GLONASS

Open Service Performance Standard (OS PS)

APPENDIX A
PERFORMANCE CHARACTERISTICS CALCULATION METHODS

Edition 2.2

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A.1.1   Constellation Coverage Calculation Method

1) The constellation coverage is defined as the portion of the near–Earth region bounded by the surface of the Earth (terrain relief excluded) and the altitude of 2,000 km above the surface of the Earth.

2) The standard for the constellation coverage is a ratio of the volume of the constellation coverage region, for which the performance is established in this OS PS to the entire volume of the constellation coverage.

   Note: The standard (100%) in this OS PS is established without verification.

A.1.2   Per–slot Coverage Calculation Method

1) The per–slot coverage is defined as the portion of the near–Earth region bounded by the surface of the Earth (terrain relief excluded), the altitude of 2,000 km above the surface of the Earth and a SV visibility zone with a 5–degree mask angle.

2) The standard for the per–slot coverage is a ratio of the volume of the per–slot coverage region, for which the performance is established in this OS PS to the entire volume of the per–slot coverage.

   Note: The standard (100%) in this OS PS is established without verification.

A.2   CSA SIS Accuracy Calculation Methods

A.2.1 CSA SIS URE Calculation Method

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1) For any instant of time with the constant increment (≤ 10 min) for any healthy SV the difference is measured between the satellite ephemeris (for radius, binormal, and normal) and clock broadcast in the navigation message and the post–processed ephemeris and clock based on measurements collected by the ground monitoring facilities:

$$\Delta R(SV_h, t), \Delta B(SV_h, t), \Delta N(SV_h, t), \Delta\mathrm{T}(SV_h, t),$$

where SV_h is a SV indicated as healthy in the navigation message data.

2) For any instant of time for any healthy SV in every site within the constellation coverage area (with the constant increment along longitude (1 degree) and the variable increment along latitude to provide for the equality of areas), the instantaneous SIS URE values $URE(\varphi, \lambda, \mathrm{SV}_h, t)$ are measured. To accomplish this, the difference between the broadcast and the post–processed ephemeris and clock are projected on the site–to–SV direction.

3) For any instant of time for any healthy SV the RMS Global Average SIS URE is defined:

$$URE_{GlobalAverage}(SV_h, t) = \sigma_{\varphi\mathrm{cov}, \lambda\mathrm{cov}}[URE(\varphi, \lambda, \mathrm{SV}_h, t)] = \sqrt{\frac{\displaystyle\sum_{\varphi\mathrm{cov}, \lambda\mathrm{cov}} URE^2(\varphi, \lambda, \mathrm{SV}_h, t)}{N_{SitesCov}}},$$

where $\varphi\mathrm{cov}, \lambda\mathrm{cov}, N_{SitesCov}$ — latitude, longitude, number of sites within the per–slot coverage area.

4) For any instant of time for any healthy SV the Worst Case Single Point Average URE is computed:

$$URE_{WorstCase}(SV_h, t) = \max_{\varphi\mathrm{cov}, \lambda\mathrm{cov}}[URE(\varphi, \lambda, \mathrm{SV}_h, t)].$$

5) For any healthy SV the value of 95% Global Average URE is computed which corresponds to 95% temporal distribution $URE_{GlobalAverage}(SV_h, t)$ over the ergodic interval (30 days): $URE_{95\%ergod\_GlobalAverage}(SV_h)$.

> Note: To verify the standards it is feasible to provide values obtained over the "sliding" ergodic interval during one year. The sliding interval is an interval which is longer than the increment for this interval, used when assessing performance.

A.2.1.2   CSA SIS URE Calculation Method Based on Ephemeris and Clock Data Errors

1) For any instant of time with the constant increment (≤ 10 min) for any healthy SV the difference is measured between the broadcast satellite ephemeris (for radius, binormal, and normal) and clock and the post–processed ephemeris and clock:

$$\Delta R(SV_h, t), \Delta B(SV_h, t), \Delta N(SV_h, t), \Delta T(SV_h, t),$$

Where SV_h is a SV indicated as healthy in the navigation message data.

2) For any instant of time for any healthy SV the RMS Global Average SIS URE is computed:

$$URE_{GlobalAverage}(SV_h, t) = \sqrt{(0.98 \cdot \Delta R(SV_h, t) - c \cdot \Delta T(SV_h, t))^2 + 0.19^2 \cdot (\Delta N(SV_h, t)^2 + \Delta B(SV_h, t)^2)}$$

3) For any instant of time for any healthy SV the Worst Case Single Point Average URE is computed:

$$URE_{WorstCase}(SV_h, t) = \max_{-|\beta| \le \alpha \le |\beta|} [\ \Delta R(SV_h, t) \cdot \cos(\alpha) - c \Delta T(SV_h, t) +$$

$$+ \sin(\alpha) \cdot \sqrt{\Delta N^2(SV_h, t) + \Delta B^2(SV_h, t)}\,],$$

$$\beta = \arcsin(\frac{\sin(90° + mask) \cdot 6731}{25508.2}),$$

$$mask = 5°.$$

4) For any healthy SV the value of 95% Global Average URE for any healthy SIS is computed which corresponds to 95% temporal distribution of $URE_{GlobalAverage}(SV_h, t)$ over the ergodic interval (30 days):

$$URE_{95\% ergod\_GlobalAverage}(SV_h).$$

Note: To verify the standards it is feasible to provide values obtained over the "sliding" ergodic interval during one year.

5) The value of 95% Global Average URE over all healthy SIS is computed which corresponds to 95% distribution of $URE_{GlobalAverage}(SV_h, t)$ over time and over entire constellation over the 1–day interval:

$$URE_{95\% day\_GlobalAverage\_costellation}.$$

Note: To verify the standards it is feasible to provide values obtained over the "sliding" ergodic interval during one year.

A.2.1.3   Threshold CSA SIS URE Calculation Method

1) For any healthy SV based on measurement interval of one year with the constant increment of $\le$ 30 min the RMS $URE_{GlobalAverage}(SV_h, t)$ over one day interval is computed:

$$URE_{RMS\_day\_GlobalAverage}(SV_h) =$$

$$= \sigma_t[URE_{GlobalAverage}(SV_h, t)] = \sqrt{\frac{\sum_t URE^2{}_{GlobalAverage}(SV_h, t)}{N_t}}$$

2) **99,37% Global Average URE** is computed which corresponds to the 99,37% distribution level of daily $URE_{RMS\_day\_GlobalAverage}(SV_h)$ based on measurement interval of one year:

$$URE_{99.37\% \text{ year}\_GlobalAverage}(SV_h).$$

3) For any healthy SV based on measurement interval of one year with the constant increment of ≤ 30 min the RMS $URE_{WorstCase}(SV_h, t)$ over one day interval is computed:

$$URE_{RMS\_day\_WorstCase}(SV_h) =$$

$$= \sigma_t[URE_{WorstCase}(SV_h, t)] = \sqrt{\frac{\sum_t URE^2{}_{WorstCase}(SV_h, t)}{N_t}}$$

4) **99,14% Worst Case Single Point Average URE** is computed which corresponds to the 99,14% distribution level of daily $URE_{RMS\_day\_WorstCase}(SV_h)$ based on measurement interval of one year :

$$URE_{99.14\% \text{ year}\_WorstCase}(SV_h).$$

Note: To verify the standards it is feasible to provide values obtained over the "sliding" one year interval during several years.

A.2.1.4   CSA SIS URE Reliability Calculation Method (Conservative Approach)

1) For any healthy SV for any instant *t* with the constant increment of ≤ 10 min the instantaneous $URE_{GlobalAverage}(SV_h, t)$ and $URE_{WorstCase}(SV_h, t)$ are calculated. For any healthy SV over one day interval the daily reliability is calculated as a probability that instantaneous $URE_{GlobalAverage}(SV_h, t)$ and $URE_{WorstCase}(SV_h, t)$ are less than or equal to 18 m:

$$R_{\text{URE\_GlobalAverage\_day}}(SV_h, t_{day}) = \frac{\sum_t R_{\text{URE\_GlobalAverage}}(SV_h, t)}{N_t},$$

$$R_{\text{URE\_GlobalAverage}}(SV_h, t) = \begin{cases} 1, URE_{GlobalAverage}(SV_h, t) \le 18 \text{ m} \\ 0, URE_{GlobalAverage}(SV_h, t) > 18 \text{ m} \end{cases}$$

$$R_{\text{URE\_}WorstCase\_day}(SV_h, t_{day}) = \frac{\sum_t R_{\text{URE\_}WorstCase}(SV_h, t)}{N_t},$$

$$R_{\text{URE\_}WorstCase}(SV_h, t) = \begin{cases} 1, & URE_{WorstCase}(SV_h, t) \leq 18 \text{ m} \\ 0, & URE_{WorstCase}(SV_h, t) > 18 \text{ m} \end{cases}$$

2) Based on the estimated daily reliability values the **Global Average Reliability and Worst Case Single Point Reliability** are computed for any healthy SV over one year interval:

$$R_{URE\_GlobalAverage\_year}(SV_h) == \frac{\sum_{t_{day}} R_{\text{URE\_GlobalAverage\_day}}(SV_h, t_{day})}{N_{tday}},$$

$$R_{URE\_WorstCase\_year}(SV_h) == \frac{\sum_{t_{day}} R_{\text{URE\_}WorstCase\_day}(SV_h, t_{day})}{N_{tday}},$$

where N_{tday} is the number of one day intervals.

A.2.2 CSA SIS URRE Calculation Method

A.2.2.1 CSA SIS URRE Calculation Method Based on Sampling Users in the Per–Slot Coverage Area

1) For any instant with the constant increment of 3 sec for any healthy SV and for any site within a SV's per–slot coverage area the instantaneous SIS URRE values are measured:

$$URRE(\varphi, \lambda, SV_h, t) = \frac{URE(\varphi, \lambda, SV_h, t + 3 \text{ sec}) - URE(\varphi, \lambda, SV_h, t)}{3 \text{ sec}}.$$

2) For any instant of time and for any healthy SV the RMS Global Average SIS URRE is defined:

$$URRE_{GlobalAverage}(SV_h, t) = \sigma_{\varphi\text{cov}, \lambda\text{cov}}[URRE(\varphi, \lambda, SV_h, t)] = \sqrt{\frac{\sum_{\varphi\text{cov}, \lambda\text{cov}} URRE^2(\varphi, \lambda, SV_h, t)}{N_{SitesCov}}},$$

Where $\varphi\text{cov}, \lambda\text{cov}, N_{SitesCov}$ are latitude, longitude, number of sites within the per–slot coverage area, correspondingly.

3) For any healthy SV **the 95% Global Average URRE** over ergodic interval (of 1 day) is computed: $URRE_{95\% ergod\_GlobalAverage}(SV_h)$.

Note: To verify the standards it is feasible to provide values obtained over the "sliding" ergodic interval during one year.

A.2.2.2   CSA SIS URRE Calculation Method Based on Onboard AFS Short–term Stability

1) Over ergodic interval of 1 day the Allan variance for the onboard AFS is defined using the minimum averaging interval (k sec) for every healthy SV in the constellation:

$$\sigma_{\text{AFS\_k\_day}}(\text{SV}_h) .$$

2) The **95% Global Average URRE** value which corresponds to the 95% time distribution level of $URRE_{GlobalAverage}(SV_h, t)$ over the ergodic interval of one day can be assessed as a contribution to SIS URE of the AFS stability over 3–sec interval attributed to time:

$$URRE_{95\%ergod\_GlobalAverage}(\text{SV}_h) = \frac{\sigma_{\text{AFS\_k\_day}}(\text{SV}_h) \cdot \sqrt{k/3} \cdot 3 \cdot 10^9 \cdot 0.3 \cdot 1,95}{3} .$$

Notes:

1) To verify the standard it is feasible to provide values obtained over the "sliding" ergodic interval during one year.

2) With one day stability of AFS equaling $1 \cdot 10^{-13}$, the 95% Global Average URRE is 0.01m/sec.

A.2.3 CSA SIS URAE Calculation Method

A.2.3.1   CSA SIS URAE Calculation Method Based on Sampling Users in the Per–slot Coverage Area

1) For any instant of time, for any healthy SV at any site of its per–slot coverage area instantaneous URAE is measured :

$$URAE(\varphi, \lambda, \text{SV}_h, t) = \frac{URRE(\varphi, \lambda, \text{SV}_h, t + 3 \sec) - URRE(\varphi, \lambda, \text{SV}_h, t)}{3 \sec} .$$

2) For any instant of time, for any healthy SV the average rms URAE for the per–slot coverage area is determined:

$$URAE_{GlobalAverage}(SV_h, t) = \sigma_{\varphi\text{cov},\lambda\text{cov}}[URAE(\varphi, \lambda, \text{SV}_h, t)] = \sqrt{\frac{\sum_{\varphi\text{cov},\lambda\text{cov}} URAE^2(\varphi, \lambda, \text{SV}_h, t)}{N_{SitesCov}}} ,$$

Where $\varphi\text{cov}, \lambda\text{cov}, N_{SitesCov}$ are latitude, longitude and the number of sites within the SV's per–slot coverage area, correspondingly.

3) For any healthy SV the value of the **95% Global Average URAE** is determined
which corresponds to the 95% time distribution level of $URAE_{GlobalAverage}(SV_h, t)$
over the ergodic interval of one day:

$$URAE_{95\%ergod\_GlobalAverage}(SV_h).$$

*Note: To verify the standard it is feasible to provide values obtained over the
"sliding" ergodic interval during one year.*

A.2.3.2 CSA SIS URAE Calculation Method Based on Onboard AFS Short–term Stability

1) Over the ergodic interval of 1 day the Allan variance for the onboard AFS is
defined using the minimum averaging interval (*k* sec) for every healthy SV in the
constellation:

$$\sigma_{AFS\_k\_day}(SV_h).$$

2) The **95% Global Average URAE** value which corresponds to the 95% time
distribution level of $URAE_{GlobalAverage}(SV_h, t)$ over the ergodic interval of one day
can be assessed as a contribution to SIS URE of the AFS stability over 3–sec
interval, attributed to time:

$$URAE_{95\%ergod\_GlobalAverage}(SV_h) = \frac{\sigma_{AFS\_k\_day}(SV_h) \cdot \sqrt{k/3} \cdot 3 \cdot 10^9 \cdot 0.3 \cdot 1,95}{9}.$$

Notes:

*1) To verify the standard it is feasible to provide values obtained over the
"sliding" ergodic interval during one year.*

*2) With one day stability of AFS equaling $1 \cdot 10^{-13}$, the 95% Global Average
URAE is 0.0033 m/sec.*

A.2.4 CSA SIS UTCOE Calculation Method

1) For any instant of time for any healthy SV with the constant increment of ≤ 10
min UTCOE is determined as a difference between the broadcast offset and the
GLONASS Time–UTC (SU) offset obtained by the reference timing facilities:

$$UTCOE(SV_h, t).$$

2) For any healthy SV the value of the **95% Global Average UTCOE** is determined
which corresponds to the 95% time distribution level of $UTCOE(SV_h, t)$ over the
ergodic interval of 30 days: $UTCOE_{95\%ergod\_GlobalAverage}(SV_h).$

*Note: To verify the standard it is feasible to provide values obtained over the
"sliding" ergodic interval during one year.*

A.3   Probability of CSA Major Service Failure Calculation Method

1) For any instant of time t with the constant increment ($S \leq 10$ min) for any SV its health status (H_flag) is determined based on availability of trackable SIS and the corresponding indication in the navigation message:

   H_flag=O (healthy), provided SIS is trackable, $B_n(I_n)$=O и C_n=1

   $B_n(I_n)$ and C_n parameters are described in the corresponding ICD.

2) For any healthy SV and for any instant of time t, the instantaneous $URE_{WorstCase}(SV_h, t)$ are computed.

3) For any healthy SV and for any instant of time t, the value of logical function for the instant t of a Major Service Failure

$$F_{MSF}(SV_h, t_i) = \begin{cases} 1, & (H\_flag(SV_h, t_i) = 0) \,\&\, (URE_{WorstCase}(SV_h, t_i) > 70 \text{ m}) \\ 0, & otherwise \end{cases}$$

4) For any healthy SV for the instant of time t, the value of logical function for the instant t of Single Major Service Failure (induced by single independent failures):

$$F_{MSF\_SAT}(SV_h, t_i) = \begin{cases} 1, & (F_{MSF}(SV_h, t_i) = 1) \,\&\, (\forall k \neq h, F_{MSF}(SV_k, t_i) = 0) \\ 0, & otherwise \end{cases}$$

5) For any healthy SV for the instant of time t, the value of logical function for the instant t of Multiple Major Service Failure (induced by simultaneous failures of two or more SV):

$$F_{MSF\_CONST}(t_i) = \begin{cases} 1, & (F_{MSF}(SV_h, t_i) = 1) \,\&\, (\exists k \neq h, F_{MSF}(SV_k, t_i) = 1) \\ 0, & otherwise \end{cases}$$

6) The average **Probability of Single Major Service Failure** over one year interval is determined as a ratio of the total duration of single failures during one year to the measurement interval and the number of SVs:

$$P_{SAT} = \frac{\sum\limits_{SV_h}\sum\limits_{t_i} F_{MSF\_SAT}(SV_h, t_i) \cdot S}{N_t \cdot S \cdot N_{SV}} = \frac{\sum\limits_{SV_h}\sum\limits_{t_i} F_{MSF\_SAT}(SV_h, t_i)}{N_t \cdot N_{SV}},$$

   N_t is the number of measurement instants over one year interval,

   N_{SV} is the nominal number of SVs in the constellation (24 for GLONASS).

7) The average **Probability of Multiple Major Service Failure** over the whole interval of available measurements is determined as a ratio of the total duration of multiple service failures over the whole interval of available measurements to the measurement interval:

$$P_{SAT} = \frac{\sum\limits_{t_i} F_{MSF\_CONST}(SV_h, t_i) \cdot S}{N_t \cdot S \cdot} = \frac{\sum\limits_{t_i} F_{MSF\_CONST}(SV_h, t_i)}{N_t \cdot},$$

   N_t is the number of measurement instants over the whole interval of available measurements.

A.4   CSA SIS Continuity Calculation Method

1) For any SV and for any instant of time t with the constant increment of $\leq$ 10 min, its health status (H_flag) is determined based on the availability of a trackable SIS and the corresponding indications in the navigation message data:

$$H\_flag=0 \text{ (healthy), if SIS is trackable, } B_n(l_n)=0 \text{ и } C_n=1.$$

The parameters $B_n(l_n)$ and C_n are described in the GLONASS ICD.

2) For the instant of time t the availability of a 48–hour advance notice of a scheduled interruption of CSA SIS($NAGU\_flag$) is determined based on NAGU:

$$NAGU\_flag =1 \text{ (there was a timely advance notice).}$$

3) For any healthy SV and for any instant of time t the value of the logical function is determined for the SV's loss of healthy CSA SIS without an advance notice:

$$F_{CON}(SV_h, t_i) = \begin{cases} 1, & (H\_flag(SV_h, t_i)=1) \& (NAGU\_flag(t_i)=0) \\ 0, & otherwise \end{cases}.$$

4) For every SV and for the instant of time t_{hour} with the constant increment of $\leq$ 1 hour, the value of the logical function is determined for the loss of continuity over one hour (loss of healthy CSA SIS over any hour, given that the CSA SIS is available from the slot at the start of the hour and a 48–hour advance notice was not issued):

$$F_{CON\_hour}(SV_h, t_{hour}) = \begin{cases} 1, & (H\_flag(SV_h, t_{hour})=0) \& (\exists t_i \in (t_{hour}, t_{hour}+1 \text{ ч}), F_{CON}(SV_h, t_i)=1) \\ 0, & otherwise \end{cases}$$

5) The average **SIS Continuity** for the constellation over one year is determined as a ratio of the number of one–hour intervals without loss of continuity to the total number of one–hour intervals and the number of SVs:

$$P_{CON} = \frac{\displaystyle\sum_{SV_h} \sum_{t_{hour}} (1 - F_{CON\_hour}(SV_h, t_{hour}))}{N_{hours} \cdot N_{SV}},$$

Where N_{hours} is the number of one–hour intervals;

N_{SV} is the nominal constellation (24 SVs for GLONASS).

A.5   CSA SIS Availability Calculation Method

A.5.1   CSA SIS Per–slot Availability Calculation

1) For any SV and for any instant of time t with the constant increment of $\leq$ 10 min, its health status (H_flag) is determined based on the availability of a trackable SIS and the corresponding indications in the navigation message data:

$H\_flag=0$ (healthy), if SIS is trackable, $B_n(I_n)=0$ and $C_n=1$.

The parameters $B_n(I_n)$ and C_n are described in the GLONASS ICD.

2) The average **SIS Per–Slot Availability** over one year interval is determined:

$$A_{per-slot} = \frac{\sum_{SV_h} \sum_t (1 - H\_flag(SV_h, t))}{N_t \cdot N_{SV}},$$

Where N_t is the number of measurement instants;

N_{SV} is the nominal GLONASS constellation (24 SVs).

A.5.2   CSA SIS Constellation Availability Calculation

1) For every SV and for any instant of time t with the constant increment of $\leq$ 10 min, its health status (H_flag) is determined based on the availability of a trackable SIS and the corresponding indications in the navigation message:

$H\_flag=0$ (healthy), if SIS is trackable, $B_n(I_n)=0$ and $C_n=1$.

The parameters $B_n(I_n)$ and C_n are described in the GLONASS ICD.

2) For any instant of time t the number of healthy SVs in the constellation is determined

(N_{SV_H}):

$$N_{SV\_H}(t) = \sum_{SV} (1 - H\_flag(SV, t)).$$

3) For any instant of time t the value of the logical function is determined that 21 Slots will not be occupied by a SVs broadcasting a healthy CSA SIS:

$$\} F_{SV\_H<21}(t) = \begin{cases} 1, & N_{SV\_H}(t) < 21 \\ 0, & otherwise \end{cases}.$$

4) The average **Constellation Availability** over one year interval is determined as a ratio of the number of measurement instants when at least 21 Slots are occupied by SVs broadcasting Healthy CSA SIS to the total of measurement instants:

$$A_{SV\_H} = \frac{\sum_t (1 - F_{SV\_H<21}(t))}{N_t},$$

where N_t is the number of measurement instants.

A.6   CSA Position/Time Domain Standards Calculation Methods

A.6.1 CSA PDOP Availability Calculation

1) For any instant of time with the constant increment of ≤ 10 min for every site within the constellation coverage zone (with the constant increment along longitude (1 degree) and the variable increment along latitude to provide for the equality of areas) the value of $PDOP(t, \varphi, \lambda)$ is determined for all healthy SV above 5° mask angles.

2) The local PDOP availability for any site over 24–hour interval is computed as a ratio of the number of instants at which $\mathrm{PDOP}(t, \varphi, \lambda)$ is 6 or less, to the total number of measurement instants *(N$_t$):*

$$A_{PDOP\_Local}(\varphi, \lambda) = \frac{\sum_{t} A_{PDOP\_\mathrm{Inst}}(t)}{N_t},$$

$$A_{PDOP\_\mathrm{Inst}}(t) = \begin{cases} 1, & \mathrm{PDOP}(t, \varphi, \lambda) \leq 6 \\ 0, & \mathrm{PDOP}(t, \varphi, \lambda) > 6 \end{cases}$$

3) The **Global PDOP Availability** is computed based on the local PDOP availability values for any site:

$$A_{PDOP\_Global} = \frac{\sum_{\varphi, \lambda} A_{PDOP\_Local}(\varphi, \lambda)}{N_{Sites}} \; .$$

4) **The Worst Site PDOP Availability** is picked out from the local PDOP availability values for every site over 24–hour interval:

$$A_{PDOP\_WorstSite} = \min_{\varphi, \lambda}[A_{PDOP\_Local}(\varphi, \lambda)].$$

Note: In order to verify the standards it is feasible to provide sequential values of the Global PDOP Availability with the increment of 30 min that is 48 values for 24–hour interval each of which obtained over the previous 24–hour interval.

A.6.2 CSA Position Error Calculation Method

1) For any instant of time with the constant increment (≤ 10 min) for any healthy SV the difference is measured between the broadcast satellite ephemeris (for radius, binormal, and normal) and clock and the post–processed ephemeris and clock:

$$\Delta R(SV_h,t), \Delta B(SV_h,t), \Delta N(SV_h,t), \Delta T(SV_h,t),$$

Where SV$_h$ is a SV indicated as healthy in the navigation message data.

2) For any instant of time for any healthy SV above 5° mask angle in every site within the constellation coverage area (with the constant increment along longitude (1 degree) and the variable increment along latitude to provide for the equality of areas), given PDOP<6, the instantaneous SIS URE values ($URE(\varphi,\lambda,SV_h,t)$)are measured. To accomplish this, the difference between the broadcast and the post–processed ephemeris and clock are projected on the site–to–SV direction. That is for every site on the Earth's surface the real observed SIS URE values for each SV are measured.

3) As a result of parametric navigation solution, for any site at any instant of time the Vertical Position Error ($VPE(\varphi,\lambda,t)$) and Horizontal Position Error ($HPE(\varphi,\lambda,t)$) are determined.

4) For any site, the 95% time distribution level of $HPE(\varphi,\lambda,t)$ over 24–hour interval is computed:

$$HPE_{95\%\,day}(\varphi,\lambda).$$

5) For any site, the 95% time distribution level of $VPE(\varphi,\lambda,t)$ over 24–hour interval is computed:

$$VPE_{95\%\,day}(\varphi,\lambda).$$

6) The RMS value of the **Global Average 95% Horizontal Position Error** is computed as per):

$$HPE_{GlobalAverage95\%\,day} = \sigma_{\varphi,\lambda}[HPE_{95\%\,day}] = \sqrt{\frac{\sum_{\varphi,\lambda} HPE_{95\%\,day}^{2}(\varphi,\lambda)}{N_{sites}}},$$

Where N$_{sites}$ is the number of sites on the Earth's surface.

7) The RMS value of the **Global Average 95% Vertical Position Error** is computed as per:

$$VPE_{GlobalAverage95\%\,day} = \sigma_{\varphi,\lambda}[VPE_{95\%\,day}] = \sqrt{\frac{\sum_{\varphi,\lambda} VPE_{95\%\,day}^{2}(\varphi,\lambda)}{N_{sites}}},$$

where N$_{sites}$ is the number of sites on the surface

8) The **Worst Site 95% Horizontal Position Error** is determined:

$$HPE_{WorstSite95\% \, day} = \max_{\varphi,\lambda}[HPE_{95\% \, day}(\varphi, \lambda)].$$

9) **Worst Site 95% Vertical Position Error** is determined:

$$VPE_{WorstSite95\% \, day} = \max_{\varphi,\lambda}[VPE_{95\% \, day}(\varphi, \lambda)].$$

Note: To verify the standard it is feasible to provide values obtained over the "sliding" 24–hour interval during one year.

A.6.3 CSA Service Availability Calculation Method

1) For any instant of time t_{day} with the constant increment ($\leq$ 24 hours) $URE_{95\% \, day\_GlobalAverage\_\cos tellation}$ (refer to paragraph 2.1.2) is determined.

2) For any instant of time with the constant increment ($\leq$ 10 min)for any site within within the constellation coverage area (with the constant increment along longitude (1 degree) and the variable increment along latitude to provide for the equality of areas), the values for $HDOP(t,\varphi,\lambda)$ and $VDOP(t,\varphi,\lambda)$ are determined for all healthy SVs above 5 ° mask angle.

3) The local horizontal service availability for any site over 24–hour interval is determined as a ratio of instants of time when the horizontal position error predicted by multiplying $URE_{95\% \, day\_GlobalAverage\_\cos tellation}$ by $HDOP(t,\varphi,\lambda)$ is less than or equal to 12 m, to the total number of instants over 24–hour interval [t_{day}–24 ч, t_{day}]:

$$A_{\text{HPE}\_95\% \, day\_Local}(\varphi, \lambda) = \frac{\sum_{t_{day}-24ч}^{t_{day}} A_{\text{HPE}\_95\%}(t)}{N_t},$$

$$A_{\text{HPE}\_95\%}(t) = \begin{cases} 1, \, URE_{95\% \, day\_GlobalAverage\_\cos tellation} \cdot HDOP(\varphi,\lambda,t) \leq 12 \text{ м} \\ 0, \, URE_{95\% \, day\_GlobalAverage\_\cos tellation} \cdot HDOP(\varphi,\lambda,t) > 12 \text{ м} \end{cases}$$

where N_t is the number of measurement instants over 24–hour interval.

4) Based on the values of local horizontal service availability obtained for any site, the **Horizontal Service Availability, average location** is computed as per:

$$A_{HPE\_GlobalAverage} = \frac{\sum_{\varphi,\lambda} A_{\text{HPE}\_95\% \, day\_Local}(\varphi, \lambda)}{N_{Sites}},$$

where N_{sites} is the number of sites on the surface.

5) Based on the values of local horizontal service availability obtained for any site, the **Horizontal Service Availability, worst–case location** is picked out:**Horizontal Service Availability, worst–case location** is picked out:

$$A_{HPE\_WorstSite} = \min_{\varphi,\lambda}[A_{\text{HPE\_95\% day\_}Local}(\varphi,\lambda)].$$

6) The local vertical service availability for any site over 24–hour interval is determined as a ratio of instants of time when the vertical position error predicted by multiplying $URE_{95\% day\_GlobalAverage\_constellation}$ by $VDOP(t,\varphi,\lambda)$ is less than or equal to 25 m, to the total number of instants over 24–hour interval $[t_{day}$–24 ч, $t_{day}]$:

$$A_{\text{VPE\_95\% day\_}Local}(\varphi,\lambda) = \frac{\displaystyle\sum_{t_{day}-24ч}^{t_{day}} A_{\text{VPE\_95\%}}(t)}{N_t},$$

$$A_{\text{VPE\_95\%}}(t) = \begin{cases} 1, & URE_{95\% day\_GlobalAverage\_constellation} \cdot VDOP(\varphi,\lambda,t) \le 25\ \text{м} \\ 0, & URE_{95\% day\_GlobalAverage\_constellation} \cdot VDOP(\varphi,\lambda,t) > 25\ \text{м} \end{cases}$$

7) Based on the values of local vertical service availability obtained for any site, the **Vertical Service Availability, average location** is obtained as per:

$$A_{VPE\_GlobalAverage} = \frac{\displaystyle\sum_{\varphi,\lambda} A_{\text{VPE\_95\% day\_}Local}(\varphi,\lambda)}{N_{Sites}},$$

Where N_{sites} is the number of sites on the surface.

8) Based on the values of local vertical service availability obtained for any site, the **Vertical Service Availability, worst–case location** is picked out::

$$A_{VPE\_WorstSite} = \min_{\varphi,\lambda}[A_{\text{VPE\_95\% day\_}Local}(\varphi,\lambda)].$$

Note: To verify the standard it is feasible to provide values obtained over the "sliding" one year interval during several years.

A.6.4 CSA Time Transfer Accuracy Calculation Method

1) For any instant of time with the constant increment ($\le$ 10 мин) for any healthy SV< the difference between the broadcast satellite ephemeris (for radius, binormal, and normal) and clock and the post–processed ephemeris and clock is determined:

$$\Delta R(SV_h,t), \Delta B(SV_h,t), \Delta N(SV_h,t), \Delta \text{T}(SV_h,t),$$

where SV_h is a healthy SV as per the health status broadcast within the navigation message.

2) Foe any instant of time and for any healthy SV above 5 ° mask angle for any site within the constellation coverage area (with the constant increment along longitude (1 degree) and the variable increment along latitude to provide for the equality of areas), provided PDOP <6, the instantaneous SIS URE values ($URE(\varphi,\lambda,SV_h,t)$) are determined. To accomplish it the difference between the

broadcast and the post–processed ephemeris and clock are projected on the site–to–SV direction. That is for every site on the Earth's surface the real observed SIS URE values for each SV are measured.

3) As a result of navigation solution with four parameters, $UTE(\varphi, \lambda, t)$ – User Time Error is determined for any site at any instant of time.

4) The value of 95% time distribution level of $HPE(\varphi, \lambda, t)$ over 24–hour interval is determined: $UTE_{95\%\,day}(\varphi, \lambda)$.

5) The RMS 95% UTE for 24–hour interval is dtermined:

$$\sigma_{\varphi,\lambda}[UTE_{95\%\,day}] = \sqrt{\frac{\sum\limits_{\lambda,\varphi} UTE_{95\%\,day}{}^{2}(\varphi, \lambda)}{N_{sites}}} \;,$$

Where N_{sites} is the number of sites on the surface.

6) For any healthy SV and for any instant of time 95% $UTCOE_{95\%\,day}(\mathrm{SV}_h)$ are determined.

The RMS 95% UTCOE over 24–hour interval is determined:

$$\sigma_{\mathrm{SV}_h}[UTCOE_{95\%\,day}] = \sqrt{\frac{\sum\limits_{\mathrm{SV}_h} UTCOE_{95\%\,day}{}^{2}(\mathrm{SV}_h)}{N_{\mathrm{SV}_h}}} \;.$$

7) The RMS **Global Average 95% Time Transfer Error over 24–hour interval** is determined as per:

$$TTE_{GlobalAverage95\%\,day} = \sqrt{\sigma_{\varphi,\lambda}[UTE_{95\%\,day}]^{2} + \sigma_{\mathrm{SV}_h}[UTCOE_{95\%\,day}]^{2}} \;.$$

Note: To verify the standard it is feasible to provide values obtained over the "sliding" 24–hour interval during one year.