**GNSS Timescale Description**

**QZSS**

**Definition of System**

1. **System timescale:** QZSST

2. **Generation of system timescale:**
   Master clock(QZSST) is the receiver clock located at Koganei.

3. **Is system timescale steered to a reference UTC timescale?**
   Yes (Actually the source of QZSST is the UTC(NICT) physical clock.)

   a. **To which reference timescale:** UTC(NICT)

   b. **Whole second offset from reference timescale?**
      Yes, TAI is 19 seconds ahead of the QZSS time scale. QZSST relation to UTC changes corresponding to the addition/subtraction of leap seconds.

   c. **Maximum offset (modulo 1s) from reference timescale?**
      1 microsecond, typically within 20 nanoseconds.

4. **Corrections to convert from satellite to system timescale?**
   Yes. **If yes:**

   a. **Type of corrections given; include statement on relativistic corrections**
      Quadratic coefficients broadcast as part of the QZSS navigation message. The expression for relativistic correction is given in the Interface Specifications for QZSS(IS-QZSS*). This expression accounts for 1st order deviations in eccentricity of individual QZSS orbits from the mean orbital elements.
      * http://qz-vision.jaxa.jp/USE/is-qzss/index_e.html

   b. **Specified accuracy of corrections to system timescale**
      part of the overall QZSS system specification of user range error which is expressed as a combination of satellite position error and satellite clock error: 1.6 meter (95%).

**c. Location of corrections in broadcast messages**

Subframe 1 of the QZSS legacy type navigation message.(L1C/A signal,Legacy message)
Message type 30-35,37,46,47,49,51 and 53 of the QZSS CNAV type navigation message.(L2C and L5 signal,CNAV message)
Subframe 2 of the QZSS CNAV2 type navigation message.(L1C signal,CNAV2 message)

**d. Equations to correct satellite timescale to system timescale**

a_f0 + a_f1(t-t_oc) + a_f2(t-t_oc)^2 + delta_t_r

With: a_f0, a_f1, a_f2 = Quadratic coefficients
t = GPS system time
t_oc = Time of clock data
delta_t_r = Delta time due to relativistic correction

delta_t_r = F e sqrt(A) sin(E_k)

With: F = -2 sqrt(mu) / c^2 = constant
mu = value of Earth's Universal gravitational parameters
c = Speed of Light
e = Eccentricity
A = Semi-major axis
E_k = Eccentric anomaly

**5. Corrections to convert from system to reference UTC timescale?** YES

**If yes:**

**a. Type of corrections given**

Linear coefficients and leap second terms

**b. Specified accuracy of corrections to reference timescale**

Not specified, but typically within 20ns.

**c. Location of corrections in broadcast messages**

Subframe 4, data ID=11(hex) svID=56(d) on the QZSS L1C/A, legacy type message.
Message type 33 and 49 on the QZSS L2C and L5 signals,CNAV type message.
Subframe 3, page 1 and 17 on the QZSS L1C signal, CNAV2 type message.

d. **Equations to correct system timescale to reference timescale**

delta_t_utc = delta_t_LS + A_0 + A_1 (t_E - t_ot + 604800(WN-WN_t))

With: delta_t_LS = delta time due to leap seconds
A_0, A_1 = linear coefficients
t_E = GPS time as estimated by the user

t_ot = Reference time for UTC data
WN = current week number
WN_t = UTC reference week number

6. **Specified stability of system timescale**
   Not specified.

7. **Specified stability of reference timescale**
   Not specified, but typically 1x10^-15/day.

8. **Specified stability of satellite clocks**
   Specification data or Actual measured performance data are to be provided.

9. **Availability of System to GNSS Time Offset (GQTO)**
   QZSS broadcasts GNSS-QZSS Time Offset (GQTO) correction as part of the modernized navigation messages. But GPS-QZSS Time Offset is already included in the above clock polynomial message, so the GNSS-QZSS Time Offset in the following parameters hereafter for GPS is set to zero.

   a. **Systems for which corrections are given?**
      Up to 7 GNSS systems.

   b. **Type of GQTO corrections given**
      Quadratic coefficients.

   c. **Stated accuracy of GQTO correction, if available**
      GPS-QZSS Time Offset is within 6.67ns(95%) for estimation during AOD (Age Of Data) 35min.
      Specifications of GQTO except GPS are not determined.

   d. **Location of corrections in broadcast messages**
      Message type 35 and 51 on the QZSS L2C and L5 signals,CNAV type message.
      Subframe 3, page 2 and 18 on the QZSS L1C signal, CNAV2

type message.

**e. Equations used for GQTO message**

t_gnss = t_E – (A_0ggto + A_1ggto (t_E - t_ggto + 604800(WN-WN_ggto)+A_2ggto (t_E - t_ggto + 604800(WN-WN_ggto))^2)

With: A_0gtto, A_1gtto, A_2gtto = quadratic coefficients
t_E = GPS time as estimated by the user
t_ggto = Reference time for GGTO data
WN = current week number
WN_ggto = GGTO reference week number

NOTE: Current system has no function to generate GGTO for other GNSS systems except for GPS. For GPS, the GQTO is included in clock offset parameters described in Section 4, GGTO for GPS transmitted by QZSS is to be set "Zero".

**Describe the details of the system, i.e. locations of system and reference timescale clocks, generation of timescales, and other details.**

The QZSS Master Control Station(MCS) is located in Tsukuba space Center, Ibaragi, Japan and QZSS Time is computed as part of the clock and orbit estimation process.

QZSS operates 9 monitor stations regionally distributed around the Asia-Oceania area.

The Koganei and Hawaii monitor stations use Hydrogen MASER clocks, and the rest of each monitor station receiver is referenced to a Cesium atomic clock.

The oscillator frequencies onboard the QZSS satellites have been offset from their nominal values in order to account for special and general relativistic effects with respect to ground-based observers so that the received frequencies at the Earth's surface are consistent with terrestrial time (e.g., UTC), assuming mean nominal QZSS orbital elements.

UTC(NICT) is generated from 18 Cesium clocks and 3 H-masers located at Koganei, Tokyo. UTC(NICT) is transferred using GPS and TWSTFT with UTC(USNO) and UTC(PTB) to contribute to UTC generation.

**Describe how the timescale transfers from the reference**

**timescale to the system timescale and finally to the satellites. Include the nominal rate of SV updates.**

Operation w.r.t. SV Clocks Parameters

The source of QZSST(which is the Koganei Receiver Clock) is the UTC(NICT) physical clock with some amount of offset due to the line length. Therefore the transfer from the reference timescale to the system timescale is realized by physical connection.

The time offset between QZSST and GPST is estimated in QZSS ground control segment and it is included in SV clock parameters so that users don't need to consider it in the PVT computation for combining use with GPS.

Operation w.r.t. UTC Parameters

NICT monitors the offset data between QZSST(which is the Koganei Receiver Clock) and UTC(NICT) and transfers this data to MCS.

MCS calculates the UTC parameters based on the data from NICT and the time offset of the Koganei Receiver Clock to GPS Time.

Satellites are nominally updated at least once per day.

**If any other pertinent details exist concerning the generation and realization of system and/or reference time, include them as well.**

QZSS Time is realized by simultaneous L1C/A and L2C pseudorange observations used in a linear combination to remove the 1st order ionospheric propagation delay.

Users of other QZSS signals or combinations must account for inter-signal code biases or tgd(time of group delay) to obtain the broadcast QZSS Time consistently.