List of changes, corrections and comments to the text of GLONASS ICD-98

This purpose of this list is to eliminate inconsistencies in designations of parameters given in both preceding (ICD-95) and current (ICD-98) versions of the GLONASS Interface Control Document, take into account revealed misprints, and provide clarifications on particular parameters and statements of the document As soon as this list is published, only ICD-98 (4.0) is considered as valid, but ICD-95 is cancelled.

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No.	Paragraph, (Fig., Table)	Text	Corrections (Comments)
1	Table 3.2	Second zonal harmonic of the geopotential (J_2^0) = 1082625.7x10^{-9} Fourth zonal harmonic of the geopotential (J_4^0) = (- 2370.90x10^{-9})	To compute orbital parameters some references use following normalized harmonic coefficients of Earth's gravitational field (PZ-90): $\bar{C}_{20}^{\,0}$ = -484165,0x10^{-9}; $\bar{C}_{40}^{\,0}$ = 790,3x10^{-9} There is following relationship between these coefficients and the parameters given in ICD: $J_2^0 = -(5)^{1/2}\,\bar{C}_{20}^{\,0}$ = 1082625.7x10^{-9}; $(J_4^0) = -3\,\bar{C}_{40}^{\,0}$ = - 2370.9x10^{-9} Furthermore, following relationships should be taken into account upon transition from normal gravitational field of Earth to abnormal one: $\Delta\bar{C}_{20} = \bar{C}_{20} - \bar{C}_{20}^{\,0} = 0$ $\Delta\bar{C}_{40} = \bar{C}_{40} - \bar{C}_{40}^{\,0}$ = -246.8x10^{-9}
2.	Fig. 4.2a Fig. 4.2b	Strings 7,9,11,13, and 15 within frame: Word $t_{\lambda n}{}^A$ (time of the first ascending node passage of n^A –satellite orbit within N^A -day) is mistakenly designated as $\tau_\lambda{}^A$.	Instead of "$\tau_\lambda{}^A$" read "$t_{\lambda n}{}^A$ "
3.	Fig. 4.2a Fig. 4.2b	Strings 7,9,11,13, and 15 within frame: Word $H_n{}^A$ (carrier frequency number of navigation RF signal transmitted by n^A-satellite) is mistakenly designated as $\Delta H_n{}^A$	Instead of "$\Delta H_n{}^A$ " read "$H_n{}^A$ "
4.	Fig. 4.2a Fig. 4.2b	String 7 within frame: Superfluous symbol τ_c is mistakenly inserted into position for the word $t_{\lambda n}{}^A$	Symbol τ_c is not to read
5.	Table 4.6	Bit numbers for word $\Delta\tau_n$ within frame are mistakenly written as 54,58	Instead of "54,58" read "54 – 58"

6	Table 4.9	Effective range for Word H_n^A should not be 1…31 but 0…31 (according to GLONASS frequency plan that stipulates usage of "0" (zero) frequency channel)	In column "Effective range" for Word H_n^A read "0…31" not "1…31"
7	Table 4.9	There are misprints in references for words τ_c and τ_n^A	For Word τ_c read "$\tau_c^{(1),(2), \text{and } (4)}$ " For Word τ_n^A read "$\tau_n^{A\ (2)}$ "
8	Table 4.12	In accordance with Note to Table 4.12 (Arrangement of reserved bits within superframe) position or reserved bits within superframe is given with regard to Notes 1 and 4 to Tables 4.5 and 4.10, that is taking into account planned modernization of GLONASS-M navigation message.	To provide status quo for current GLONASS satellites (as was given in preceding ICD-95) Annex D.1 of this list contains data on arrangement of reserved bits within current GLONASS (not GLONASS-M) satellite.
9	Appendix 3, A.3.1	There is some inconsistency in designations for zonal coefficients (see item 2 on this list and Table 3.2 in ICD 4.0 1998)	Instead of "C_{20} " in equations (1) read "J_2^0 " Then below equations (1) read description of C_{20} as follows: *J_2^0 - second zonal coefficient of spherical harmonic expansion for Earth's gravitational field. It is equal to* *1082625.7x10^{-9} ($J_2^0 = -(5)^{1/2}\ \bar{C}_{20}^{\ 0}$, where $\bar{C}_{20}^{\ 0}$ – normalized value of harmonic coefficient which is equal to (- 484165.0x10^{-9})) [PZ-90 Reference Document].* According to above, the signs before C_{20} parameter in equations (1) should be changed as follows: instead "+" read "-".
10	Appendix 3, A.3.1	There is misprint in parameters (indexes) below equation (2): $\mu_л$ and μ_c	Instead of "$\mu_л$" read "μ_l"; Instead of "μ_c" read "μ_s"
11	Appendix 3, A.3.1	There is misprint in equation (3) parameter ξ_{se}	Instead of "ξ_{se}" read "ξ_s"
12	Appendix 3, A.3.1	There are misprints in description of following parameters (indexes) below equations (3): g_{om} = 358°28′33″,04 g_{om} = 129596579″,10	Instead of: g_{om} = 358°28′33″,04 g_{om} = 129596579″,10 read g_{0c} = 358°28′33″,04 g_{1c} = 129596579″,10
13	Appendix 3, A.3.1	The values of the epochs below equations (3) contain mistakes: T is a time from the epoch 5 January 1900 (GMT) to time reference t_e of ephemeris parameters (in Julian centuries of 36525 ephemeris days); 27392.375 is a number of days from the epoch 5 January 1900 to the epoch 0 January 1975 (Moscow Time or MT) taking into account the three-hour offset between MT and GMT when re-computing t_e into GMT; Σ_{days} – sum of days from the epoch at 00 hours MT on 0 January 1975 to the epoch at 00 hours MT of current date within which the instant t_e is.	It should be read: **T** is a time from the epoch at 12 hours on 00 January 1900 (GMT) to time reference t_e of ephemeris parameters (in Julian centuries of 36525 ephemeris days); 27392.375 is a number of days from the epoch at 12 hours on 00 January 1900 to the epoch at 00 hours on 00 January 1975 (Moscow Time or MT) taking into account the three-hour offset between MT and GMT when re-computing t_e into GMT; Σ_{days} - sum of days from the epoch at 00 hours MT on 00 January 1975 to the epoch at 00 hours MT of current date within which the instant t_e is.

14	Appendix 3 A.3.1	Algorithm for calculation of satellite ephemeris to current time given in A.3.1 of ICD-98 is different from the algorithm of precedent version of the document (ICD-95).	To facilitate usage of ICD for development of standards and provide succession of current ICD-98 concerning to precedent ICD-95, Annex D.2 of this list contains another one example of simplified algorithm.

ANNEX D.1

Reserved bits within GLONASS superframe (not taking into consideration planned modernization of navigation message in GLONASS-M

String numbers within superframe	Position of bits within string	Number of bits
1, 16, 31, 46, 61	79 - 80	2
2, 17, 32, 47, 62	65 – 69	5
3, 18, 33, 48, 63	65 – 68	4
4, 19, 34, 49, 64	9 – 48	40
5, 20, 35, 50, 65	9 – 41	33
6, 8, 10, 12, 14, 21, 23, 25, 27, 29, 36, 38, 40, 42, 44, 51, 53, 55, 57, 59, 66, 68, 70, 72	78 – 79	2
7, 9, 11, 13, 15, 22, 24, 26, 28, 30, 37, 39, 41, 43, 45, 52, 54, 56, 58, 60, 67, 69, 71, 73	9	1
74, 75	9 – 80	72

ANNEX D.2

Simplified algorithm for recalculation of satellite ephemeris parameters to current time

Recalculation of ephemeris from instant t_b to instant t_i within the interval ($|\tau_i| = |t_i - t_b| \leq 15$ minutes) is performed using technique of numerical integration of differential equations describing motion of the satellites. In right-hand parts of these equations the accelerations determined using gravitational constant μ, zonal coefficient J_{20} which defines polar flattening of Earth, and accelerations due to luni-solar perturbation are taken into account. The equations are integrated in PZ-90 coordinate system with applying the Runge-Kutta technique of 4th order, as indicated below

$$dx/dt = V_x$$
$$dy/dt = V_y$$
$$dz/dt = V_z$$

$$dV_x/dt = -\frac{\mu}{r^3}x - \frac{3}{2}J_{20}\frac{\mu a_e^2}{r^5}x\left(1-\frac{5z^2}{r^2}\right) + \omega_з^2 x + 2\omega_з V_y + \ddot{x}$$
$$dV_y/dt = -\frac{\mu}{r^3}y - \frac{3}{2}J_{20}\frac{\mu a_e^2}{r^5}y\left(1-\frac{5z^2}{r^2}\right) + \omega_з^2 y + 2\omega_з V_x + \ddot{y}$$
$$dV_z/dt = -\frac{\mu}{r^3}z - \frac{3}{2}J_{20}\frac{\mu a_e^2}{r^5}z\left(3-\frac{5z^2}{r^2}\right) + \ddot{z}$$

$$r = \sqrt{x^2 + y^2 + z^2};$$

where

$\mu = 398600.44 \times 10^{-9}\ m^3/s^2$ - gravitational constant;
$a_e = 6\,378\,136\ m$ – semi-major axis;
$J_{20} = 1082625.7 \times 10^{-9}$ - second zonal harmonic of the geopotential;
$\omega_E = 7.292115 \times 10^{-5}\ radian/s^1$ – Earth rotation rate.

The values of the parameters μ, a_e, J_{20}, ω_E are defined in PZ-90 coordinate system.

Coordinates $x_n(t_b)$, $y_n(t_b)$, $z_n(t_b)$, and velocity vactor components $x_n'(t_b) = V_x$, $y_n'(t_b) = V_y$, $z_n'(t_b) = V_z$. are initial conditions for the integration. Accelerations due to luni-solar perturbation $x_n''(t_b)$, $y_n''(t_b)''$, $z_n''(t_b)$ are constant on the integration interval ±15 minutes.