Summary of Draft Changes to GPS Standard Positioning Service (SPS) Performance Standard (PS)

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Document Structure

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Overview

- Draft 5th Edition of the SPS PS is in internal USAF review
- This briefing describes major changes in the draft
- The new edition covers L2C and L5 (I5 & Q5)
  - Conditions and performance for accuracy and integrity
  - Continuity and availability is not covered in this edition

This presentation describes the draft content of an updated GPS SPS Performance Standard. These proposed updates are not final and may change in the published version of the GPS SPS Performance Standard.

Main Body: Section 1

Standard Positioning Service (Overview)

- Section 1.4 *Backward Compatibility*
  - SIS will remain compliant with applicable ICD/IS at time of IOC declaration
    - L1 C/A IOC in 1993 → ICD-GPS-200C and subsequent
    - L2C IOC → *TBD*
    - I5 and Q5 IOCs → *TBD*
- Section 1.6 *GPS System Overview*
  - Describe broadcast configurations across three carriers
    - L1, L2, L5
  - Distinguishing between LNAV and CNAV
  - Defines SPS SIS to include C/A, L2C, I5, Q5, and respective NAV data

Main Body: Section 2

SIS Characteristics and Minimum Usage Assumptions

- New additions/clarifications include:
  - L2C, I5, and Q5 to "Overview of SPS SIS Interface Characteristics"
  - High-level CNAV description to "GPS NAV Message Characteristics"
  - Table 2.2-2 for description of covered combinations

Table 2.2-2. SPS SIS Component Combinations Covered by this Edition of the *SPS PS*

One Carrier, Single Frequency (SF)	Two Carriers, Dual Frequency (DF)	Three Carriers, Triple Frequency (TF)
C/A-code + LNAV Data	(C/A + L2C)-codes + CNAV Data	(C/A + L2C + I5)-codes +CNAV Data
L2C-code + CNAV Data	(C/A + I5)-codes + CNAV Data	(C/A + L2C + Q5)-codes +CNAV Data
I5-code + CNAV Data	(C/A + Q5)-codes + CNAV Data	(C/A + L2C + I5+Q5)-codes +CNAV Data
Q5-code + CNAV Data	(C/A + I5+Q5)-codes + CNAV Data	
(I5+Q5)-codes + CNAV Data		

Notes:

1. *Proper use of L2C-code, I5-code, and Q5-code requires the application of the current inter-signal correction (ISC) values which are provided in the CNAV data stream. Use of Q5-code in SF mode by itself or in DF mode with C/A-code imposes additional effort to obtain the required ISC values.*
2. *The I5-code and the Q5-code can be used separately (e.g., independently or sequentially) or jointly (e.g., concurrently).*
3. *DF operation with the L2C signal and either of the L5 signals is not covered – and is not recommended – by this by this edition of the SPS PS.*

  - SPS SIS availability (per slot and constellation availability), SPS SIS Health (L2C, I5, Q5), SPS SIS Integrity (IAURA, LNAV URA, CNAV IAURA)

Main Body: Section 3

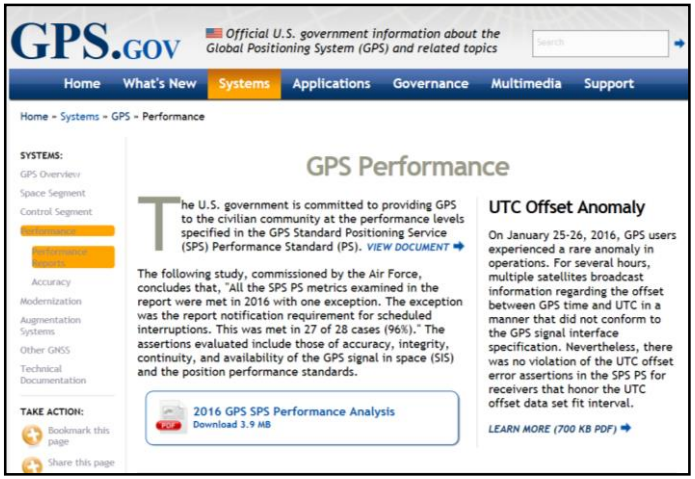
SPS SIS Performance Standards

- Section 3.2 *Constellation Slot Definitions*
  - Administrative change to update reference epoch from *00:00:00 UTC, 1 July 1993* to *0000 GPST, 1 January 2017*
- Section 3.4 *SPS SIS Accuracy*
  - Updated Table 3.4-1 (SPS SIS URE Accuracy) and Table 3.4-4 (SPS SIS UTCOE Accuracy) with new values; changed *Single Frequency C/A-Code* to *C/A Code*
- Section 3.5 *SPS SIS Integrity*
  - New P_{sat} and P_{const} values; $\leq 1x10^{-5}$ and $\leq 1x10^{-8}$, respectively

Appendices

- Appendix A *SIS Background Information*
  - Updates and clarifications include:
    - Accuracy – Added Inter-Signal Correction (ISC) Errors
    - Integrity – Added component combinations
    - Availability – Removed Availability of Accuracy
    - Position Time Domain – Relocated from Appendix B
- Appendix B *PVT Performance Expectations*
  - Deleted obsolete PVT reference information
- Appendix C *Terms, Definitions, Acronyms*
  - Administrative updates to terms, definitions, abbreviations, and acronyms

GPS Performance Reports



- 2013-2016 performance reports now available on gps.gov
- These reports measure GPS performance against GPS SPS PS commitments

Performance Standard Metric	2013	2014	2015	2016
SIS URE Accuracy	✓	✓	✓	✓
SIS URRE Accuracy	N/A	N/A	N/A	✓
SIS URAE Accuracy	N/A	N/A	N/A	✓
SIS UTCOE Accuracy	N/A	N/A	✓	✓
SIS Instantaneous URE Integrity	✓	✓	✓	✓
SIS Instantaneous UTCOE Integrity	N/A	N/A	✓	✓
SIS Continuity – Unscheduled Failure Interruptions	✓	✓	✓	✓
Status and Problems Reporting	N/A	×	✓	×
SIS Per-Slot Availability	✓	✓	✓	✓
SIS Constellation Availability	✓	✓	✓	✓
Operational Satellite Counts	✓	✓	✓	✓
PDOP Availability	✓	✓	✓	✓
Position Service Availability	✓	✓	✓	✓
Position Accuracy	✓	✓	✓	✓

BACKUP Charts

- Additional details for the GPS SPS PS enthusiast

- SPS SIS Component Combinations (New)
  - Single, dual, and triple frequency combinations of signals introduced
  - Table 2.2-2 specifies the combinations covered by the SPS PS

Table 2.2-2. SPS SIS Component Combinations Covered by this Edition of the *SPS PS*

One Carrier, Single Frequency (SF)	Two Carriers, Dual Frequency (DF)	Three Carriers, Triple Frequency (TF)
C/A-code + LNAV Data	(C/A + L2C)-codes + CNAV Data	(C/A + L2C + I5)-codes +CNAV Data
L2C-code + CNAV Data	(C/A + I5)-codes + CNAV Data	(C/A + L2C + Q5)-codes +CNAV Data
I5-code + CNAV Data	(C/A + Q5)-codes + CNAV Data	(C/A + L2C + I5+Q5)-codes +CNAV Data
Q5-code + CNAV Data	(C/A + I5+Q5)-codes + CNAV Data	
(I5+Q5)-codes + CNAV Data		

Notes:

1. *Proper use of L2C-code, I5-code, and Q5-code requires the application of the current inter-signal correction (ISC) values which are provided in the CNAV data stream. Use of Q5-code in SF mode by itself or in DF mode with C/A-code imposes additional effort to obtain the required ISC values.*
2. *The I5-code and the Q5-code can be used separately (e.g., independently or sequentially) or jointly (e.g., concurrently).*
3. *DF operation with the L2C signal and either of the L5 signals is not covered – and is not recommended – by this by this edition of the SPS PS.*

- Overview of SPS SIS Performance Characteristics
  - **SPS SIS Availability**
    - Addition: Explanation that Per-Slot and Constellation Availability apply individually to each SPS SIS (C/A, L2C, I5, Q5)
  - **SPS SIS Health**
    - Additions for L2C, I5, Q5: 'Healthy', 'Marginal', 'Unhealthy', and 'Not Applicable'
      - 'Not Applicable' is not applicable to L1 C/A (not allowed)
  - **SPS SIS Integrity**
    - Addition: Integrity Assured URA (IAURA) introduced
    - Distinctions between LNAV URA and CNAV IAURA explained

Main Body

Section 3.4 SPS SIS Accuracy

Table 3.4-1. SPS SIS URE Accuracy Standards

SIS Accuracy Standard	Conditions and Constraints
Each SPS SIS Component Combination per Table 2.2-2~~Single Frequency C/A Code~~: • ≤ ~~7.8~~7.0 m 95% Global Average URE during Normal Operations over all AODs • ≤ ~~6.0~~4.7 m 95% Global Average URE during Normal Operations at Zero AOD • ≤ ~~12.8~~11.4 m 95% Global Average URE during Normal Operations at Any AOD	• For any trackable and healthy SPS SIS • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Including ISC errors
Each SPS SIS Component Combination per Table 2.2-2~~Single Frequency C/A Code~~: • ≤ 30 m 99.94% Global Average URE during Normal Operations • ≤ 30 m 99.79% Worst Case Single Point Average URE during Normal Operations	• For any trackable and healthy SPS SIS • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Including ISC errors • Standard based on measurement interval of one year; average of daily values within the service volume • Standard based on 3 service failures per year, lasting no more than 6 hours each
S~~ingle Frequency~~ C/A-Code: • ≤ 388 m 95% Global Average URE during Extended Operations after 14 Days without Upload	• For any trackable and healthy SPS SIS
Each SPS SIS Component Combination per Table 2.2-2: • ≤ 2.0 m 95% Global Average URE during Normal Operations over all AODs	• Across all trackable and healthy SPS SISs • Neglecting single-frequency ionospheric delay model errors • Including group delay time correction (T_{GD}) errors at L1 • Including inter-signal bias (P(Y)-code to C/A-code) errors at L1 • Including ISC errors

Table 3.4-4. SPS SIS UTCOE Accuracy Standards

SIS Accuracy Standard	Conditions and Constraints
Each SPS SIS Component Combination per Table 2.2-2~~Single Frequency C/A Code~~: • ≤ ~~4~~30 nsec 95% Global Average UTCOE during Normal Operations at Any AOD	• For any trackable and healthy SPS SIS

- New: Psat and Pconst

Table 3.5-5. SPS SIS Instantaneous P_{sat} and P_{const} Standards

SIS Integrity Standard	Conditions and Constraints
Each SPS SIS Component Combination per Table 2.2-2: • ≤ 1×10^{-5} Fraction of Time When the SPS SIS Instantaneous URE Exceeds the NTE Tolerance Without a Timely Alert during Normal Operations	• Applies to any trackable and healthy SPS SIS • SPS SIS URE NTE tolerance defined to be ±4.42 times the relevant IAURA value currently broadcast by the satellite • Average case for delayed alert is 1 hour
	• Neglecting single-frequency ionospheric delay model errors
Each SPS SIS Component Combination per Table 2.2-2: • ≤ 1×10^{-6} Fraction of Time When the SPS SIS Instantaneous URE from Two or More Satellites Exceeds the NTE Tolerance Due to a Common Cause Without a Timely Alert during Normal Operations	• Applies across all trackable and healthy SPS SIS • SPS SIS URE NTE tolerance defined to be ±4.42 times the relevant IAURA value currently broadcast by the satellite • Average case for delayed alert is 1 hour • Neglecting single-frequency ionospheric delay model errors