Change Topic: CNAV Reference Times

This change package accommodates the text changes to support the proposed solution (see table below) within the public Signals-in-Space (SiS) documents. All comments must be submitted in Comments Resolution Matrix (CRM) form.

The columns in the WAS/IS table following this page are defined below:

Section Number: This number indicates the location of the text change within the document.

Proposed Heading: Contains existing and/or proposed changes to section titles and/or the titles to new sections

(WAS) <Document Title>: Contains the baseline text of the impacted document.

Proposed Object Text: Contains proposed changes to baseline text.

PROBLEM STATEMENT:
The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
SOLUTION: *(Proposed)*
State the complete list of timing parameters that pertain to the CNAV signal.
Note: The proposed changes for CNAV Reference times in IS-GPS-200G reflect the complete list of the reference time and epoch time parameters associated with the CNAV signal. The data cutover algorithm has also been updated to apply to the CNAV signal.

<table>
<tr><th>Section</th><th>IS-GPS-200 RevG (5 Sep 2012) Navstar GPS Space Segment/Navigation User Interfaces</th><th>Proposed Changes</th><th>Rationale</th></tr>
<tr><td>30.3.3.5.1.1</td><td><table><tr><th colspan="2">Table 30-VIII. Application of EOP Parameters</th></tr><tr><th>Element/Equation</th><th>Description</th></tr><tr><td>$UT1 = UTC + \Delta UT1 + \Delta \dot{UT}1 \ (t - t_{EOP})$</td><td>Compute Universal Time at time t</td></tr><tr><td>$x_p = PM\_X + PM\dot{X} \ (t - t_{EOP})$</td><td>Polar Motion in the x-axis</td></tr><tr><td>$y_p = PM\_Y + PM\dot{Y} \ (t - t_{EOP})$</td><td>Polar Motion in the y-axis</td></tr><tr><td colspan="2">t is GPS system time at time of transmission, i.e., GPS time corrected for transit time (range/speed of light).</td></tr></table></td><td><table><tr><th colspan="2">Table 30-VIII. Application of EOP Parameters</th></tr><tr><th>Element/Equation</th><th>Description</th></tr><tr><td>$UT1 = UTC + \Delta UT1 + \Delta \dot{UT}1 \ (t - t_{EOP})$ *</td><td>Compute Universal Time at time t</td></tr><tr><td>$x_p = PM\_X + PM\dot{X} \ (t - t_{EOP})$ *</td><td>Polar Motion in the x-axis</td></tr><tr><td>$y_p = PM\_Y + PM\dot{Y} \ (t - t_{EOP})$ *</td><td>Polar Motion in the y-axis</td></tr><tr><td colspan="2">*t is GPS system time at time of transmission, i.e., GPS time corrected for transit time (range/speed of light).
Furthermore, the quantity ($t-t_{EOP}$) shall be the actual total time difference between the time t and the epoch time t_{EOP}, and must account for beginning or end of week crossovers. That is, if ($t-t_{EOP}$) is greater than 302,400 seconds, subtract 604,800 seconds from ($t-t_{EOP}$). If ($t-t_{EOP}$) is less than -302,400 seconds, add 604,800 seconds to ($t-t_{EOP}$).</td></tr></table></td><td>The footnote has been expanded to clarify the application of tEOP.</td></tr>
<tr><td>30.3.3.7.4</td><td>The user will construct a set of initial (uncorrected) elements by:

$A_i = A_0$
$e_i = e_n$
$i_i = i_{0-n}$
$\Omega_i = \Omega_{0-n}$
$\alpha_i = e_n \cos(\omega_n)$
$\beta_i = e_n \sin(\omega_n)$
$\gamma_i = M_{0-n} + \omega_n$

where A_0, e_n, i_{0-n}, Ω_{0-n}, ω_n and M_{0-n} are obtained from the applicable SV's message types 10 and 11 data. The terms α_i, β_i, and γ_i form a subset of stabilized ephemeris elements which are subsequently corrected by $\Delta\alpha$, $\Delta\beta$ and $\Delta\gamma$—the values of which are supplied in the message types 34 or 14 - as follows:

$\alpha_c = \alpha_i + \Delta\alpha$
$\beta_c = \beta_i + \Delta\beta$</td><td>The user will construct a set of initial (uncorrected) elements by:

$A_i = A_0$
$e_i = e_n$
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$\alpha_c = \alpha_i + \Delta\alpha$
$\beta_c = \beta_i + \Delta\beta$</td><td>The line "where WN(oe) is the week number associated with the t(oe) and WN is the current week number" has been inserted to make the equation consistent with the correct utility of the Mean Anomaly equation in another non public ICD.</td></tr>
</table>

Section	IS-GPS-200 RevG (5 Sep 2012) Navstar GPS Space Segment/Navigation User Interfaces	Proposed Changes	Rationale
	$\gamma_c = \gamma_i + \Delta\gamma$ The quasi-Keplerian elements are then corrected by $A_c = A_i + \Delta A$ $e_c = (\alpha_c^2 + \beta_c^2)^{1/2}$ $i_c = i_i + \Delta i$ $\Omega_c = \Omega_i + \Delta\Omega$ $\omega_c = \tan^{-1}(\beta_c/\alpha_c)$ $M_{0-c} = \gamma_c - \omega_c + \Delta M_0$ where ΔA, Δi and $\Delta\Omega$ are provided in the EDC data packet of the message type 34 or 14 and ΔM_0 is obtained from $\Delta M_0 = \frac{-3}{2}\left(\frac{\mu}{A_0^3}\right)^{\frac{1}{2}}\left(\frac{\Delta A_0}{A_0}\right)[(t_{oe} + WN_{oe} * 604{,}800) - (t_{OD} + WN * 604{,}800)]$ The corrected quasi-Keplerian elements above are applied to the user algorithm for determination of antenna phase center position in Section 30.3.3.1.3, Table 30-II.	$\gamma_c = \gamma_i + \Delta\gamma$ The quasi-Keplerian elements are then corrected by $A_c = A_i + \Delta A$ $e_c = (\alpha_c^2 + \beta_c^2)^{1/2}$ $i_c = i_i + \Delta i$ $\Omega_c = \Omega_i + \Delta\Omega$ $\omega_c = \tan^{-1}(\beta_c/\alpha_c)$ $M_{0-c} = \gamma_c - \omega_c + \Delta M_0$ where ΔA, Δi and $\Delta\Omega$ are provided in the EDC data packet of the message type 34 or 14 and ΔM_0 is obtained from $\Delta M_0 = \frac{-3}{2}\left(\frac{\mu}{A_0^3}\right)^{\frac{1}{2}}\left(\frac{\Delta A_0}{A_0}\right)[(t_{oe} + WN_{oe} * 604{,}800) - (t_{OD} + WN * 604{,}800)]$ where WN(oe) is the week number associated with the t(oe) and WN is the current week number. The corrected quasi-Keplerian elements above are applied to the user algorithm for determination of antenna phase center position in Section 30.3.3.1.3, Table 30-II.	
30.3.4.5	The LNAV reference time information in paragraph 20.3.4.5 also applies to the CNAV reference times.	Many of the parameters which describe the SV state vary with true time, and must therefore be expressed as time functions with coefficients provided by the Navigation Message to be evaluated by the user equipment. These include the following parameters as functions of GPS time: a. SV time, b. Semi-major axis, c. Mean anomaly, d. Longitude of ascending node,	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers

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		e. Inclination, f. UTC, g. URA_{NED}, h. EOP, i. Differential corrections, j. GGTO.	from correctly processing the modernized GPS signal.
30.3.4.5		Each of these parameters is formulated as a polynomial in time. The specific time scale of expansion can be arbitrary. Due to the short data field lengths available in the Navigation Message format, the epoch of the polynomial is chosen near the midpoint of the expansion range so that quantization error is small. This results in time epoch values which can be different for each data set. Time epochs contained in the Navigation Message and the different algorithms which utilize them are related as follows:	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
30.3.4.5		Epoch Application Algorithm Reference t_{oc} 20.3.3.3.3.1 t_{oe} 20.3.3.4.3 t_{oa} 20.3.3.5.2.2 and 20.3.3.5.2.3 t_{ot} 20.3.3.5.2.4 and 30.3.3.6.2 t_{op} 30.3.3.2.4 t_{EOP} 30.3.3.5.1 t_{OD} 30.3.3.7	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the

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		t_{GGTO} 30.3.3.8.2	modernized GPS signal.
30.3.4.5		For those parameters for which fit interval and transmission interval are relevant, Table 30-XIII specifies the fit interval, the nominal transmission interval, and the nominal selection of the fit point (which will be expressed modulo 604,800 seconds in the Navigation Message).	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
30.3.4.5		The coefficients of expansion are obviously dependent upon choice of epoch, and thus the epoch time and expansion coefficients must be treated as an inseparable parameter set. Note that a user applying current navigation data will normally be working with negative values of ($t-t_{oc}$) and ($t-t_{oe}$) in evaluating the expansions.	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
30.3.4.5		The CS (Block IIR-M/IIF) and SS (GPS III) shall assure that the t_{oe} value, for at least the first data set transmitted by an SV after a new upload, is different from that transmitted prior to the cutover (see paragraph 30.3.4.4). As such, when a new upload is cutover for transmission, the CS (Block IIR-M/IIF) and SS (GPS III) shall introduce a small deviation in the t_{oe} resulting in the t_{oe} value that is offset from the nominal location of 1.5 hours into the fit interval (see Table 30-XIII). This offset t_{oe} will be transmitted by an SV in the first data set after a new upload cutover and the second data set, following the first data set, may also	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters,

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		continue to reflect the same offset in the t_{oe}.	epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
30.3.4.5		When the t_{oe}, immediately prior to a new upload cutover, already reflects a small deviation (i.e. a new upload cutover has occurred in the recent past), then the CS (Block IIR-M/IIF) and SS (GPS III) shall introduce an additional deviation to the t_{oe} when a new upload is cutover for transmission.	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.
30.3.4.5		For CNAV data, the user may use the following example algorithm to detect the occurrence of a new upload cutover: DEV = t_{oe} [modulo 7200] If DEV ≠ 5400, then a new upload cutover has occurred within the past 4 hours.	The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV). Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.

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<tr><td>30.3.4.5</td><td></td><td>
<table>
<tr><th colspan="6">Table 30-XIII. Reference Times</th></tr>
<tr><th rowspan="2">Fit Interval (hours)</th><th rowspan="2">Transmission Interval (hours)</th><th colspan="4">Hours After First Valid Transmission Time</th></tr>
<tr><th>t_{oc} (clock)</th><th>t_{oe} (ephemeris)</th><th>t_{oa} (almanac)</th><th>t_{ot} (UTC)</th></tr>
<tr><td>3*</td><td>2*</td><td>1.5</td><td>1.5</td><td></td><td></td></tr>
<tr><td>144 (6 days)</td><td>144</td><td></td><td></td><td>70</td><td>70</td></tr>
<tr><td>≥144 (6 days)</td><td>≥144</td><td></td><td></td><td>70</td><td>70</td></tr>
<tr><td colspan="6">* Defined in Section 30.3.3.1.1</td></tr>
</table>
</td><td>The current CNAV signals (L2C, L5, and L1C) reference time parameters are stated to be 100% common to the LNAV reference time parameters. However, there are additional time parameters that apply to the CNAV signals (reference time parameters, epoch times, and algorithms detecting cutovers specific to CNAV).

Not applying the additional time parameters to receivers processing the CNAV signal may prevent receivers from correctly processing the modernized GPS signal.</td></tr>
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