



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

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# Document Structure



TABLE OF CONTENTS	
List of Figures .....	iii
List of Tables .....	iii
List of Appendices .....	iv
Executive Summary .....	v
<b>SECTION 1.0 The GPS Standard Positioning Service .....</b>	<b>1</b>
1.1 Purpose .....	1
1.2 Scope .....	2
1.3 GPS SPS Definition .....	3
1.4 <u>Backward Compatibility</u> .....	3
1.5.4 Key Terms and Definitions .....	x
1.6 Global Positioning System Overview .....	x
1.6.1 GPS Space Segment (SS) .....	x
1.6.2 GPS Control Segment (CS) .....	x
<b>SECTION 2.0 SPS SIS Characteristics and Minimum Usage Assumptions .....</b>	<b>x</b>
2.1 SPS SIS Interface Specification Requirements .....	x
2.2 Overview of SPS SIS Interface Characteristics .....	x
2.2.1 SPS SIS RF Characteristics .....	x
2.2.2 GPS NAV Message Characteristics .....	x
2.2.3 <u>GPS SPS SIS Component Combinations</u> .....	x
2.3 Overview of SPS SIS Performance Characteristics .....	x
2.3.1 SPS SIS Availability .....	x
2.3.2 SPS SIS Health .....	x
2.3.3 SPS SIS Accuracy .....	1x
2.3.4 SPS SIS Integrity .....	1x
2.3.5 SPS SIS Continuity .....	1x
2.3.6 SPS SIS UTC(USNO) Accuracy .....	1x
2.4 Usage Assumptions for SPS Performance Standards .....	1x
2.4.1 SPS User .....	1x
2.4.2 <u>SPS SIS Configuration</u> <del>CIA Code</del> .....	1x
2.4.3 Single-/Dual-/Triple-Frequency Operation .....	1x
2.4.4 SPS SIS Health .....	1x
2.4.5 Excluded Errors .....	1x
<b>SECTION 3.0 SPS SIS Performance Standards .....</b>	<b>1x</b>
3.1 Overview .....	1x
3.2 24-Slot Constellation Definitions .....	1x
3.3 SPS SIS Coverage .....	1x

3.3.1 Per Satellite Coverage .....	1x
3.3.2 Baseline/Expandable 24-Slot Constellation Coverage .....	2x
3.4 SPS SIS Accuracy .....	2x
3.4.1 SPS SIS URE Accuracy Standards .....	2x
3.4.2 SPS SIS URRE Accuracy Standards .....	2x
3.4.3 SPS SIS URAE Accuracy Standards .....	2x
3.4.4 SPS SIS UTCOE Accuracy Standards .....	2x
3.5 SPS SIS Integrity .....	2x
3.5.1 SPS SIS Instantaneous URE Integrity Standards .....	2x
3.5.2 SPS SIS Instantaneous URRE Integrity Standards .....	2x
3.5.3 SPS SIS Instantaneous URAE Integrity Standards .....	2x
3.5.4 SPS SIS Instantaneous UTCOE Integrity Standards .....	2x
3.5.5 <u>Per- and Post- Standards</u> .....	2x
3.6 SPS SIS Continuity .....	2x
3.6.1 SPS SIS Continuity Standards – Unscheduled Failure Interruptions .....	2x
3.6.2 SPS SIS Continuity Standards – Unscheduled Maintenance Interruptions .....	2x
3.6.3 SPS Status and Problem Reporting Standards .....	2x
3.7 SPS SIS Availability .....	3x
3.7.1 SPS SIS Per-Slot Availability Standards .....	3x
3.7.2 SPS SIS Constellation Availability Standards .....	3x
3.7.3 Operational Satellite Count Standards .....	3x
3.8 SPS Position/Time Domain Standards .....	3x
3.8.1 PDOP Availability Standards .....	3x
3.8.2 SPS Position Service Availability Standards .....	3x
3.8.3 SPS Position/Time Accuracy Standards .....	3x
<b>SECTION 4.0 References .....</b>	<b>3x</b>
4.1 Government Documents .....	3x
4.2 Non-Government Documents .....	3x



# Overview



- Draft 5<sup>th</sup> 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**

<b>One Carrier, Single Frequency (SF)</b>	<b>Two Carriers, Dual Frequency (DF)</b>	<b>Three Carriers, Triple Frequency (TF)</b>
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  $P_{\text{sat}}$  and  $P_{\text{const}}$  values;  $\leq 1 \times 10^{-5}$  and  $\leq 1 \times 10^{-8}$ , 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

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	✓	✓	✓	✓

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





# *BACKUP Charts*



- Additional details for the GPS SPS PS enthusiast



# Main Body

## Section 2, SIS Characteristics and Minimum Usage Assumptions (2/3)

- 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**

<b>One Carrier, Single Frequency (SF)</b>	<b>Two Carriers, Dual Frequency (DF)</b>	<b>Three Carriers, Triple Frequency (TF)</b>
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.



# Main Body

## Section 2, SIS Characteristics and Minimum Usage Assumptions (3/3)

- 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
<p><a href="#">Each SPS SIS Component Combination per Table 2.2-2 Single-Frequency C/A-Code:</a></p> <ul style="list-style-type: none"> <li>• <del>7.8</del><b>7.0</b> m 95% Global Average URE during Normal Operations over all AODs</li> <li>• <del>6.0</del><b>4.7</b> m 95% Global Average URE during Normal Operations at Zero AOD</li> <li>• <del>42.8</del><b>11.4</b> m 95% Global Average URE during Normal Operations at Any AOD</li> </ul>	<ul style="list-style-type: none"> <li>• For any <a href="#">trackable and</a> healthy SPS SIS</li> <li>• Neglecting single-frequency ionospheric delay model errors</li> <li>• Including group delay time correction (<math>T_{GD}</math>) errors at L1</li> <li>• Including inter-signal bias (P(Y)-code to C/A-code) errors at L1</li> <li>• <a href="#">Including ISC errors</a></li> </ul>
<p><a href="#">Each SPS SIS Component Combination per Table 2.2-2 Single-Frequency C/A-Code:</a></p> <ul style="list-style-type: none"> <li>• <math>\leq 30</math> m 99.94% Global Average URE during Normal Operations</li> <li>• <math>\leq 30</math> m 99.79% Worst Case Single Point Average URE during Normal Operations</li> </ul>	<ul style="list-style-type: none"> <li>• For any <a href="#">trackable and</a> healthy SPS SIS</li> <li>• Neglecting single-frequency ionospheric delay model errors</li> <li>• Including group delay time correction (<math>T_{GD}</math>) errors at L1</li> <li>• Including inter-signal bias (P(Y)-code to C/A-code) errors at L1</li> <li>• <a href="#">Including ISC errors</a></li> <li>• Standard based on measurement interval of one year; average of daily values within the service volume</li> <li>• Standard based on 3 service failures per year, lasting no more than 6 hours each</li> </ul>
<p><a href="#">Single-Frequency C/A-Code:</a></p> <ul style="list-style-type: none"> <li>• <math>\leq 388</math> m 95% Global Average URE during Extended Operations after 14 Days without Upload</li> </ul>	<ul style="list-style-type: none"> <li>• For any <a href="#">trackable and</a> healthy SPS SIS</li> </ul>
<p><a href="#">Each SPS SIS Component Combination per Table 2.2-2:</a></p> <ul style="list-style-type: none"> <li>• <math>\leq 2.0</math> m 95% Global Average URE during Normal Operations over all AODs</li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Across all trackable and healthy SPS SISs</a></li> <li>• <a href="#">Neglecting single-frequency ionospheric delay model errors</a></li> <li>• <a href="#">Including group delay time correction (<math>T_{GD}</math>) errors at L1</a></li> <li>• <a href="#">Including inter-signal bias (P(Y)-code to C/A-code) errors at L1</a></li> <li>• <a href="#">Including ISC errors</a></li> </ul>

Table 3.4-4. SPS SIS UTCOE Accuracy Standards

SIS Accuracy Standard	Conditions and Constraints
<p><a href="#">Each SPS SIS Component Combination per Table 2.2-2 Single-Frequency C/A-Code:</a></p> <ul style="list-style-type: none"> <li>• <math>\leq 4</math><del>3</del><b>0</b> nsec 95% Global Average UTCOE during Normal Operations at Any AOD</li> </ul>	<ul style="list-style-type: none"> <li>• For any <a href="#">trackable and</a> healthy SPS SIS</li> </ul>



# Main Body

## Section 3.5 SPS SIS Integrity

- New: Psat and Pconst

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

<u>SIS Integrity Standard</u>	<u>Conditions and Constraints</u>
<p><u>Each SPS SIS Component Combination per Table 2.2-2:</u></p> <ul style="list-style-type: none"> <li>• <u><math>\leq 1 \times 10^{-5}</math> Fraction of Time When the SPS SIS Instantaneous URE Exceeds the NTE Tolerance Without a Timely Alert during Normal Operations</u></li> </ul>	<ul style="list-style-type: none"> <li>• <u>Applies to any trackable and healthy SPS SIS</u></li> <li>• <u>SPS SIS URE NTE tolerance defined to be <math>\pm 4.42</math> times the relevant IAURA value currently broadcast by the satellite</u></li> <li>• <u>Average case for delayed alert is 1 hour</u></li> </ul>
	<ul style="list-style-type: none"> <li>• <u>Neglecting single-frequency ionospheric delay model errors</u></li> </ul>
<p><u>Each SPS SIS Component Combination per Table 2.2-2:</u></p> <ul style="list-style-type: none"> <li>• <u><math>\leq 1 \times 10^{-6}</math> 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</u></li> </ul>	<ul style="list-style-type: none"> <li>• <u>Applies across all trackable and healthy SPS SIS</u></li> <li>• <u>SPS SIS URE NTE tolerance defined to be <math>\pm 4.42</math> times the relevant IAURA value currently broadcast by the satellite</u></li> <li>• <u>Average case for delayed alert is 1 hour</u></li> <li>• <u>Neglecting single-frequency ionospheric delay model errors</u></li> </ul>