HARMONIC CONSTANTS
Product Specification

Edition 1.0

Contents

1. Introduction

1.1 General

The tide is a periodical movement in the level of the surface of the sea or ocean, due to the gravitational attraction between the Earth, Moon and Sun. By collating and analysing tidal data it is possible to derive harmonic constants that can be used in the prediction of sea levels.

The Harmonic Constants Product Specification sets out the rules which have to be followed when transferring tidal harmonic data.

1.2 Definitions

Harmonic analysis — The mathematical process by which the observed tide or tidal current at any place is separated into basic harmonic constituents.

Harmonic Constituents — One of the harmonic elements in a mathematical expression of the tide-producing force, and in corresponding formulae for the tide or tidal stream. Each constituent represents a periodic change of relative position of the Earth, Sun and Moon.

Harmonic Constants — The amplitude (H) and phase lag (g) of each harmonic constituent of the tide or tidal stream at any place, in a specific time zone.

Species of Tide

Long Period — Includes all tidal oscillations with periods ranging from 1 to 2 days through to 19 years.

Diurnal — A tidal cycle with a period lasting approximately a day, on average 24 hours 50 minutes.

Semidiurnal — A tidal cycle roughly occupying half a day, on average 12hours 25 minutes.

2. General Information

2.1 Observation of the Tide

Observations of sea level are made by automated tide gauges over a period of time at specific locations. The two main tidal features recorded are the tidal range, measured as the height between successive high and low levels and the period, the time laps between one high (or low) level and the next high (or low) level. Tidal analysis of the data collected produces calculated constants which can be used to compute predicted sea-levels. Analysis of the data also provides researchers with information on changes in Mean Sea Level which is used for impact analysis. In reality these calculated constants can only be approximate as the observation period often varies from a year to a month. These observations are also subject to errors induced by natural meteorological occurrences. The principal factors being atmospheric pressure and the winds acting on the sea surface to create storm surges.

2.2 Harmonic Analysis

In general, a simple Harmonic term can be expressed in the form:

$$X(t) = H_n \cos(\sigma_n t - g_n)$$

Where	X	= Value of the variable quantity at time t
	H_n	= Amplitude of oscillation
	g_n	= Phase lag
	σ_n	= Angular speed
	t	= Time

The amplitudes and phase lags are the parameters determined by analysis which define the tidal regime for the place of observation.

Note: A full list of Harmonic Constituents with their respective Speeds and Extended Doodson Numbers (XDO) is given in Annex B.

3. Header Information

3.1 Port Name
Full port or tidal station name with no abbreviations, this is a mandatory field.

3.2 Country
IHO Country code, this is a mandatory field.

3.3 Position
A Latitude and Longitude position of observation station quoted as DDD-MM.MM together with the correct suffix dependant on the hemisphere (N-S) and the direction from the Greenwich Meridian (E-W), this is a mandatory field.

3.4 Time Zone
The difference in hours and minutes to Universal Time (UT) using standard International Maritime convention (e.g. Greece -0200; Belize +0600), this is a mandatory field.

3.5 Units
The unit of measure used to specify the Amplitude (H), this is a mandatory field.

3.6 Observation
The start and end dates of the observation period quoted as YYYY-MM-DD, this is a mandatory field.

3.7 Comments
Any useful comments and remarks that will assist processing of the data, this is not a mandatory field.

4. Data Record

4.1 Constituent Name
As specified in Annex B, no variations are allowable, this is a mandatory field.

4.2 Phase Angle (g)
The phase lag of a tidal constituent at a particular place in degrees, this is a mandatory field.

4.3 Amplitude (H)
The amplitude of a tidal constituent for a given place in metres, this is a mandatory field.

4.4 Speed
The speed of a constituent has been calculated from relevant astronomical theory, this is a mandatory field.

4.5 Extended Doodson Number (XDO)
A seven-digit numerical and alphabetical system devised as a convenient way of expressing the Harmonic Constituents in order of speed, this is not a mandatory field but is highly desirable.

5. Accuracy

5.1 Calculation

The overall accuracy of the derived constants is intrinsically linked to the length of the observation period. By increasing the observation period we can gather more measurements therefore reducing the inherent error in the derived values.

So that the calculated data is not misinterpreted as of a higher quality it is important to restrict the precision of the calculated g and H values to reflect the length of observation. The table below shows how many decimal places each derived constant should be quoted to with respect to the length of observation.

Time	Phase Angle (g)	Amplitude (H)
≥ 1 Year	X.X	X.XXX
< 1 Year or ≥ 3 x 30 days	X.X	X.XXX
< 3 x 30 days	X	X.XX

6. Extended Doodson Number (XDO)

6.1 Introduction

The XDO refers to a seven digit numbering system devised by Dr. A. T. Doodson in the 1920's as a convenient way of expressing the Harmonic Constituents in order of speed, which then in turn becomes a useful way of obtaining the phase and speed of any constituent within a computer environment. Each number represents a *multiplier* which is applied to the individual speeds of the Orbital Elements:-

The numbering system effectively 'runs-out' after the ninth-diurnal, therefore an alphabetical system continues through the tenth to fourteenth- diurnal.

The XDO, both numerical and alphabetical, is shown in the full list of IHO Harmonic Constituents (Annex B)

6.2 Computation of the Astronomical Argument (*E*) - Use of Extended Doodson Number (XDO)

1. The value of *E*, at 00hr, for any constituent can be derived from the values for Orbital Elements. For example the phase of the constituent known as R_2 can be expressed as:

$$h - p' + 180°$$

2. In practice it has been found convenient to include an additional term (h–s). The multiplier for this term is the species to which the constituent belongs. R_2 is a semi-diurnal constituent so the multiplier for this term is 2. Simple algebra means that *E* of R_2 can now be expressed as :

$$2(h-s) + 2s - h - p' + 180°$$

3. If the coefficients for the term (*h* - *s*), for each of the Orbital Elements in turn and for the number of right angles to be applied, are written in sequence, *E* of R_2 can be expressed as :

Parameter	*(h–s)*	*s*	*h*	*p*	*N*	*p′*	90°
Coefficient	+2	+2	-1	0	0	-1	+2

4. To avoid the use of negative numbers 5 is normally added to each coefficient, except the first. *E* of R_2 now becomes:

Parameter	*(h–s)*	*s*	*h*	*p*	*N*	*p′*	90°
Coefficient	2	7	4	5	5	4	7

5. In the 1920s, Dr. Doodson realised that the first three digits of this number (274 in the case of R_2) were a convenient way of tabulating harmonic constituents in order of speed and he called this the Doodson Number. What he could not have foreseen was that the full number forms a convenient shorthand for obtaining the phase and speed of any constituent within programs on electronic computers. The full number is referred to as the Extended Doodson Number (XDO).

6. Comparatively recently, electronic computers have enabled the use of constituents which overflow the above system and the UK Hydrographic Office has replaced it with an alphabetical system in which Z represents 0, the letters A to P represent coefficients of 1 to 15 respectively while R to Y represent -8 to -1. Substituting the values in Para 2.7, the XDO for R_2 now becomes :

Parameter	*(h - s)*	*s*	*h*	*p*	*N*	*p′*	90°
Coefficient	B	B	Y	Z	Z	Y	B

7. Tidal Harmonic Constant Data File Format

7.1 Header Record

Field	Name	Description
1-2	Name	Port or tidal station name
2-3	Country	IHO Country code
3-4	Latitude N - S	DDD-MM.MM
4-5	Longitude E - W	DDD-MM.MM
5-6	Time Zone	+/-HHMM Maritime Convention
6-7	Observation Start	YYYY-MM-DD
7-8	Observation End	YYYY-MM-DD
8-9	Comment	Comment or remarks

7.2 Harmonic Constants Record

Field	Name	Description			
1-2	Sa	Phase Angle of Sa constant in degrees	Amplitude of Sa in meters	Speed of Sa in degrees per mean solar hour	XDO value Numerical or alphabetical
2-3	Ssa	Phase Angle of Ssa constant in degrees	Amplitude of Ssa in meters	Speed of Ssa in degrees per mean solar hour	XDO value Numerical or alphabetical
3-4	Sta	Phase Angle of Sta constant in degrees	Amplitude of Sta in meters	Speed of Sta in degrees per mean solar hour	XDO value Numerical or alphabetical

HARMONIC CONSTANTS
Annex A

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Contents

1. Introduction

1.1 General

The following documentation gives a brief explanation of the most commonly used Harmonic constituents.

1.2 Major Tidal Constituents
Lunar

M_2	The semi-diurnal constituent of a fictitious moon, which moves in a circular orbit in the plane of the equator
N_2 & L_2	Modulate $M_{2,}$ converting the circular orbit of the fictitious moon into an elliptical one in the plane of the equator
v_2 , $\lambda_{2,}$ μ_2 & S_2	Modulate $M_{2,}$ allowing for the fact that the real moon's orbit is not elliptical, but pear shaped, since the sun attracts it more at new moon than at full moon. This S_2 is not the main semi-diurnal constituent of the mean sun.
K_2	Modulates $M_{2,}$ converting the orbit from the plane of the equator into the mean plane of the real moon.
K_1 & O_1	The diurnal constituents of a fictitious moon which has a fixed circular orbit in the mean plane of the real moon
J_1, M_1 & Q_1	Modulate K_1 & $O_{1,}$ allowing for the fact that the moon's orbit is not circular, but elliptical. M_1 is the sum of two constituents, which cannot easily be separated.
M_f & M_m	'Long Period' lunar constituents, with periods of about a fortnight and one month respectively. They have very small amplitudes, and are often masked by meteorological and shallow water effects.

1.3 Major Tidal Constituents
Solar

S_2	The semi-diurnal constituent of the mean sun, which moves in a circular orbit in the plane of the equator
T_2	Modulates S_2 allowing for the fact that the sun's orbit is an ellipse. Another constituent, which operates with T_2, is so small that it is not named and is neglected.
K_2	Modulates $S_{2,}$ allowing for the fact that the sun's orbit is in the plane of the ecliptic. Another constituent, which operates with it, is so small that it is not named and is neglected. This K_2 has the same speed as the moon's $K_{2,}$ and the two are combined.

K_1 & P_1 The diurnal constituents of a fictitious sun which has a circular orbit in the plane of the ecliptic. This K_1 has the same speed as the moon's $K_{1,}$ and the two are combined.

S_{sa} & S_a 'Long Period' solar constituents, with periods of about six months and one year respectively. They have very small amplitudes, and in practice cannot usually be distinguished from changes in MSL caused by prevailing winds and monsoons.

1.4 Major Tidal Constituents Shallow Water

M_4 The second harmonic of M_2 with twice its speed.

MS_4 A quarter diurnal constituent produced from M_2 & $S_{2.}$ It has a speed equal to the sum of their two speeds.

M_6 The third harmonic of M_2 with three times it's speed.

$2MS_6$ A sixth diurnal constituent produced from M_2 and S_2. It has a speed equal to the sum of twice the speed of M_2 plus the speed of S_2

There are of course many other shallow water constituents with high harmonic frequencies, as shown in Annex B.

HARMONIC CONSTANTS
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Long Term Constituents

Zo	0.000 000	0 555 555	Z ZZZ ZZZ	z
Sa	0.041 067	0 565 545	Z ZAZ ZYZ	z
Sa	0.041 069	0 565 555	Z ZAZ ZZZ	z
Ssa	0.082 137	0 575 555	Z ZBZ ZZZ	z
Sta	0.123 204	0 585 544	Z ZCZ ZYY	x
MSm	0.471 521	0 636 555	Z AXA ZZZ	x
Mnum (Mνm)	0.471 521	0 636 555	Z AXA ZZZ	x
Mm	0.544 375	0 654 555	Z AZY ZZZ	y
MSf	1.015 896	0 735 555	Z BXZ ZZZ	b
MSo	1.015 896	0 735 555	Z BXZ ZZZ	b
SM	1.015 896	0 735 555	Z BXZ ZZZ	x
Mf	1.098 033	0 755 555	Z BZZ ZZZ	y
KOo	1.098 033	0 755 555	Z BZZ ZZZ	x
MKo	1.098 033	0 755 555	Z BZZ ZZZ	x
Snu2 (Sν2)	1.487 417	0 816 555	Z CVA ZZZ	x
SN	1.560 270	0 834 555	Z CXY ZZZ	x
MStm	1.569 554	0 836 555	Z CXA ZZZ	x
Mfm	1.642 408	0 854 555	Z CZY ZZZ	a
2SM	2.031 792	0 915 555	Z DVZ ZZZ	c
MSqm	2.113 929	0 935 555	Z DXZ ZZZ	b
Mqm	2.186 782	0 953 555	Z DZX ZZZ	m
2SMN	2.576 166	--------------	Z EVY ZZZ	x

Diurnal Constituents

2Q1	12.854 286	1 257 554	A WZB ZZY	o
NJ1	12.854 286	1 257 554	A WZB ZZY	x
nuJ1 (νJ1)	12.927 140	1 275 554	A WBZ ZZY	o
sigma1 (σ1)	12.927 140	1 275 554	A WBZ ZZY	o
Q1	13.398 661	1 356 554	A XZA ZZY	o
NK1	13.398 661	1 356 555	A XZA ZZZ	x
rho1 (ρ1)	13.471 515	1 374 554	A XBY ZZY	o
nuK1 (νK1)	13.471 515	1 374 554	A XBY ZZY	x
O1	13.943 036	1 455 554	A YZZ ZZY	y
MK1	13.943 036	1 455 554	A YZZ ZZY	x
MS1	13.984 104	1 465 557	A YAZ ZZB	x
MP1	14.025 173	1 475 555	A YBZ ZZZ	m
MP1	14.025 173	1 475 556	A YBZ ZZA	m
tau1 (τ1)	14.025 173	1 475 556	A YBZ ZZA	k
M1B	14.487 410	1 554 554	A ZZY ZZY	y
M1B	14.487 410	1 554 556	A ZZY ZZA	Y
M1C	14.492 052	1 555 555	A ZZZ ZZZ	Y
M1	14.492 052	1 555 556	A ZZZ ZZA	Y
M1	14.492 052	1 555 557	A ZZZ ZZB	Y
NO1	14.496 694	1 556 556	A ZZA ZZA	X
M1A	14.496 694	1 556 556	A ZZA ZZA	Y
M1	14.496 694	1 556 556	A ZZA ZZA	y
LP1	14.569 548	1 574 554	A ZBY ZZY	x
chi1 (χ1)	14.569 548	1 574 556	A ZBY ZZA	j
pi1 (π1)	14.917 865	1 625 564	A AWZ ZAY	z
TK1	14.917 865	1 625 564	A AWZ ZAY	x
P1	14.958 931	1 635 554	A AXZ ZZY	z
SK1	14.958 931	1 635 555	A AXZ ZZZ	x
S1	15.000 000	1 645 555	A AYZ ZZZ	z
S1	15.000 000	1 645 557	A AYZ ZZB	z

S1	15.000 002	1 645 566	A AYZ ZAA	z
SP1	15.041 069	1 655 555	A AZZ ZZZ	x
K1	15.041 069	1 655 555	A AZZ ZZZ	y
MO1	15.041 069	1 655 555	A AZZ ZZZ	x
K1	15.041 069	1 655 556	A AZZ ZZA	y
RP1	15.082 135	1 665 544	A AAZ ZYY	x
psi1 (ψ1)	15.082 135	1 665 546	A AAZ ZYA	z
phi1 (Φ1)	15.123 206	1 675 556	A ABZ ZZA	j
KP1	15.123 206	1 675 556	A ABZ ZZA	x
lambdaO1 (λO1)	15.512 590	1 736 554	A BXA ZZY	x
theta1 (θ1)	15.512 590	1 736 556	A BXA ZZA	j
MQ1	15.585 443	1 754 555	A BZY ZZZ	x
J1	15.585 443	1 754 556	A BZY ZZA	y
2PO1	15.974 827	1 815 554	A CVZ ZZY	x
SO1	16.056 964	1 835 555	A CXZ ZZZ	x
SO1	16.056 964	1 835 556	A CXZ ZZA	x
OO1	16.139 102	1 855 556	A CZZ ZZA	d
ups1 (υ1)	16.683 476	1 954 556	A DZY ZZA	d
KQ1	16.683 476	1 954 556	A DZY ZZA	x

Semi-Diurnal Constituents

2MN2S2	26.407 938	2 096 555	B UDA ZZZ	x
3M(SK)2	26.870 175	2 175 555	B VBZ ZZZ	x
3MKS2	26.870 175	2 175 555	B VBZ ZZZ	x
2NS2	26.879 459	2 177 555	B VBB ZZZ	x
3M2S2	26.952 313	2 195 555	B VDZ ZZZ	x
3MS2	26.952 313	2 195 555	B VDZ ZZZ	x
2NK2S2	26.961 596	2 197 555	B VDB ZZZ	x
OQ2	27.341 696	2 256 555	B WZA ZZZ	x
MNK2	27.341 696	2 256 555	B WZA ZZZ	x
OQ2	27.341 696	2 256 557	B WZA ZZB	x
MNS2	27.423 834	2 276 555	B WBA ZZZ	x
eps2 (ε2)	27.423 834	2 276 555	B WBA ZZZ	m
MnuS2 (MνS2)	27.496 687	2 294 555	B WDY ZZZ	x
2ML2S2	27.496 687	2 294 557	B WDY ZZB	x
MNK2S2	27.505 971	2 296 555	B WDA ZZZ	x
2MS2K2	27.803 934	2 335 555	B XXZ ZZZ	x
2MK2	27.886 071	2 355 555	B XZZ ZZZ	x
O2	27.886 071	2 355 555	B XZZ ZZZ	x
NLK2	27.886 071	2 355 557	B XZZ ZZB	x
2N2	27.895 355	2 357 555	B XZB ZZZ	m
mu2 (μ2)	27.968 208	2 375 555	B XBZ ZZZ	m
2MS2	27.968 208	2 375 555	B XBZ ZZZ	x
SNK2	28.357 592	2 436 555	B YXA ZZZ	x
NA2	28.398 661	2 446 555	B YYA ZZZ	f
NA2	28.398 663	2 446 565	B YYA ZAZ	f
N2	28.439 730	2 456 555	B YZA ZZZ	m
KQ2	28.439 730	2 456 555	B YZA ZZZ	x
NB2	28.480 796	2 466 545	B YAA ZYZ	f
NA2*	28.480 798	2 466 555	B YAA ZZZ	f
nu2 (ν2)	28.512 583	2 474 555	B YBY ZZZ	m
2KN2S2	28.604 004	2 496 555	B YDA ZZZ	x
MSK2	28.901 967	2 535 555	B ZXZ ZZZ	x
OP2	28.901 967	2 535 555	B ZXZ ZZZ	x
OP2	28.901 967	2 535 557	B ZXZ ZZB	x

gamma2 (γ2)	28.911 251	2 537 557	B ZXB ZZB	y
MA2	28.943 036	2 545 555	B ZYZ ZZZ	f
MPS2	28.943 036	2 545 556	B ZYZ ZZA	x
alpha2 (α2)	28.943 038	2 545 567	B ZYZ ZAB	y
M(SK)2	28.943 038	2 545 567	B ZYZ ZAB	x
M2	28.984 104	2 555 555	B ZZZ ZZZ	y
KO2	28.984 104	2 555 555	B ZZZ ZZZ	x
M(KS)2	29.025 171	2 565 545	B ZAZ ZYZ	x
MSP2	29.025 173	2 565 554	B ZAZ ZZY	x
MB2	29.025 173	2 565 555	B ZAZ ZZZ	f
MA2*	29.025 173	2 565 555	B ZAZ ZZZ	f
MKS2	29.066 242	2 575 555	B ZBZ ZZZ	x
delta2 (δ2)	29.066 242	2 575 555	B ZBZ ZZZ	y
M2(KS)2	29.148 379	2 595 555	B ZDZ ZZZ	x
2KM2S2	29.148 379	2 595 555	B ZDZ ZZZ	x
2SN(MK)2	29.373 488	2 616 555	B AVA ZZZ	x
lambda2 (λ2)	29.455 625	2 636 557	B AXA ZZB	m
L2	29.528 479	2 654 557	B AZY ZZB	y
2MN2	29.528 479	2 654 557	B AZY ZZB	x
L2A	29.528 479	2 654 557	B AZY ZZB	p
L2B	29.537 763	2 656 555	B AZA ZZZ	q
NKM2	29.537 763	2 656 555	B AZA ZZZ	x
2SK2	29.917 863	2 715 555	B BVZ ZZZ	x
T2	29.958 933	2 725 565	B BWZ ZAZ	z
S2	30.000 000	2 735 555	B BXZ ZZZ	z
KP2	30.000 000	2 735 555	B BXZ ZZZ	x
R2	30.041 067	2 745 547	B BYZ ZYB	z
K2	30.082 137	2 755 555	B BZZ ZZZ	y
MSnu2 (MSν2)	30.471 521	2 816 555	B CVA ZZZ	x
MSN2	30.544 375	2 834 555	B CXY ZZZ	x
xi2 (ξ2)	30.553 658	2 836 555	B CXA ZZZ	y
eta2 (η2)	30.626 512	2 854 555	B CZY ZZZ	y
KJ2	30.626 512	2 854 557	B CZY ZZB	x
2KM(SN)2	30.708 649	2 874 555	B CBY ZZZ	x
2SM2	31.015 896	2 915 555	B DVZ ZZZ	x
2MS2N2	31.088 749	2 933 555	B DXX ZZZ	x
SKM2	31.098 033	2 935 555	B DXZ ZZZ	x
2Snu2 (2Sν2)	31.487 417	--------------	B ETA ZZZ	x
3(SM)N2	31.487 417	--------------	B ETA ZZZ	x
2SN2	31.560 270	--------------	B EVY ZZZ	x
SKN2	31.642 408	--------------	B EXY ZZZ	x
3S2M2	32.031 792	--------------	B FTZ ZZZ	x
2SK2M2	32.113 929	--------------	B FVZ ZZZ	x

Third-Diurnal Constituents

MQ3	42.382 765	3 356 554	C XZA ZZY	x
NO3	42.382 765	3 356 554	C XZA ZZY	x
MQ3	42.382 765	3 356 555	C XZA ZZZ	x
NO3	42.382 765	3 356 555	C XZA ZZZ	x
MO3	42.927 140	3 455 554	C YZZ ZZY	x
2MK3	42.927 140	3 455 554	C YZZ ZZY	x

MO3	42.927 140	3 455 555	C YZZ ZZZ	x
2NKM3	42.936 423	3 457 556	C YZB ZZA	x
2MS3	42.968 208	3 465 557	C YAZ ZZB	x
2MP3	43.009 277	3 475 556	C YBZ ZZA	x
M3	43.476 156	3 555 557	C ZZZ ZZB	g
NK3	43.480 798	3 556 555	C ZZA ZZZ	x
NK3	43.480 798	3 556 556	C ZZA ZZA	x
SO3	43.943 036	3 635 554	C AXZ ZZY	x
MP3	43.943 036	3 635 554	C AXZ ZZY	x
MP3	43.943 036	3 635 555	C AXZ ZZZ	x
MS3	43.984 104	3 645 557	C AYZ ZZB	x
MK3	44.025 173	3 655 555	C AZZ ZZZ	x
MK3	44.025 173	3 655 556	C AZZ ZZA	x
NSO3	44.496 694	3 736 556	C BXA ZZA	x
2MQ3	44.569 548	3 754 556	C BZY ZZA	x
SP3	44.958 931	3 815 554	C CVZ ZZY	x
SP3	44.958 931	3 815 555	C CVZ ZZZ	x
S3	45.000 000	3 825 557	C CWZ ZZB	x
SK3	45.041 069	3 835 555	C CXZ ZZZ	x
SK3	45.041 069	3 835 556	C CXZ ZZA	x
K3	45.123 206	3 855 555	C CZZ ZZZ	x
K3	45.123 206	3 855 556	C CZZ ZZA	x
2SO3	46.056 964	-------------	C EVZ ZZA	x

Quarter-Diurnal Constituents

4MS4	55.936 417	4 195 555	D VDZ ZZZ	x
4M2S4	55.936 417	4 195 555	D VDZ ZZZ	x
2MNK4	56.325 801	4 256 555	D WZA ZZZ	x
3NM4	56.335 084	4 258 555	D WZC ZZZ	x
2MNS4	56.407 938	4 276 555	D WBA ZZZ	x
2MnuS4 (2MνS4)	56.480 792	4 294 555	D WDY ZZZ	x
3MK4	56.870 175	4 355 555	D XZZ ZZZ	x
MNLK4	56.870 175	4 355 557	D XZZ ZZB	x
N4	56.879 459	4 357 555	D XZB ZZZ	x
2N4	56.879 459	4 357 555	D XZB ZZZ	x
3MS4	56.952 313	4 375 555	D XBZ ZZZ	x
2NKS4	56.961 596	4 377 555	D XBB ZZZ	x
MSNK4	57.341 696	4 436 555	D YXA ZZZ	x
MN4	57.423 834	4 456 555	D YZA ZZZ	x
Mnu4 (Mν4)	57.496 687	4 474 555	D YBY ZZZ	x
2MLS4	57.496 687	4 474 557	D YBY ZZB	x
MNKS4	57.505 971	4 476 555	D YBA ZZZ	x
2MSK4	57.886 071	4 535 555	D ZXZ ZZZ	x
MA4	57.927 140	4 545 555	D ZYZ ZZZ	x
M4	57.968 208	4 555 555	D ZZZ ZZZ	x
2MRS4	58.009 275	4 565 547	D ZAZ ZYB	x
2MKS4	58.050 346	4 575 555	D ZBZ ZZZ	x
SN4	58.439 730	4 636 555	D AXA ZZZ	x
3MN4	58.512 583	4 654 555	D AZY ZZZ	x
ML4	58.512 583	4 654 555	D AZY ZZZ	x
ML4	58.512 583	4 654 557	D AZY ZZB	x
KN4	58.521 867	4 656 555	D AZA ZZZ	x
NK4	58.521 867	4 656 555	D AZA ZZZ	x
2SMK4	58.901 967	4 715 555	D BVZ ZZZ	x
M2SK4	58.901 967	4 715 555	D BVZ ZZZ	x

MT4	58.943 038	4 725 565	D BWZ ZAZ	x
MS4	58.984 104	4 735 555	D BXZ ZZZ	x
MR4	59.025 171	4 745 547	D BYZ ZYB	x
MK4	59.066 242	4 755 555	D BZZ ZZZ	x
2SNM4	59.455 625	4 816 555	D CVA ZZZ	x
2MSN4	59.528 479	4 834 555	D CXY ZZZ	x
2MSN4	59.528 479	4 834 557	D CXY ZZB	x
SL4	59.528 479	4 834 557	D CXY ZZB	x
2MKN4	59.610 616	4 854 555	D CZY ZZZ	x
ST4	59.958.933	4 905 565	D DUZ ZAZ	x
S4	60.000 000	4 915 555	D DVZ ZZZ	x
SK4	60.082 137	4 935 555	D DXZ ZZZ	x
K4	60.164 275	4 955 555	D DZZ ZZZ	x
3SM4	61.015 896	-------------	D FTZ ZZZ	x
2SKM4	61.098 033	-------------	D FVZ ZZZ	x

Fifth-Diurnal Constituents

MNO5	71.366 869	5 356 554	E XZA ZZY	x
2MQ5	71.366 869	5 356 554	E XZA ZZY	x
2NKMS5	71.453 648	5 377 556	E XBB ZZA	x
3MK5	71.911 244	5 455 554	E YZZ ZZY	x
2MO5	71.911 244	5 455 554	E YZZ ZZY	x
2NK5	71.920 528	5 457 556	E YZB ZZA	x
3MS5	71.952 313	5 465 557	E YAZ ZZB	x
3MP5	71.993 381	5 475 556	E YBZ ZZA	x
NSO5	72.382 765	5 536 554	E ZXA ZZY	x
M5	72.460 261	5 555 556	E ZZZ ZZA	g
M5	72.460 261	5 555 557	E ZZZ ZZB	g
M5	72.464 902	5 556 556	E ZZA ZZA	g
MNK5	72.464 902	5 556 556	E ZZA ZZA	x
MB5	72.501 329	5 565 556	E ZAZ ZZA	x
MSO5	72.927 140	5 635 554	E AXZ ZZY	x
2MP5	72.927 140	5 635 554	E AXZ ZZY	x
2MS5	72.968 208	5 645 557	E AYZ ZZB	x
3MO5	73.009 277	5 655 556	E AZZ ZZA	x
2MK5	73.009 277	5 655 556	E AZZ ZZA	x
NSK5	73.471 515	5 734 556	E BXY ZZA	x
3MQ5	73.553 652	5 754 556	E BZY ZZA	x
MSP5	73.943 036	5 815 554	E CVZ ZZY	x
MSK5	74.025 173	5 835 555	E CXZ ZZZ	x
MSK5	74.025 173	5 835 556	E CXZ ZZA	x
3KM5	74.107 310	5 855 554	E CZZ ZZY	x
2SP5	74.958 931	-------------	E ETZ ZZY	x
2SK5	75.041 069	-------------	E EVZ ZZA	x
(SK)K5	75.123 206	-------------	E EXZ ZZA	x

Sixth-Diurnal Constituents

2(MN)K6	84.765 530	6 157 555	F VZB ZZZ	x
5MKS6	84.838 384	6 175 555	F VBZ ZZZ	x
2(MN)S6	84.847 668	6 177 555	F VBB ZZZ	x
5M2S6	84.920 521	6 195 555	F VDZ ZZZ	x
3MNK6	85.309 905	6 256 555	F WZA ZZZ	x
N6	85.319 189	6 258 555	F WZC ZZZ	x
3MNS6	85.392 042	6 276 555	F WBA ZZZ	x
3NKS6	85.401 326	6 278 555	F WBC ZZZ	x
3MnuS6 (3MνS6)	85.464 896	6 294 555	F WDY ZZZ	x

4MK6	85.854 280	6 355 555	F XZZ ZZZ	x
2NM6	85.863 563	6 357 555	F XZB ZZZ	x
M2N6	85.863 563	6 357 555	F XZB ZZZ	x
4MS6	85.936 417	6 375 555	F XBZ ZZZ	x
2NMKS6	85.945 701	6 377 555	F XBB ZZZ	x
2MSNK6	86.325 801	6 436 555	F YXA ZZZ	x
2MN6	86.407 938	6 456 555	F YZA ZZZ	x
2Mnu6 (2Mν6)	86.480 792	6 474 555	F YBY ZZZ	x
2MNO6	86.480 792	6 474 555	F YBY ZZZ	x
2MNKS6	86.490 075	6 476 555	F YBA ZZZ	x
3MSK6	86.870 175	6 535 555	F ZXZ ZZZ	x
MA6	86.911 244	6 545 555	F ZYZ ZZZ	x
M6	86.952 313	6 555 555	F ZZZ ZZZ	x
3MKS6	87.034 450	6 575 555	F ZBZ ZZZ	x
MTN6	87.382 767	6 626 565	F AWA ZAZ	x
MSN6	87.423 834	6 636 555	F AXA ZZZ	x
4MN6	87.496 687	6 654 555	F AZY ZZZ	x
2ML6	87.496 687	6 654 557	F AZY ZZB	x
MNK6	87.505 971	6 656 555	F AZA ZZZ	x
MKN6	87.505 971	6 656 555	F AZA ZZZ	x
MKnu6 (MKν6)	87.578 825	6 674 555	F ABY ZZZ	x
2(MS)K6	87.886 071	6 715 555	F BVZ ZZZ	x
2MT6	87.927 142	6 725 565	F BWZ ZAZ	x
2MS6	87.968 208	6 735 555	F BXZ ZZZ	x
2MK6	88.050 346	6 755 555	F BZZ ZZZ	x
2SN6	88.439 730	6 816 555	F CVA ZZZ	x
3MTN6	88.471 517	6 824 565	F CWY ZAZ	x
3MSN6	88.512 583	6 834 555	F CXY ZZZ	x
MSL6	88.512 583	6 834 557	F CXY ZZB	x
NSK6	88.521 867	6 836 555	F CXA ZZZ	x
SNK6	88.521 867	6 836 555	F CXA ZZZ	x
MKL6	88.594 720	6 854 557	F CZY ZZB	x
3MKN6	88.594 720	6 854 555	F CZY ZZZ	x
MST6	88.943 038	6 905 565	F DUZ ZAZ	x
2SM6	88.984 104	6 915 555	F DVZ ZZZ	x
MSK6	89.066 242	6 935 555	F DXZ ZZZ	x
SKM6	89.066 242	6 935 555	F DXZ ZZZ	x
2KM6	89.148 379	6 955 555	F DZZ ZZZ	x
2MSTN6	89.487 412	--------------	F EUY ZAZ	x
2(MS)N6	89.528 479	--------------	F EVY ZZZ	x
2MSKN6	89.610 616	--------------	F EXY ZZZ	x
S6	90.000 000	--------------	F FTZ ZZZ	x

Seventh-Diurnal Constituents

2MNO7	100.350 974	7 356 554	G XZA ZZY	x
3MQ7	100.350 974	7 356 554	G XZA ZZY	x
4MK7	100.895 348	7 455 554	G YZZ ZZY	x
2NMK7	100.904 632	7 457 556	G YZB ZZA	x
MNSO7	101.366 869	7 536 554	G ZXA ZZY	x
M7	101.444 365	7 555 557	G ZZZ ZZB	g
M7	101.449 007	7 556 556	G ZZA ZZA	g
2MNK7	101.449 007	7 556 556	G ZZA ZZA	x
MNKO7	101.449 007	7 556 556	G ZZA ZZA	x
2MSO7	101.911 244	7 635 554	G AXZ ZZY	x
3MK7	101.993 381	7 655 556	G AZZ ZZA	x
MSKO7	103.009 277	7 835 554	G CXZ ZZY	x

Eighth-Diurnal Constituents

3M2NS8	113.831 772	8 177 555	H VBB ZZZ	x
4MNS8	114.376 146	8 276 555	H WBA ZZZ	x
5MK8	114.838 384	8 355 555	H XZZ ZZZ	x
2(MN)8	114.847 668	8 357 555	H XZB ZZZ	x
5MS8	114.920 521	8 375 555	H XBZ ZZZ	x
2(MN)KS8	114.929 805	8 377 555	H XBB ZZZ	x
3MSNK8	115.309 905	8 436 555	H YXA ZZZ	x
3MN8	115.392 042	8 456 555	H YZA ZZZ	x
3Mnu8 (3Mν8)	115.464 896	8 474 555	H YBY ZZZ	x
3MNKS8	115.474 180	8 476 555	H YBA ZZZ	x
4MSK8	115.854 280	8 535 555	H ZXZ ZZZ	x
MA8	115.895 348	8 545 555	H ZYZ ZZZ	x
M8	115.936 417	8 555 555	H ZZZ ZZZ	x
4MKS8	116.018 554	8 575 555	H ZBZ ZZZ	x
2MSN8	116.407 938	8 636 555	H AXA ZZZ	x
3ML8	116.480 792	8 654 555	H AZY ZZZ	x
2MNK8	116.490 075	8 656 555	H AZA ZZZ	x
3M2SK8	116.870 175	8 715 555	H BVZ ZZZ	x
2(NS)8	116.879 459	8 717 555	H BVB ZZZ	x
3MT8	116.911 246	8 725 565	H BWZ ZAZ	x
3MS8	116.952 313	8 735 555	H BXZ ZZZ	x
3MK8	117.034 450	8 755 555	H BZZ ZZZ	x
2SNM8	117.423 834	8 816 555	H CVA ZZZ	x
2SMN8	117.423 834	8 816 555	H CVA ZZZ	x
2MSL8	117.496 687	8 834 557	H CXY ZZB	x
MSNK8	117.505 971	8 836 555	H CXA ZZZ	x
4MSN8	117.578 825	8 854 555	H CZY ZZZ	x
2MST8	117.927 142	8 905 565	H DUZ ZAZ	x
2(MS)8	117.968 208	8 915 555	H DVZ ZZZ	x
2MSK8	118.050 346	8 935 555	H DXZ ZZZ	x
2(MK)8	118.132 483	8 955 555	H DZZ ZZZ	x
3SN8	118.439.730	--------------	H ETA ZZZ	x
2SML8	118.512 583	--------------	H EVY ZZB	x
2SKN8	118.521 867	--------------	H EVA ZZZ	x
MSKL8	118.594 720	--------------	H EXY ZZB	x
3SM8	118.984 104	--------------	H FTZ ZZZ	x
2SMK8	119.066 242	--------------	H FVZ ZZZ	x
S8	120.000 000	--------------	H HRZ ZZZ	x

Ninth-Diurnal Constituents

3MNO9	129.335 076	9 356 554	I XZA ZZY	x
2M2NK9	129.888 738	9 457 556	I YZB ZZA	x
2(MN)K9	129.888 738	9 457 556	I YZB ZZA	x
MA9	130.387 400	9 545 555	I ZYZ ZZZ	x
3MNK9	130.433 113	9 556 556	I ZZA ZZA	x
4MK9	130.977 488	9 655 556	I AZZ ZZA	x
3MSK9	131.993 383	9 835 556	I CXZ ZZA	x

Tenth-Diurnal Constituents

5MNS10	143.360 251	--------------	J WBA ZZZ	x
3M2N10	143.831 772	--------------	J XZB ZZZ	x

6MS10	143.904 625	--------------	J XBZ ZZZ	x
3M2NKS10	143.913 909	--------------	J XBB ZZZ	x
4MSNK10	144.294 009	--------------	J YXA ZZZ	x
4MN10	144.376 146	--------------	J YZA ZZZ	x
4Mnu10 (4Mν10)	144.449 000	--------------	J YBY ZZZ	x
5MSK10	144.838 384	--------------	J ZXZ ZZZ	x
M10	144.920 521	--------------	J ZZZ ZZZ	x
5MKS10	145.002 658	--------------	J ZBZ ZZZ	x
3MSN10	145.392 042	--------------	J AXA ZZZ	x
6MN10	145.464 896	--------------	J AZY ZZZ	x
4ML10	145.464 896	--------------	J AZY ZZB	x
3MNK10	145.474 180	--------------	J AZA ZZZ	x
2(SN)M10	145.863 563	--------------	J BVB ZZZ	x
4MS10	145.936 417	--------------	J BXZ ZZZ	x
4MK10	146.018 554	--------------	J BZZ ZZZ	x
2(MS)N10	146.407 938	--------------	J CVA ZZZ	x
2MNSK10	146.490 075	--------------	J CXA ZZZ	x
5MSN10	146.562 929	--------------	J CZY ZZZ	x
3M2S10	146.952 313	--------------	J DVZ ZZZ	x
3MSK10	147.034 450	--------------	J DXZ ZZZ	x
3SMN10	147.423 834	--------------	J ETA ZZZ	x
2SMKN10	147.505 971	--------------	J EVA ZZZ	x
4M2SN10	147.578 825	--------------	J EXY ZZZ	x
3S2M10	147.968 208	--------------	J FTZ ZZZ	x
2(MS)K10	148.050 346	--------------	J FVZ ZZZ	x

Eleventh-Diurnal Constituent

4MSK11	160.977 486	--------------	K CXZ ZZA	x

Twelfth-Diurnal Constituents

5M2NS12	171.799 980	--------------	L VBB ZZZ	x
3(MN)12	172.271 501	--------------	L WZC ZZZ	x
6MNS12	172.344 355	--------------	L WBA ZZZ	x
4M2N12	172.815 876	--------------	L XZB ZZZ	x
7MS12	172.888 730	--------------	L XBZ ZZZ	x
4M2NKS12	172.898 013	--------------	L XBB ZZZ	x
5MSNK12	173.278 113	--------------	L YXA ZZZ	x
3N2MS12	173.362 457	--------------	L YZA YZZ	x
5MN12	173.360 251	--------------	L YZA ZZZ	x
5Mnu12 (5Mν12)	173.433 104	--------------	L YBY ZZZ	x
6MSK12	173.822 488	--------------	L ZXZ ZZZ	x
3M2SN12	173.831 772	--------------	L ZXB ZZZ	x
MA12	173.863 557	--------------	L ZYZ ZZZ	x
M12	173.904 625	--------------	L ZZZ ZZZ	x
4MSN12	174.376 146	--------------	L AXA ZZZ	x
4ML12	174.449 000	--------------	L AZY ZZB	x
4MNK12	174.458 284	--------------	L AZA ZZZ	x
2(MSN)12	174.847 668	--------------	L BVB ZZZ	x
5MT12	174.879 455	--------------	L BWZ ZAZ	x
5MS12	174.920 521	--------------	L BXZ ZZZ	x
5MK12	175.002 658	--------------	L BZZ ZZZ	x
3M2SN12	175.392 042	--------------	L CVA ZZZ	x
6MSN12	175.464 896	--------------	L CXY ZZZ	x

3MNKS12	175.474 180	--------------	L CXA ZZZ	x
5MSN12	175.547 033	--------------	L CZY ZZZ	x
4MST12	175.895 350	--------------	L DUZ ZAZ	x
4M2S12	175.936 417	--------------	L DVZ ZZZ	x
4MSK12	176.018 554	--------------	L DXZ ZZZ	x
3(MS)12	176.952 313	--------------	L FTZ ZZZ	x
3M2SK12	177.034 450	--------------	L FVZ ZZZ	x

Fourteenth-Diurnal Constituents

5MSN14	203.360 251	--------------	N AXA ZZZ	x
5MNK14	203.442 388	--------------	N AZA ZZZ	x
6MS14	203.904 625	--------------	N BXZ ZZZ	x

2. Nodal Corrections - Application

x indicates that the corrections should be derived from the name of the constituent using the principles set out in Annex B.

y indicates that reference should be made to Annex A which shows the derivations most commonly used for specific individual constituents.

z indicates that $u = 0$ and $f = 1$

a u and f are same as Mm

b u of MSf and MSo = $-u$ of M2
f of MSf and MSo = f of M2

c u of 2SM = $-2(u$ of M2$)$
f of 2SM = $(f$ of M2$)^2$

d u and f are same as KQ1

e u and f are same as K2

f there are theoretical reasons why u and f of MA2 , MB2 , NA2 , NB2 (and alternative names) should be the same as those for M2. The constituents are so small that there will be no significant error if values of $u = 0$ and $f = 1$ are used either in analysis or prediction, and this is often the case.

g apart from M1, the constituents MS (where "S" is an odd species) have values of :

$$u = -S\,(1.07 \sin N)$$

$$f = (\sqrt{f \text{ of M2}}\,)^S$$

these values are also used in place of the normal ones for M1 where this forms part of a compound constituent.

j *u* and *f* are same as J1

k *u* and *f* are same as K1

m *u* and *f* are same as M2

o *u* and *f* are same as O1

p *u* and *f* are same as 2MN2

q *u* and *f* are same as NKM2

Appendix A

Computation of Nodal Corrections *u* and *f*

The nodal corrections ***u*** and ***f*** must be derived from the Orbital Elements (p and N) using the appropriate formulae as follows :

M1B :

$$f.\sin u = 2.783 \sin 2p + 0.558 \sin (2p - N) + 0.184 \sin N$$
$$f.\cos u = 1 + 2.783 \cos 2p + 0.558 \cos (2p - N) + 0.184 \cos N$$

M1 :

$$f.\sin u = \sin p + 0.2 \sin (p - N)$$
$$f.\cos u = 2 [\cos p + 0.2 \cos (p - N)]$$

M1A :

$$f.\sin u = - 0.3593 \sin 2p - 0.2 \sin N - 0.066 \sin (2p - N)$$
$$f.\cos u = 1 + 0.3593 \cos 2p + 0.2 \cos N + 0.066 \cos (2p - N)$$

gamma 2 :

$$f.\sin u = 0.147 \sin 2(N - p)$$
$$f.\cos u = 1 + 0.147 \cos 2(N - p)$$

alpha 2 :

$$f.\sin u = - 0.0446 \sin (p - p')$$
$$f.\cos u = 1 - 0.0446 \cos (p - p')$$

delta 2 :
(B ZBZ ZZZ)

$$f.\sin u = 0.477 \sin N$$
$$f.\cos u = 1 - 0.477 \cos N$$

xi 2 / eta 2 :

$$f.\sin u = - 0.439 \sin N$$
$$f.\cos u = 1 + 0.439 \cos N$$

L2 :

$$f.\sin u = - 0.2505 \sin 2p - 0.1102 \sin (2p - N) - 0.0156 \sin (2p - 2N) - 0.037 \sin N$$
$$f.\cos u = 1 - 0.2505 \cos 2p - 0.1102 \cos (2p - N) - 0.0156 \cos (2p - 2N) - 0.037 \cos N$$

From these formulae the values of ***u*** and ***f*** can be derived

The formulae for the following fundamental constituents are :

u of Mm = 0
f of Mm = $1 - 0.1311 \cos N + 0.0538 \cos 2p + 0.0205 \cos (2p - N)$

u of Mf = $-23.7 \sin N + 2.7 \sin 2N - 0.4 \sin 3N$
f of Mf = $1.084 + 0.415 \cos N + 0.039 \cos 2N$

u of O1 = $10.80 \sin N - 1.34 \sin 2N + 0.19 \sin 3N$
f of O1 = $1.0176 + 0.1871 \cos N - 0.0147 \cos 2N$

u of K1 = $-8.86 \sin N + 0.68 \sin 2N - 0.07 \sin 3N$
f of K1 = $1.0060 + 0.1150 \cos N - 0.0088 \cos 2N + 0.0006 \cos 3N$

u of J1 = $-12.94 \sin N + 1.34 \sin 2N - 0.19 \sin 3N$
f of J1 = $1.1029 + 0.1676 \cos N - 0.0170 \cos 2N + 0.0016 \cos 3N$

u of M2 = $-2.14 \sin N$
f of M2 = $1.0007 - 0.0373 \cos N + 0.0002 \cos 2N$

u of K2 = $-17.74 \sin N + 0.68 \sin 2N - 0.04 \sin 3N$
f of K2 = $1.0246 + 0.2863 \cos N + 0.0083 \cos 2N - 0.0015 \cos 3N$

u of M3 = $-3.21 \sin N$
f of M3 = $(\sqrt{\text{f of M2}})^3$

Values for all other constituents can either be derived form the above using the methods described in Annex B or else they have values of *u* = 0 and *f* = 1.

Appendix B

Derivation of Speeds and values of *u* and *f* from Constituent Names

As shown in Annex A the values of ***u*** and ***f*** have been derived from the Orbital Elements for the constituents given, but the values for other constituents can be derived from the construction of the individual constituent names using the principles below.

Speeds :

Starting from the left add all the values of the letters of the same name. Therefore, for example, MS4 = M2 + S2.
But if such addition produces the wrong number of cycles per day, then the signs of the compound constituents must be changed progressively from the right until the correct number of cycles is reached. Thus :

2MN6 = 2 x M2 + N2 resulting in the correct 6 cycles per day

however, 4MN6 = 4 x M2 + N2 which gives incorrect 10 cycles per day, therefore changing the sign of N2 produces :

4MN6 = 4 x M2 – N2 which gives the correct value of 6 cycles per day

Some other examples are :

MP1 = M2 – P1

3M2S2 = 3 x M2 – 2 x S2

Value of *u* :

When using the above principles it needs to be borne in mind that ***u*** sometimes has a value of zero.

For example, *u* of 3M2S2 = 3 x (*u* of M2) – 2 x (*u* of S2) but *u* of S2 = 0

therefore, *u* of 3M2S2 = 3 x (*u* of M2)

Likewise, *u* of MP1 = (*u* of M2) – (*u* of P1) but *u* of P1 = 0

therefore, *u* of MP1 = *u* of M2

In addition, because several astronomical constituents have the same values of ***u*** the expression may sometimes be simplified. For example, M2 and N2 have the same value for ***u*** and therefore,

u of 2MN6 = 3 x (u of M2)

Value of *f* :

The values of ***f*** are obtained in basically the same manner but multiplying instead of adding the individual contributions. Furthermore, ***f*** is always obtained by multiplication and not by division even if a change of sign becomes necessary as explained above.

As with the values of ***u*** the expression if often simplified by the fact that some astronomical constituents have values of $f = 1$, and several have the same value.

For example,

f of MS4 = f of M2 x f of S2 but f of S2 = 1

therefore, f of MS4 = f of M2

f of 2MN6 = (f of M2)^2 x f of N2 but f of N2 = f of M2

therefore, f of 2MN6 = (f of M2)^3

f of 4MN6 = (f of M2)^4 x f of N2 but f of N2 = f of M2

therefore, f of 4MN6 = (f of M2)^5

f of MP1 = f of M2 x f of P1 but f of P1 = 1

therefore, f of MP1 = f of M2

f of 3M2S2 = (f of M2)^3 x (f of S2)^2 but f of S2 = 1

therefore, f of 3M2S2 = (f of M2)^3

Exceptions :

There are several exceptions to all the above principles. The primary ones are :

MSf this has a speed equal to (S2 – M2) and should be treated, therefore, as if it were SMf, and hence the value of ***u*** becomes (–u of M2). This will of course have no effect on the value of ***f***, which is always obtained by multiplication and thus equals (f of M2).

MA2 and MB2 :

despite their appearance neither of them, nor constituents of other species which include A and B, are compound constituents – there are no constituents A or B to form a compound. They are constituents whose speeds differ by one cycle a year from that of M2. The A in MA2 was intended to signify the Annual differences.

MB2 was originally called Ma2 but this became ambiguous when spoken, or typed on computers without lower case, and so it was initially changed to MA2*. However, this in turn was thought to be clumsy and hence MB2 was finally adopted. Although theoretically they should have the same values of ***u*** and ***f*** as M2, they are so small that they are commonly treated as having values of $u = 0$ and $f = 1$.

NA2 and NB2 :

the self same reasoning applies to these two constituents. They are constituents whose speeds differ by one cycle a year from that of N2. Although theoretically they should have the same values of ***u*** and ***f*** as N2 they are so small that they are commonly treated as having values of $u = 0$ and $f = 1$.

M3 despite the fact that it has more than 2 cycles per day it is nevertheless an astronomical constituent.

MSm found in some lists is apparently mis-named. Its speed corresponds to a name of MNum (Mνm) by which name it is referred to in the foregoing list.

Note :

Greek letters present difficulties for most computer keyboards and the solution often employed is to spell out the letter phonetically – for example, theta1 ; mu2.

Care has to be taken when using this method in order not to confuse P1 with the Greek PI 1 (= π_1). ν (nu or Nu) by virtue of its close resemblance to the letter v is often written as v or V. Thus Mν4 may be written as Mnu4 ; MNu4 ; Mv4 or MV4.