ axis is defined by $\underline{Y}_{ARF2/5} \times \underline{L}_{ARF2/5}$, where $\underline{Y}_{ARF2/5}$ is the unit vector of the $Y_{ARF2/5}$ axis and $\underline{L}_{ARF2/5}$ is the unit vector normal to the internal wall of the lower plate of the cage (the lower plate is placed on the same side of the sole plate), positive in the opposite direction of the sole plate. $X_{ARF2/5}$ is nominally parallel to the second ultra-sensitive axis of the accelerometer.
 - $Z_{ARF2/5}$ axis parallel to $\underline{X}_{ARF2/5} \times \underline{Y}_{ARF2/5}$ with the same sign of $\underline{X}_{ARF2/5} \times \underline{Y}_{ARF2/5}$. $Z_{ARF2/5}$ is nominally parallel to the less sensitive axis of the accelerometer.
- For the accelerometers A_3 and A_6 forming the OAG_3 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 .
 - $X_{ARF3/6}$ axis is defined by $\underline{L}_{ARF3/6} \times \underline{Z}_{ARF3/6}$, where $\underline{Z}_{ARF3/6}$ is the unit vector of the $Z_{ARF3/6}$ axis and $\underline{L}_{ARF3/6}$ is the unit vector normal to the internal wall of the lower plate of the cage (the lower plate is placed on the same side of the sole plate), positive in the opposite direction of the sole plate. $X_{ARF3/6}$ is nominally parallel to the second ultra-sensitive axis of the accelerometer.
 - $Y_{ARF3/6}$ axis parallel to $\underline{Z}_{ARF3/6} \times \underline{X}_{ARF3/6}$ with the same sign of $\underline{Z}_{ARF3/6} \times \underline{X}_{ARF3/6}$. $Y_{ARF3/6}$ is nominally parallel to the less sensitive axis of the accelerometer.

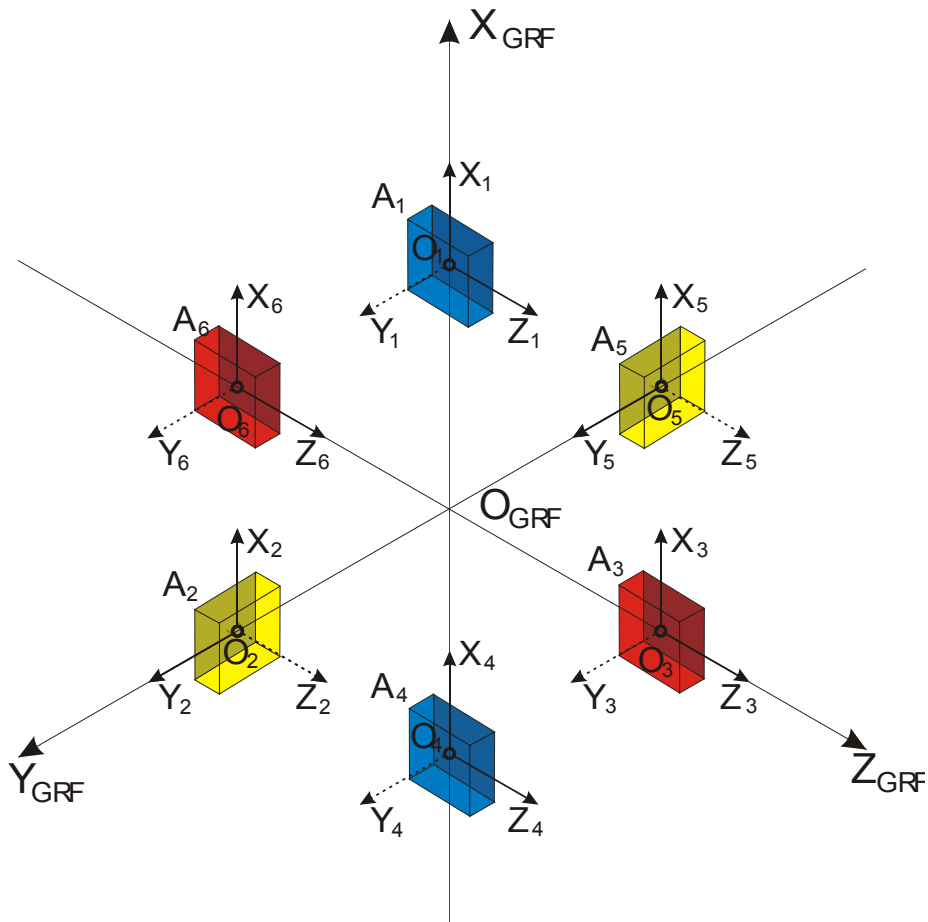


Figure 8-3: Nomenclatura and location of the 6 accelerometers of the GOCE gradiometer in the GRF and with all ARF's. The axes of the ARF shown by solid arrows are aligned with ultra sensitive axes of the accelerometer. The axes of the ARF shown by dashed arrows are aligned to the less sensitive axes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

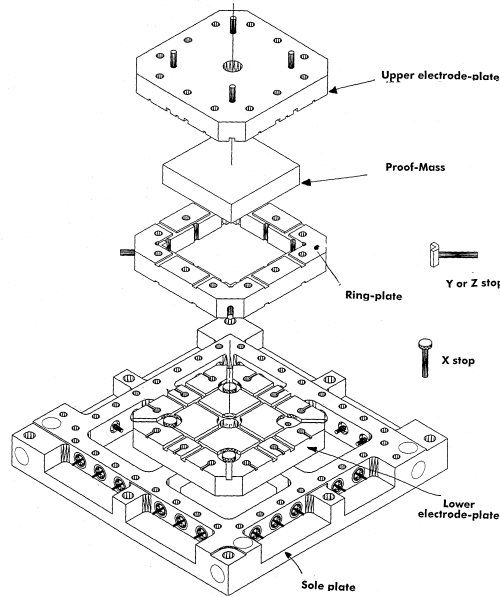


Figure 8-4: Exploded view of the accelerometer core showing the proof mass, the sole plate, the lower and upper electrode plate.

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 OAG₁, which is composed of accelerometers A₁ and A₄:

- Origin O_{OAG1} located at the midpoint of the straight line joining the origin of ARF₄ and ARF₁.
- X_{OAG1} axis parallel to the line joining O₄ to O₁, oriented from O₄ to O₁
- Y_{OAG1} axis parallel to and with the same versus of the vector $\bar{Y}_{OAG1} = \frac{Y'_{ARF1}}{|Y'_{ARF1}|} + \frac{Y'_{ARF4}}{|Y'_{ARF4}|}$

where \underline{Y}'_{ARF1} , \underline{Y}'_{ARF4} are the projections of the vectors \underline{Y}_{ARF1} and \underline{Y}_{ARF4} on the plane perpendicular to the X_{OAG1} axis.

- Z axis is parallel to $\underline{X}_{OAG1} \times \underline{Y}_{OAG1}$ with the same sign of $\underline{X}_{OAG1} \times \underline{Y}_{OAG1}$

For OAG₂, which is composed of accelerometers A₂ and A₅:

- Origin O_{OAG2} located at the midpoint of the straight line joining the origin of ARF₅ and ARF₂.
- Y_{OAG2} axis parallel to the line joining O₅ to O₂, oriented from O₅ to O₂
- Z_{OAG2} axis parallel to and with the same versus of the vector $\bar{Z}_{OAG2} = \frac{Z'_{ARF2}}{|Z'_{ARF2}|} + \frac{Z'_{ARF5}}{|Z'_{ARF5}|}$

where \underline{Z}'_{ARF2} , \underline{Z}'_{ARF5} are the projections of the vectors \underline{Z}_{ARF2} and \underline{Z}_{ARF5} on the plane perpendicular to the Y_{OAG2} axis.

- X_{OAG2} axis is parallel to $\underline{Y}_{OAG2} \times \underline{Z}_{OAG2}$ with the same sign of $\underline{Y}_{OAG2} \times \underline{Z}_{OAG2}$

For OAG₃, which is composed of accelerometers A₃ and A₆:

- Origin O_{OAG3} located at the midpoint of the straight line joining the origin of ARF₆ and ARF₃.

- Z_{OAG3} axis parallel to the line joining O_6 to O_3 , oriented from O_6 to O_3
- Y_{OAG3} axis parallel to and with the same versus of the vector $\bar{Y}_{OAG3} = \frac{Y'_{ARF3}}{|Y'_{ARF3}|} + \frac{Y'_{ARF6}}{|Y'_{ARF6}|}$
where Y'_{ARF3}, Y'_{ARF6} are the projections of the vectors Y_{ARF3} and Y_{ARF6} on the plane perpendicular to the Z_{OAG3} axis.
- X_{OAG3} axis is parallel to $\bar{Y}_{OAG3} \times Z_{OAG3}$ 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. It is defined as follows:

- Origin O_{SSRF} in the centre of the star sensor.
- Z_{SSRF} axis along the boresight of the star sensor
- X_{SSRF}, Y_{SSRF} axes lying on the star sensor focal plane, perpendicular with the Z_{SSRF} axis forming with it a right-handed coordinate system.

The SSRF is connected to the GRF by a constant rotation. The rotation matrices from the GRF to the SSRF are defined as follows:

Star-tracker 1:

$$\bar{R}_{SSRF_GRF} = \begin{bmatrix} 0 & \sin(\alpha_{STR}) & -\cos(\alpha_{STR}) \\ -1 & 0 & 0 \\ 0 & \cos(\alpha_{STR}) & \sin(\alpha_{STR}) \end{bmatrix} \quad (89)$$

Star-tracker 2:

$$\bar{R}_{SSRF_GRF} = \begin{bmatrix} 0 & \cos(\beta_{STR}) & -\sin(\beta_{STR}) \\ -1 & 0 & 0 \\ 0 & \sin(\beta_{STR}) & \cos(\beta_{STR}) \end{bmatrix} \quad (90)$$

Star-tracker 3:

$$\bar{R}_{SSRF_GRF} = \begin{bmatrix} 0 & \sin(\alpha_{STR}) & -\cos(\alpha_{STR}) \\ -\cos(\gamma_{STR}) & \cos(\alpha_{STR})\sin(\gamma_{STR}) & \sin(\alpha_{STR})\sin(\gamma_{STR}) \\ \sin(\gamma_{STR}) & \cos(\alpha_{STR})\cos(\gamma_{STR}) & \sin(\alpha_{STR})\cos(\gamma_{STR}) \end{bmatrix} \quad (91)$$

with the nominal, design, values of the angles $\alpha_{STR}, \beta_{STR}, \gamma_{STR}$:

Angle	Nominal value dawn-dusk orbit (winter launch)	Nominal value dusk-dawn orbit (summer launch)
α_{STR}	30°	-30°
β_{STR}	20°	160°
γ_{STR}	40°	40°

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 48 of 72</p>
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The actual values will be the result of the measurement of the star tracker orientation relative to the gradiometer that will be performed once the satellite will be integrated. At that time, the actual values will be made available, together with the measurement errors.

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.

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 49 of 72</p>
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		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 50 of 72</p>
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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
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
IRF	Inertial Reference Frame
JD	Julian Date
JPL	Jet Propulsion 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

		<p style="text-align: right;"><i>GOCE Standards</i></p> <p>Doc. Nr: GO-TN-HPF-GS-0111 Issue: 2.0 Date: 22.09.2006 Page: 52 of 72</p>
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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
*   F1 F2 F3 F4 F5 chi Pole (microarcseconds)   UT1 (microseconds)
*   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

* Earth Orientation Parameters EOP (IERS) C 04
*
* Extracted from the file http://hpiers.obspm.fr/eoppc/eop/eopc04/eopc04_IAU2000.62-now
*
* Start date 2002/11/01
* End date 2003/01/31
* Number of records
92

Table with 7 columns: Date (Oh UTC), MJD, xpole (arcsec), ypole (arcsec), UT1-UTC (seconds), dX (arcsec), dY (arcsec). Rows contain data for dates from 2002-11-01 to 2003-01-16.



Table with 8 columns: Year, Day, X, Y, Z, X', Y', Z'. Contains data for years 2003 and 2002.

11.3 Terrestrial to Celestial Transformation Matrices

* 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

Large table with 10 columns: (1,1), (1,2), (1,3), (2,1), (2,2), (2,3), (3,1), (3,2), (3,3). Contains numerical data for 73 matrices.



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 = 1
485868.249036 1717915923.2178 31.8792 0.051635 -0.00024470
* F2 = 1'
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
*   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 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 0 2 -5 0 0 -1 144.40 240.90 128.60 -77.10
0 0 0 0 0 0 0 3 -5 0 0 0 0 0 -2 206.50 0.00 0.00 89.50
0 0 0 1 -1 1 0 0 -8 12 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 0 2 -116.60 0.00 0.00 50.50
0 0 0 0 0 1 0 0 0 -1 2 0 0 0 0 0 -46.00 -43.50 -23.20 24.60
0 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 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 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 0 4 -6 0 0 0 0 0 -2 -49.00 0.00 0.00 -21.30
0 0 0 0 0 0 0 2 -4 0 0 0 0 0 -2 45.80 0.00 0.00 19.80
0 0 0 2 -2 1 0 0 -5 6 0 0 0 0 0 -1.80 -43.60 -23.30 0.90
0 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 0 2 0 0 0 0 0 2 37.00 -0.80 0.00 -16.00
0 0 0 0 0 1 0 0 4 -8 3 0 0 0 0 -8.20 29.20 15.60 4.40
0 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 0 1 1 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 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 2 -26.20 0.00 0.00 11.40
0 0 0 1 -1 1 0 0 -1 0 0 -1 0 0 0 17.40 8.40 4.50 -9.30
0 0 0 1 -1 1 0 0 0 -1 0 0 -1 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 0 8 -13 0 0 0 0 0 -2 4.10 17.50 -7.60 1.70
0 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	0	1	-1	1	0	0	-1	0	2	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	0	1	-1	1	0	-5	7	0	0	0	0	0	14.00	2.70	1.40	-7.50
0	0	0	0	0	0	0	0	0	0	0	2	0	0	5.10	11.40	6.10	-2.70
0	0	0	1	-1	1	0	0	-1	0	0	2	0	0	-4.80	-11.00	-5.90	2.60
0	0	0	0	0	0	0	0	3	0	-2	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	0	1	2	0	0	0	2	-8.50	-7.00	-3.10	3.70
0	0	0	0	0	0	0	0	3	-2	0	0	0	2	8.00	-7.10	-3.10	-3.50
0	0	0	0	0	0	0	0	0	0	3	0	0	2	-12.70	2.10	0.90	5.50
0	0	0	0	0	0	0	0	4	-2	0	0	0	2	14.30	-0.30	-0.10	-6.20
0	0	0	0	0	0	0	0	0	0	0	2	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	0	2	-2	1	0	-3	3	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	0	1	-1	1	0	0	3	-8	3	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	0	1	-1	1	0	0	-5	8	-3	0	0	0	9.90	0.00	0.00	-5.30
0	0	0	0	0	1	0	-8	13	0	0	0	0	0	-4.00	5.70	3.00	2.10
0	0	0	0	1	0	0	0	0	0	-2	5	0	0	7.60	1.70	0.90	-4.10
0	0	0	0	1	0	0	0	0	0	2	-5	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	6	-16	4	5	0	0	-2	0	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	0	1	-1	1	0	0	-1	0	0	1	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	0	1	-1	1	0	0	-2	2	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	0	1	-1	1	0	0	-1	0	1	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	3	-6	0	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	1	0	-4	0	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	1	-8	3	0	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	0	3	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	0	3	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	7	-13	0	0	0	0	0	-2	0.40	0.80	-0.30	0.20
0	0	0	0	0	0	0	0	0	3	0	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	0	1.10	0.00	0.00	-0.60
0	0	1	-1	-1	0	0	0	-2	0	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	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	2	0	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	-2	0	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	1	0	-1	0	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	5	-10	0	0	0	0	0	-2	0.00	-0.50	0.20	0.00
0	0	0	0	0	0	4	0	-4	0	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	7	-8	0	0	0	0	0	2	0.00	-0.40	-0.20	0.00
0	0	0	0	0	0	7	-9	0	0	0	0	0	2	0.00	-0.40	-0.20	0.00
0	0	0	0	0	0	6	-10	0	0	0	0	0	-2	0.00	0.40	-0.20	-0.10
0	0	0	0	0	0	3	0	0	0	0	0	0	2	0.00	0.40	0.20	0.00
0	0	0	0	0	0	3	-8	3	0	0	0	0	-2	0.40	0.00	0.00	0.20
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	2	-4	0	0	0	0	1	0.40	0.00	0.00	-0.20	
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	1	0	-1	0	0	0	-1	0.00	-0.40	0.20	0.00	
2	0	2	-2	2	0	-2	0	3	0	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	4	-8	3	0	0	0	0	0	0.00	0.30	0.10	0.00
1	0	2	0	2	0	-4	8	-3	0	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	1	0	-1	0	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	9	-17	0	0	0	0	0	-2	-0.30	0.00	0.00	-0.20
0	0	0	0	0	0	7	-7	0	0	0	0	0	2	0.00	0.30	-0.20	0.00
0	0	0	0	0	0	7	-12	0	0	0	0	0	-2	0.00	0.30	-0.10	0.00
0	0	0	0	0	0	6	-4	0	0	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	6	-8	1	5	0	0	0	2	0.00	-0.30	-0.10	0.00
0	0	0	0	0	0	6	-9	0	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	5	0	-4	0	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	5	-7	0	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	5	-8	3	0	0	0	0	2	-0.30	0.00	0.00	0.10
0	0	0	0	0	0	5	-9	0	0	0	0	0	-1	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	5	-13	0	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	5	-16	4	5	0	0	0	-2	0.30	0.00	0.00	0.10
0	0	0	0	0	0	4	-7	0	0	0	0	0	-1	-0.30	0.00	0.00	-0.20
0	0	0	0	0	0	4	-8	3	0	0	0	0	1	0.30	0.00	0.00	-0.20
0	0	0	0	0	0	4	-8	3	0	0	0	0	-1	0.30	0.00	0.00	0.20
0	0	0	0	0	0	3	0	-5	0	0	0	0	-2	-0.30	0.00	0.00	-0.10
0	0	0	0	0	0	3	-5	0	0	0	0	0	-1	0.00	-0.30	0.20	-0.10
0	0	0	0	0	0	3	-7	0	0	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	3	-9	0	0	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	2	1	0	0	0	0	0	2	0.30	0.00	0.10	-0.10
0	0	0	0	0	0	2	0	2	0	0	0	0	2	0.30	0.00	0.00	-0.10
0	0	0	0	0	0	2	-8	1	5	0	0	0	-2	0.00	-0.30	0.10	0.00
0	0	0	0	0	0	1	0	1	0	0	0	0	1	0.00	0.30	0.20	0.00
0	0	0	0	0	0	1	0	0	2	0	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	4	-8	3	0	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	8	-16	4	5	0	0	0	0	144.00	0.00	0.00	0.00
0	0	0	0	0	0	1	0	-1	0	0	0	0	0	-122.30	-2.90	0.00	0.00
0	0	0	0	0	0	1	-2	0	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	1	0	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	0	-5	6	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	2	-3	0	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	0	-6	8	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	1	0	0	0	-1	0	0	0	-7.50	0.00	0.00	0.00
0	0	0	0	0	0	8	-15	0	0	0	0	0	0	4.50	-2.20	0.00	0.00
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1.10	5.60	0.00	0.00
0	0	0	0	0	0	1	0	-3	0	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	0	5.90	0.00	0.00	0.00
0	0	0	0	0	0	0	3	-5	0	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	0	5.30	0.00	0.00	0.00
0	0	0	0	0	0	5	-8	0	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	0	-2.50	2.20	0.00	0.00
0	0	0	0	0	0	0	1	0	2	-5	0	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	0	-3.50	-0.70	0.00	0.00
0	0	0	0	0	0	6	-6	0	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	0	-1.60	2.30	0.00	0.00
2	0	0	-2	0	0	0	-6	8	0	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	0	2.40	1.20	0.00	0.00
2	0	-1	-1	0	0	0	3	-7	0	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	0.00	3.50	0.00	0.00
0	0	0	0	0	0	0	1	0	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	0	3.40	0.00	0.00	0.00
2	0	0	0	0	0	0	-2	0	3	0	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	-0.40	-2.80	0.00	0.00
0	0	0	0	0	0	0	3	-6	0	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	0	-1.90	-1.10	0.00	0.00
0	0	0	0	0	0	7	-7	0	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	0	2.70	0.00	0.00	0.00
0	0	0	0	0	0	0	1	0	0	-2	0	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	0.90	-1.60	0.00	0.00
0	0	0	0	0	0	2	-1	0	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	0	-2.50	0.00	0.00	0.00
1	0	0	-1	0	0	0	-3	4	0	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	0.00	2.40	0.00	0.00
0	0	0	0	0	0	0	5	-8	3	0	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	0	1.60	-0.60	0.00	0.00
0	0	0	0	0	0	0	4	-7	0	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	0	1.60	-0.50	0.00	0.00
0	0	0	0	0	0	0	3	0	-3	0	0	0	0	0	1.80	-0.30	0.00	0.00
0	0	1	-1	0	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	0.70	1.30	0.00	0.00
0	0	1	-1	0	0	0	-1	0	2	0	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	0.80	1.10	0.00	0.00
1	0	0	-2	0	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	0	1.90	0.00	0.00	0.00
0	0	0	0	0	0	0	3	0	-2	0	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	0.60	-0.90	0.00	0.00
2	0	0	-2	0	0	0	-2	0	3	-1	0	0	0	0	-1.50	0.00	0.00	0.00
0	0	0	0	0	0	0	-11	0	0	0	0	0	0	0	0.90	0.60	0.00	0.00
0	0	0	0	0	0	0	2	0	-2	0	0	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	0	1.10	0.40	0.00	0.00
1	0	0	-2	0	0	0	-2	0	3	0	0	0	0	0	-1.30	0.00	0.00	0.00
0	0	2	-2	0	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	0.40	0.90	0.00	0.00
0	0	0	0	0	0	9	-9	0	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	0.50	-0.70	0.00	0.00
0	0	0	0	0	0	0	0	0	2	-5	0	0	2	0	-1.20	0.00	0.00	0.00
0	0	0	0	0	0	1	-3	0	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	0.50	-0.60	0.00	0.00
0	0	0	0	0	0	0	5	-8	0	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	0	1.00	0.00	0.00	0.00
0	0	0	0	0	0	2	-4	0	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	0	1.00	0.00	0.00	0.00
0	0	0	0	0	0	6	-7	0	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	0.00	0.90	0.00	0.00
1	0	0	-2	0	0	20	-21	0	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	0.30	-0.50	0.00	0.00
0	0	0	0	0	1	0	-4	0	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	0.80	0.00	0.00	0.00
0	0	0	0	0	0	5	-6	0	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	0.80	0.00	0.00	0.00
0	0	0	0	0	0	0	4	-8	0	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	-0.40	0.40	0.00	0.00
1	0	0	-2	0	0	0	1	0	-1	0	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	-0.70	0.00	0.00	0.00
0	0	0	0	0	0	0	4	0	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	-0.60	0.00	0.00	0.00
1	0	0	-2	0	0	2	-2	0	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	0.00	0.60	0.00	0.00
0	0	0	0	0	0	0	0	2	0	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	-0.50	0.00	0.00	0.00
2	0	0	-2	0	0	-2	2	0	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	0.00	-0.50	0.00	0.00
1	0	0	0	0	0	0	-4	8	-3	0	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	0.50	0.00	0.00	0.00
1	0	0	-1	0	0	0	-2	2	0	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	0.00	0.50	0.00	0.00
0	0	2	-2	0	0	0	-2	0	2	0	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	0.00	-0.50	0.00	0.00
0	0	0	0	0	0	0	3	0	-4	0	0	0	0	0	0.50	0.00	0.00	0.00
0	0	0	0	0	0	0	0	0	0	1	-2	-2	0	0	0.00	0.50	0.00	0.00
2	0	0	-2	0	0	0	-2	0	2	2	0	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	0.40	0.00	0.00	0.00
1	0	0	0	0	0	1	-1	0	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	-0.40	0.00	0.00	0.00
1	0	0	-2	0	0	1	-1	0	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	0.00	-0.40	0.00	0.00
1	0	0	-2	0	0	0	-4	8	-3	0	0	0	0	0	0.00	-0.40	0.00	0.00
1	0	0	-2	0	0	0	-2	2	0	0	0	0	0	0	-0.40	0.00	0.00	0.00
0	0	2	-2	0	0	0	-4	4	0	0	0							



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	8	-15	0	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	-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	6	-10	0	0	0	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	0	5	-6	0	0	0	0	0	0	0.30	0.00	0.00	0.00
0	0	0	0	0	0	2	0	0	-3	0	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	1	0	0	0	0.00	0.30	0.00	0.00
0	0	0	0	0	1	0	-3	0	0	0	0	-2	-0.10	0.00	0.00	0.00	
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

* dpsio0

-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
* F1 F2 F3 F4 F5 f6 f7 f8 f9 f10 f11 f12 f13 f14 Coefficients (microarcseconds)
* Es Ec E's E'c
*
0 0 0 0 1 0 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 0 63.52 -0.02
0 0 2 -2 3 0 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 0 11.21 0.01
0 0 2 -2 2 0 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 0 2.02 0.00
0 0 2 0 1 0 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 0 -1.72 0.00
0 1 0 0 1 0 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 0 -1.26 -0.01
1 0 0 0 -1 0 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 -0.63 0.00
0 1 2 -2 3 0 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 0.45 0.00
0 0 4 -4 4 0 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 -0.24 -0.12
0 0 2 0 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 0.28 0.00
1 0 2 0 3 0 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 0.26 0.00
0 0 2 -2 0 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 0.19 0.00
0 1 -2 2 -1 0 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 0 -1 -0.10 0.05
0 0 0 2 0 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 -0.14 0.00
1 0 0 -2 1 0 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 -0.14 0.00
1 0 0 -2 -1 0 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 0.13 0.00
0 0 2 -2 4 0 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 0.11 0.00
1 0 -2 0 -1 0 0 0 0 0 0 0 0 0 0 0.11 0.00
*
* TE0 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

```



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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