CNAV Test Modes for IIF SV#1 (SVN62) On-Orbit Testing

The GPS Wing is conducting an on-orbit checkout of the first GPS IIF satellite through the August 2010 time frame. The GPS IIF satellites (SV)s include two new civil navigation signals, L2C and L5, which are designed to enhance civil navigation performance and utility. The L2C signal is composed of the time division multiplexed combination of the following two sub-codes; L2 CM ⊕ CNAV data and L2 CL. The L5 signal is composed of two ranging codes which are in phase quadrature; L5 I5 ⊕ CNAV data and L5 Q5. The CNAV message which is modulated onto the aforementioned codes consists of a 300 bit message packet, Table 1 provides a breakdown of the CNAV message structure. Complete details on the civil signals are provided in IS-GPS-200D and IS-GPS-705.

Civil signal testing is an integral part of the GPS Wing's L-Band Signal-in-Space (SIS) performance assessment. To support this performance assessment the GPS Wing will be utilizing their Modernized Signal Test Asset (MSTA) to monitor and record the civil signals [L1 C/A, L2C and L5] to ascertain signal performance and assess specification compliance. Additionally, the FAA Technical Center will operate the following equipment: L2C and L5 receivers at multiple U.S. locations including their Wide Area Augmentation System (WAAS) and National Satellite Test Bed (NSTB) networks. FAA Technical Center hosts the NSTB which provides connectivity to monitor stations throughout North America.

Currently the scheduled date for the deployment of CNAV capabilities to the GPS Control Segment is many years away, so the GPS Wing directed Boeing, the GPS IIF satellite prime contractor, to provide an interim CNAV test capability. Experience has shown that the myriad of civil receiver developers make different architectural decisions as part of their receiver development process; so to promote specification compliant receiver development the GPS Wing has developed a small set of CNAV test vectors which will be broadcast during on-orbit checkout; these CNAV test vectors have been successfully utilized during GPS IIF SV ground testing. The GPS Wing is providing the following CNAV information as a collaborative effort to the larger civil community to support CNAV message processing activities.

These CNAV Test Modes are intended to exercise GPS IIF CNAV functionality; the primary purpose of each test mode is to ensure the Navigation Data Unit software is functioning as designed. The specific CNAV message types and message data which will be utilized by the test modes is identified in subsequent paragraphs.

1. CNAV Test Mode 1 - Baseline CNAV Message Sequence
2. CNAV Test Mode 2 - Data Set Transition
3. CNAV Test Mode 3 - Message Sequence Transition

GPS IIF on-orbit checkout SV Configuration:
To protect the users from unintentionally using IIF SV#1 (SVN62) during on-orbit checkout the GPS Control Segment will configure the Legacy NAV message to indicate the SV is unhealthy (i.e., the six SV health bits in Subframe 1 of the Legacy NAV message will be set to all ones. Also, the health bits specified in Subframes 4 and 5 of the Legacy NAV message will be set to all ones).
Additionally, the L2C signal and/or the L5 signal will be switched off during specific periods of IIF OOT.

At the conclusion on-orbit checkout, all CNAV uploads contained in the Navigation Data Unit will be deleted; this action will result in the broadcast of CNAV message Type 0 for L2C and L5 I5.

CNAV Test Mode 1 - Baseline CNAV Message Sequence:

The Baseline CNAV Message sequence for L2C CNAV and L5 I5 CNAV is illustrated in Figure 1. This CNAV message sequence [Msg Types 10, 11 and 30] will be broadcast (continuously repeated) by the Navigation Payload after initialization and for the vast majority of time during GPS IIF on-orbit checkout. However, Message Type 0 (alternating ones and zeros) may be broadcast for short periods of time. For this configuration, each CNAV message type [10, 11 and 30] will broadcast the data content (hex values) as defined in Table 2 for Data Set 1.

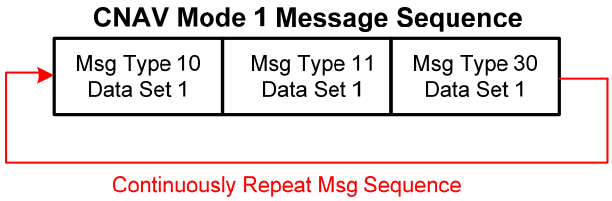

Figure 1: CNAV Test Mode 1 Message Sequence

CNAV Test Mode 2 – Data Set Transition:

CNAV Test Mode 2 will exercise the GPS IIF Modernized Message data control functionality (i.e. CNAV Data Set Transitions). Figure 4 illustrates the time and event sequence for CNAV Test Mode 2; this applies equally to L2C and L5 I5 CNAV. From Figure 4, the specified CNAV upload will be activated. After 30 minutes, the NDTE transition for each message type will occur. After 30 minutes, the transition from Data Set #1 to Data Set #2 will occur. As illustrated in Figure 2, the data set transitions will occur at the same time for each message type. For this configuration, each CNAV message type [10, 11 and 30] will broadcast the data content (hex values) as defined in Table 2 for Data Set 1 and 2 at the appropriate time.

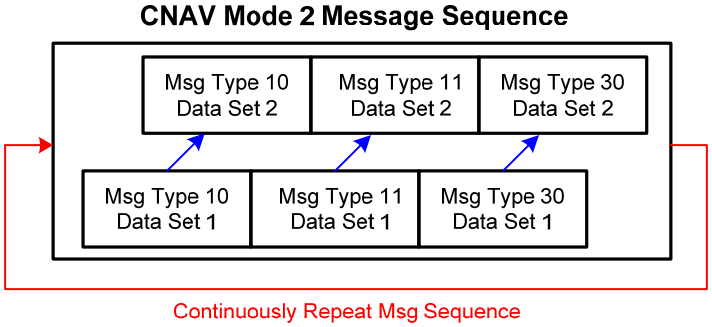

Figure 2: CNAV Test Mode 2 Message Sequence

CNAV Test Mode 3 – CNAV Message Sequence Transition:

CNAV Test Mode 3 will exercise the GPS IIF Modernized Message control functionality (i.e. CNAV Message Type transitions). Figure 4 illustrates the time and event sequence for CNAV Test Mode 3; this applies equally to L2C and L5 I5 CNAV. From Figure 4, the Message Types will transition 15 minutes after the specified CNAV upload has activated. As illustrated in Figure 3, the CNAV message types will switch from [10, 11, 30] to types [13, 14, 31]. For this configuration, each CNAV message type [10, 11, 30, 13, 14 and 31] will broadcast the data content (hex values) as defined in Table 2 for Data Set 1.

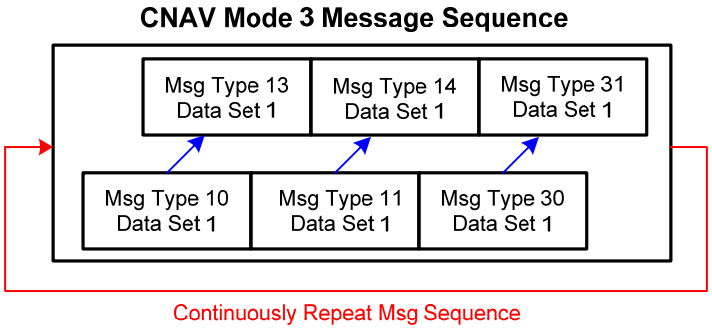

Figure 3: CNAV Mode 3 Message Sequence

Figure 4 illustrates the timing and event sequences for CNAV Test Modes 2 and 3; both modes will be executed in sequence during the same visible SV pass over CONUS. The GPS Control Segment will generate the required CNAV uploads with the specified activation times to support both CNAV Test Modes 2 and 3.

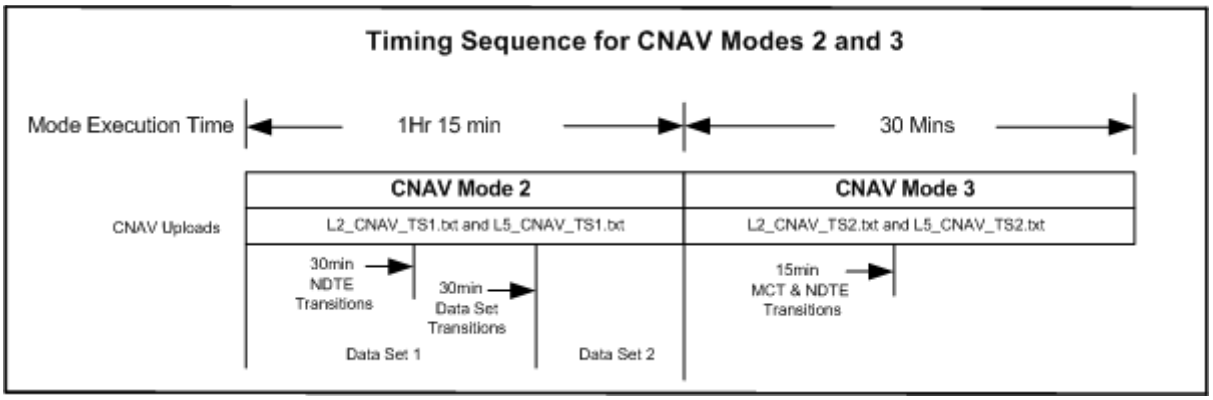

Figure 4: Execution Timing for CNAV Modes 2 and 3

L2C and L5 I5 CNAV Message Structures per IS-GPS-200D and IS-GPS-705:

Table 1: L2C and L5 I5 CNAV Message Structures (300 bits)

Message Bit Definition (300 Bits)	Source
• Bits (1 - 8) contains the fixed preamble "$8b_{16}$" • Bits (9-14) contains the SV PRN • Bits (15-20) contains the message Type ID • Bits (21-37) contains the message TOW • Bit (38) is the alert flag	Defined by IS-GPS-200D and IS-GPS-705
• Bits (39 – 276) contains the message data	Test vector data (see below)
• Bits (277 -300) contains the CRC	Defined by IS-GPS-200D and IS-GPS-705

L2C and L5C CNAV Message Test Vectors (Hex listings)

The message data defined in Table 2 are test vectors which will be utilized during IIF OOT for test purposes only and are **not** to be considered as real data for these messages. Each message data set defines the 238 message data bits.

Table 2: L2C and L5 I5 CNAV Message Test Vectors

Type	Description	Data Set	Test Vector Data
10	(Ephemeris 1)	1	2C BE 7F F0 7F E0 02 7F B0 00 00 00 00 00 00 00 00 7B AB DF 50 08 EB 20 00 DF 13 02 FF 80
		2	2C BE 7F F0 7F E0 02 7F B0 00 00 00 00 00 00 00 01 26 D3 24 86 08 EB 20 00 DF 13 02 FF 88
11	(Ephemeris 2)	1	0F 1F FF 57 25 52 6F 65 66 60 19 B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0C
		2	12 1F FF 44 38 C2 6F 65 66 60 19 B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
30	(Clock, IONO & Group Delay)	1	00 10 00 3C 00 3F 39 00 08 00 00 00 00 00 00 00 00 00 00 01 40 BF FF C9 C1 3F FE 80 00 04
		2	00 10 00 48 00 3F 39 00 08 00 00 00 00 00 00 00 00 00 00 01 40 BF FF C9 C1 3F FE 80 00 00
13	(Clock Differential Correction)	1	00 00 02 0E 00 00 08 42 00 00 01 08 48 00 00 21 0A 00 00 04 21 60 00 00 84 30 00 00 10 00
14	(Ephemeris Differential Correction)	1	00 00 02 08 00 00 00 00 00 00 00 00 00 02 10 50 00 00 00 00 00 00 00 00 00 10 00 00 00 08
31	(Clock & Reduced Almanac)	1	00 10 00 3C 00 3F 39 00 08 00 00 16 59 10 50 2A 5F 40 C0 5A 70 01 C0 34 5D 04 00 BF 7A 04