Simulator Data Set Description

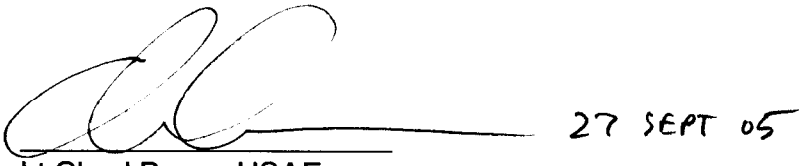
Version 2.0

September 22, 2005

THIS PAGE INTENTIONALLY LEFT BLANK

Change Log		
Date	***Rev***	***Action/Preparer***
March 29, 2005	1.0	E. Weston, J. Bencke
July 12, 2005	1.0b	J. Bencke – added units to description file outputs.
Aug 30, 2005	1.1	J. Bencke – Updated format and definition of Cat 1, 2, 3, and 4
Sep 22, 2005	2.0a	C. Stroing, E. Weston – Misc.

Approved by:



Lt Chad Bown, USAF
Chief, User Equipment Test
SMC/GPET

THIS PAGE INTENTIONALLY LEFT BLANK

1 Introduction

1.1 Purpose

The purpose of this document is to describe the Simulator Data Set (SDS) processing functions that must be added to a Precise Positioning Service (PPS) Advanced Encryption Standard (AES) M-code (AKA pseudo M-code or M') simulator so that it can generate RF signals suitable for testing the operational M-code capabilities of modernized military User Equipment (i.e., M-code capable UE). SDS are digital data files that contain all of the necessary MNSA unique information to allow a simulator to generate an operational MNSA signal without access to MNSA algorithms.

1.2 Simulator Data Set Overview

PPS GPS Satellite Signal Simulators (SSS) have limits to their functionality due to security regulations. PPS SSS designs may include generation of the unclassified AES M-code signal. That is, with JPO security approval a PPS SSS design may include the C/A code [as defined in IS-GPS-200], SA/A-S legacy P(Y) code [as defined in ICD-GPS-200/226] and AES M-code [as defined in ICD-GPS-700]. Such a simulator has substantial utility as a test tool, however it cannot generate the full-modernized GPS signal, lacking both SAASM and operational (MNSA) M-code capabilities. Security regulations prevent such a simulator from implementing the algorithms required to generate a SAASM signal. However, it may provide a limited SAASM signal generation capability by implementing SAASM test vectors. Similarly, a PPS SSS AES M-code simulator may possess a limited operational M-code capability through SDS. That is, with JPO security approval, a simulator vendor can modify his design to include SDS, by implementing Simulator Data Sets as described in this document.

Most M-code UE testing can be performed without SDS files, utilizing the simulator's AES M-code capability. However, when there is a need to exercise the MNSA specific UE functionality, an SDS capable simulator along with appropriate SDS files can meet any test requirement. SDS contains all of the information required by a PPS SSS AES M-code simulator to generate a particular operational M-code signal. This includes an M-code sequence and data messages (MNAV). The simulator may implement a wide range of scenarios utilizing a particular set of SDS files, however, it is limited to the time periods, key values, PRNs, etcetera, associated with the SDS files. That is, the simulator may implement any operational M-code scenario, if it can produce the corresponding AES M-code signal, and if SDS files are available to support the scenario.

An SDS simulator may have either a Basic or Advanced capability. The Basic capability allows an arbitrary M-code scenario to be supported, but the MNAV data streams are fully determined by the provided SDS files. An Advanced capability allows the tester considerable flexibility in determining the contents of all MNAV messages. Testers are encouraged to acquire Advanced capability SDS simulators.

The content of some SDS files will be classified. A classified appendix to this document (Appendix B, “Classified SDS Descriptions”) describes this material. Access to this appendix may be given to individuals with a “need to know” who meet the necessary JPO security requirements.

1.3 Terms and Acronyms

AES	Advanced Encryption Standard
CRC	Cyclic Redundancy Check
FEC	Forward Error Correction
GPS	Global Positioning System
MICE	MIlitary Clock/Ephemeris
MNAV	Military NAVigation message
MNSA	Modernized NAVSTAR Security Algorithm
MSR	Military Space Receiver
MUE	Military User Equipment
NGA	National Geo-spatial Agency
MMCT	MNAV Message Correction Table
PA	Puncture Acquisition code
PPS	Precise Positioning System
PRN	Pseudo-Random Noise (also satellite identifier)
PSI	Pseudorandom Secure Interleaver
SA/A-S	Selective Availability/Anti-Spoofing
SAASM	Selective Availability/Anti-Spoofing Module
SDS	Simulator Data Sets
SSS	Satellite Signal Simulator
TDDM	Time Division Data Multiplex
TLM	Telemetry
UTC	Universal Time, Coordinated

2 Applicable Documents

IS-GPS-200D, December 7, 2004
ICD-GPS-700A with IRN-700A-001, September 23, 2004
IS-GPS-703, September 30, 2004
ICD-GPS-226

3 Simulator Processing of SDS

3.1 SDS File Usage

Figure 1 provides a high level description of the M code generation process. MNAV data is a 400-bit message that includes calculated Cyclic Redundancy Check (CRC). The 400-bit message is encoded into the MNAV 800 symbol message. The encoding process includes Forward Error Correction (FEC) that transforms the 400-bit message into 800 symbols, and interleaving which uses Pseudorandom Secure Interleaver (PSI) variables. The MNAV 800 symbol message can be transmitted at either a high (200 Hz) or low (50 Hz) data rate. The M code is a 5.115 MHz chip sequence. The MNAV 800 symbol message is Time Division Data Multiplex (TDDM) Modulo-2 added to the M code sequence. TDDM means that MNAV is only added to every other M code chip. The resultant bit stream is modulated by a 10.23 MHz square wave to form the Binary Offset Code BOC(10,5) waveform. Note, the TDDM and BOC functions can be performed in reverse order; the resultant waveform will be the same.

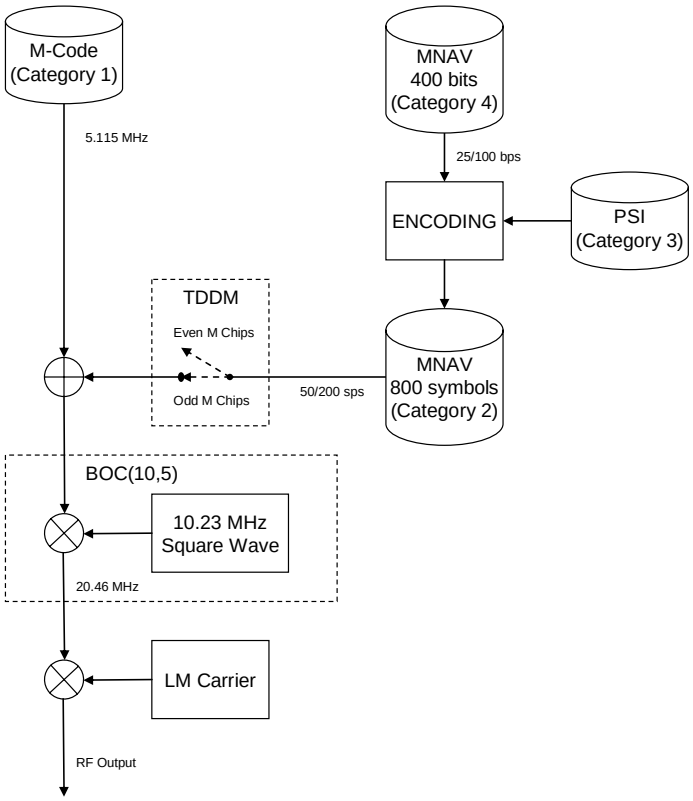


Figure 1. M-Code Generation Block Diagram

Figure 1 also shows the use of the four SDS file categories in the generation of an M-code RF signal. Category 1 files would be used to replace the simulator generated M code sequence. Category 2 files would be used to replace the simulator generated MNAV 800 symbol messages.

Category 3 files would be used to replace the simulator generated PSI variables. Category 4 files would be used to replace, or augment, the simulator generated MNAV 400 bit messages.

The Category 1 "M-code sequence" is a time ordered segment of the 5.115 MHz M-code. A binary file contains the M-code chip sequence. An ASCII file contains the descriptive information about the binary file. Together these two files are called the "M-code sequence Simulator Data Set" package and are defined in section 4.2.1.

The Category 2 "MNAV 800 symbol Messages" is a time ordered segment of the MNAV data stream. A binary file contains a sequence of MNAV data that has been encoded to 800 symbols and is ready to modulate on to the M code. An ASCII file contains the descriptive information about the binary file, including the data contents of the message types and order of transmission. Together these two files are called a "MNAV 800 symbol Messages Simulator Data Set" package and are defined in section 4.2.2.

The Category 3 "MNAV PSI data" is a time ordered series of Pseudorandom Secure Interleaver (PSI) data. A binary file contains the PSI data. An ASCII file contains the descriptive information about the binary file. Together these two files are called a "MNAV PSI data Simulator Data Set" package and are defined in section 4.2.3.

The Category 4 "MNAV 400 bit Messages" is a set of MNAV messages. A binary file contains the MNAV messages. An ASCII file contains the descriptive information about the binary file, including the data contents of the message types. Together these two files are called a "MNAV 400 bits Messages Simulator Data Set" package and are defined in section 4.2.4

In general, the RF output by a SDS capable simulator will include the C/A and P(Y) codes as well as M-code. It is important that the Navigation Message data stream of the legacy codes be consistent with the M-code MNAV data stream. There are multiple methods for simulating the Legacy Navigation Messages included on the C/A and P/Y codes. One method is using a package of three ASCII files containing legacy Almanac, Ephemeris and certain other data, which may be provided along with SDS files. These files provide data values that describe satellite clock, ephemeris and other data similar to the content of MNAV messages 6, 7, 8, 9 and 11. The content of these files is described in appendix A.

3.1.1 SDS File Usage – Basic Capability

Two levels of SDS capability have been defined, a Basic and an Advanced. The Basic capability can support an arbitrary M-CODE UE test scenario, but the Advanced will allow more flexibility in testing. For a simulator to implement a Basic capability it will need to accept the Category 1 and 2 SDS files. To generate a test scenario, files from both categories must be available for multiple satellites with compatible file attributes (i.e. data interval, keys). The simulator must be able to transition between files from the same category on any 48-second epoch.

The Basic capability provides for the implementation of predefined, or "canned" M-code scenarios (Note, only the M-code data to be modulated on the carriers is predetermined, all other aspects of a scenario are under user control). Simulators can implement some core government generated SDS files with a Basic SDS capability.

3.1.2 SDS File Usage – Advanced Capability

Although the Basic capability allows an arbitrary test scenario to be generated, it allows no flexibility for the tester in regard to the MNAV stream to be implemented in a scenario. Both the M-code sequence and MNAV stream are completely predefined. The Advanced capability gives the tester much more control of the MNAV stream. The simulator users have the capability to generate their own MNAV messages using the native capability of his AES simulator, and intermix them in an arbitrary manner with MNAV messages provided in SDS files. To provide the Advanced capability a simulator must support SDS Categories 3 and 4. Category 4 files contain 400 bit MNAV messages, and Category 3 files contain the operational M-code unique PSI data required to interleave MNAV messages. The simulator must allow the users to generate their own 400 bit MNAV messages, utilize as is or modify the provided Category 4 400 bit MNAV messages, and specify which message from either source may be inserted in each MNAV time slot. Regardless of the source of the 400-bit MNAV message, the PSI data will allow it to be encoded as an operational M-code 800 symbol message. The simulator must also allow compatible Category 2 file records to be incorporated in an Advanced scenario, that is, instead of designating a 400-bit message for a particular time slot the user would specify that the 800-symbol record from a Category 2 file be implemented.

3.2 Functionality of an SDS Simulator

An SDS simulator is a modernized PPS simulator with SDS support added. If minimum (Category 1 and 2) SDS support is provided it is a Basic capability SDS simulator. If all categories (categories 1, 2, 3, and 4) are implemented it is an Advanced SDS simulator.

3.2.1 Modernized PPS Simulator Functions

A modernized PPS simulator will have the following capabilities:

a. The simulator must generate the C/A and P codes and the legacy Navigation Message and modulate it on L1 and L2 carriers as defined in ICD-GPS-200.
b. The simulator must generate the P(Y) codes and legacy Navigation Message and modulate it on L1 and L2 carriers as defined in ICD-GPS-226.
c. The simulator must support SAASM Test Vectors.
d. The simulator must generate the AES M-code and MNAV data and modulate it on L1 and L2 carriers as defined in ICD-GPS-700.
e. The L-band signals must be high fidelity representations of the RF, as it would be received at the antenna of a GPS receiver. That is, satellite and receiver motion, transmission delays and atmospheric effects should be included.
f. The simulator should be capable of simulating at least twelve satellites (both L1 and L2) simultaneously to create a realistic all-in-view RF environment.

3.2.2 Basic Capability SDS Simulator Functions

A Basic capability SDS simulator is a modernized PPS simulator with the following SDS capabilities added:

g. The simulator must be able to implement both the category 1 SDS files, M-code sequences, and the category 2 SDS files, MNAV 800 symbol Messages, as described in section 4.2.1 and 4.2.2.
h. The simulator must be able to generate a legacy signal consistent with the content of the MNAV 800 symbol Messages by implementing SDS Navigation Message files as described in section 4.
i. The simulator must be able to seamlessly transition between compatible files at any user specified 48-second epoch. For example, the user may want to switch between Category 1 files during a scenario, where one file has Puncture Code (PA) on, and the other off.
j. SDS functionality must be provided for all channels, i.e., simulated carriers, for which AES M-code is provided.

3.2.3 Advanced Capability SDS Simulator Functions

In order to be deemed an "Advanced Capability SDS Simulator" the simulator must have all capabilities required of a "Basic Capability SDS Simulator", and the following capabilities:

k. The simulator must be able to implement both the category 3 SDS files, MNAV PSI data, and the Category 4 SDS files, MNAV 400 bit Messages, as described in section 4.2.3 and 4.2.4.
l. The simulator must provide a suitable user interface to allow an arbitrary mixture of simulator generated MNAV messages and category 4 SDS files to be the source of the MNAV data stream for each satellite signal. Both the source of each MNAV message and the timing of its transmission must be controllable by the user.
m. For all MNAV message types described in ICD-GPS-700 the user must have the capability to modify any of the content of a category 4 SDS file message selected for transmission.
n. The simulator must be able to generate C/A and P(Y) signals consistent with the SDS file contents. That is, it must be able to generate a legacy data message (Navigation Message) with similar content to the MNAV messages. For example, satellite orbit and clock data contained in MNAV messages 6 and 7 for a particular PRN and time period, must be similar to the corresponding data in subframes 1, 2 and 3 of the legacy Navigation Message. SDS legacy Navigation Message files are provided along with MNAV SDS files to help meet this requirement.

There are additional simulator functions that may eventually be required, but are not yet well enough defined to be included in the basic or advanced SDS requirements. This includes both pseudolite support and classified SDS data processing.

4 SDS File Categories

4.1 File Names

The file naming convention for both the binary data and ASCII description files that make up each of the four SDS file categories will be as follows:

Data File: cat#_prn###_*link_paenable_key_week_time*.sds
Descriptive File: cat#_prn###_*link_paenable_key_week_time*.des

where

#	Category number (1 characters, 1-4)
###	PRN number (3 characters)
link	Link ID (l1me, l2me, l1ms, l2ms)
paenable	PA code (paon, paoff)
key	Key designator (aes###, mnsa###)
week	Week number of data (4 characters)
time	Seconds of GPS week of data (6 characters)

i.e. cat1_prn001_l1me_paon_aes000_0894_000000.sds
i.e. cat1_prn001_l1me_paon_aes000_0894_000000.des

4.2 Category Descriptions

The following sections define the format and content for both the binary data and ASCII description files that make up each of the four SDS file categories. Appendix A provides the Legacy Navigation Message ASCII file naming convention, format and content.

Standard data types are used in the ASCII description files defined below. These data types are described in Table 1.

Format	**Description**
int	Signed integer number
double	Signed decimal number
byte	8 bits of data, MSB is first bit (0).
string	Alphanumeric
hex	Hexadecimal character (0-F). Preceded by 0x
binary	Binary character, 0 or 1.
[N]	Array of N

Table 1. Data type descriptions

4.2.1 Category 1: M-Code Sequence

The Category 1 "M-Code Sequence" SDS package consists of the "M-Code Sequence" data file, and the "M-Code Sequence" descriptive file. The data file contains the code sequence, and the descriptive file defines the parameter values used to derive the code sequence (e.g., time, PRN, Key Designator, PA mode, etc.). The Key Designator or PA mode may change on any 48-second M-code epoch.

4.2.1.1 Category 1 Data File

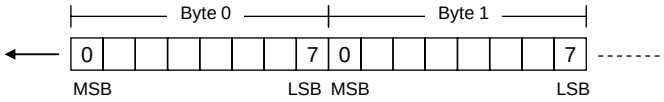
The "M-code sequence" data file is a time ordered segment of the M-code stored in a binary file. An "M-code sequence" data file contains the M-code bit stream for only one PRN and frequency. It contains the M-code bit stream at 5.115 MHz as it comes out of the generating encryption engine.

4.2.1.1.1 Category 1 Data File Content

Data	Format	Description
M-code	byte	8 bits of M code (5.115 MHz)

4.2.1.1.2 Category 1 Data File Format

Binary – Continuous data stream, with data packed 8 code bits per byte. The MSB is bit 0, and is transmitted first.



.

4.2.1.2 Category 1 Description File

The "M-code sequence" description file is an ASCII file that contains information about the data file. This information is provided in two sections: File Information and Events. The File Information section includes start time of the file, duration, PRN, Type, and Link. This information is provided once at the beginning of the file. The Events section will include time of event, the Key Designator, and Puncture Code used in the generation of the M code. This information is provided at the beginning of the file (immediately following the File Information), and any other time an event occurs that changes any of these parameters.

4.2.1.2.1 Category 1 Description File Content

4.2.1.2.1.1 File Information

Data	Format	Units	Description
--- Start of File Information ---			
GPS Week	int	week	GPS week corresponding to beginning of the data file
GPS Time	int	sec	GPS time of week corresponding to beginning of the data file
Duration	int	sec	Time interval spanned by the data file
PRN	int		PRN (0-255)
Type	string		Satellite, Pseudolite, or Simulator
Link ID	string		L1 and L2, Earth and Spot Beam (L1ME, L2ME, L1MS, L2MS)
--- End of File Information ---			

4.2.1.2.1.2 Events

Data	Format	Units	Description
--- Start of Event ---			
GPS Week	int	week	GPS week corresponding to Event
GPS Time	int	sec	GPS time of week corresponding to Event. Events always occur on the 48 second LM Epoch.
Key Designator	string		AES Key# (AES000-999) or MNSA Key# (MNSA000-999) *** See NOTE 1 below**
PA Enable	string		Puncture code (ON, OFF)
--- End of Event ---			

***NOTE 1**: The AES or MNSA Key Designator identifies the M-code keying material that must be loaded into equipment under test. Specific keys referenced by the Key Designators are defined separately from this document.

4.2.1.2.2 Category 1 Description File Format

The Category 1 Description file contains only ASCII characters. The "File Information" and "Events" sections of the Description file are in the format indicated by the following examples.

4.2.1.2.2.1 File Information

```
*--- Start of File Information ---*
GPS Week:                          894
GPS Time (sec):                    57600
Duration (sec):                    2400
PRN:                               1
Type:                              Satellite
Link ID:                           L1ME
*--- End of File Information ---*
```

4.2.1.2.2.2 Events

```
*--- Start of Event ---*
GPS Week:                          894
GPS Time (sec):                    57600
Key Designator:                    AES000
PA Enable:                         ON
*--- End of Event ---*
```

4.2.2 Category 2: MNAV 800 Symbol Message

The Category 2 "MNAV 800 Symbol Messages" SDS package consists of the "MNAV 800 Symbol Messages" data file, and the "MNAV 800 Symbol Messages" descriptive file. The data file contains the sequence of 800 symbol messages, 800 bits per message. The descriptive file defines parameter values used to derive the MNAV messages (e.g., time, PRN, Key Designator, Data Rate, etc.), and includes content from each message, in a human and machine-readable form. The Key Designator or Data Rate may change on any 48-second M-code epoch.

4.2.2.1 Category 2 Data File

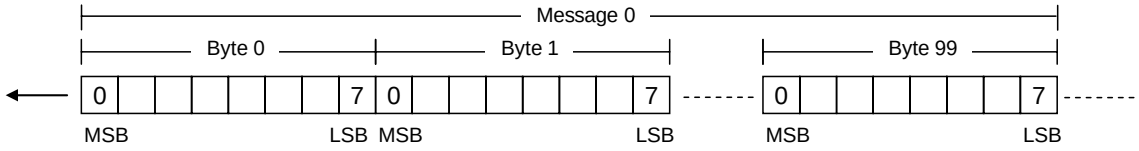
The "MNAV 800 Symbol Messages" data file is a time ordered segment of the MNAV data stream stored in a binary file. "MNAV 800 symbol messages" data file contains the MNAV bit stream for only one PRN and frequency. It contains the MNAV bit stream at the 50 Hz low or 200 Hz high data rate. Note that any change in the data rate will be indicated in the "Events" section of the description file.

4.2.2.1.1 Category 2 Data File Contents

Data	Format	Description
MNAV 800	byte[100]	800 bits of MNAV data per message.

4.2.2.1.2 Category 2 Data File Format

Binary – Continuous data stream, with each message stored in 100 contiguous bytes, packed 8 symbols per byte. The MSB is bit 0 of Byte 0, and is transmitted first.



4.2.2.2 Category 2 Description File

The "MNAV 800 Symbol Messages" description file is an ASCII file that contains information about the data file. This information is provided in three sections: File Information, Events, and Messages. The File Information section includes start time of the file, duration, PRN, Type, and Link. This information is provided once at the beginning of the file. The Events section will include time of event, Key Designator, and Data Rate used in the generation of the MNAV. This information is provided at the beginning of the file, and any other time an event occurs that changes any of these parameters. The Messages section contains the transmit time of the message, and a description of message content. The Events and Messages are interleaved in time ordered sequence. If an Event and Message have the same time tag, the Event will precede the Message.

4.2.2.2.1 Category 2 Description File Content

4.2.2.2.1.1 File Information

Data	Format	Units	Description
--- Start of File Information ---			
GPS Week	int	week	GPS week corresponding to beginning of the data file
GPS Time	int	sec	GPS time of week corresponding to beginning of the data file
Duration	int	sec	Time interval spanned by the data file
PRN	int		PRN (0-255)
Type	string		Satellite, Pseudolite, or Simulator
Link ID	string		L1 and L2, Earth and Spot Beam (L1ME, L2ME, L1MS, L2MS)
--- End of File Information ---			

4.2.2.2.1.2 Events

Data	Format	Units	Description
--- Start of Event ---			
GPS Week	int	week	GPS week corresponding to Event
GPS Time	int	sec	GPS time of week corresponding to Event. Events always occur on the 48 second LM Epoch.
Key Designator	string		AES Key# (AES000-999) or MNSA Key# (MNSA000-999) *** See NOTE 1 below**
Data Rate	string		MNAV data rate (HI, LO)
--- End of Event ---			

***NOTE 1**: The AES or MNSA Key Designator identifies the M-code keying material that must be loaded into equipment under test. Specific keys referenced by the Key Designators are defined separately from this document.

4.2.2.2.1.3 Messages

The message footer portion of each message is the same for all MNAV message types and is presented in paragraph 4.2.2.2.1.3.1. The "Message Type" portion of the message is type unique, and is presented for each message type in paragraph 4.2.2.2.1.3.2.

Data	Format	Units	Description
--- Start of Message ---			
GPS Week	int	week	Message Week Number
GPS Time	int	sec	Message Time
- Footer -			
Message Footer			See description 4.2.2.2.1.3.1
- Data Block -			
Message Type			See descriptions 4.2.2.2.1.3.2
--- End of Message ---			

4.2.2.2.1.3.1 Message Footer

The following message footer format is used for all message types.

Data	Format	Units	Description
Message ID	int		Message type (0-255)
Alert Flags	binary[5]		URA Alert, A-S, Reserved, Health, and Reserved Flags (5 bits)
LM Config Slot 1	binary[5]		Slot 1 configuration: M-code, FA-code, PA-code, Data, and Rate Flag. (5 bits)
LM Config Slot 2	binary[5]		Slot 2 configuration: M-code, FA-code, PA-code, Data, and Rate Flag.(5 bits)
LM Config Slot 3	binary[5]		Slot 3 configuration: M-code, FA-code, PA-code, Data, and Rate Flag. (5 bits)
Spare	hex[3]		Spare (10 bits)
TLM	hex[5]		TLM (18 bits)
Reserved	hex[2]		Reserved (5 bits)

4.2.2.2.1.3.2 Message Type Unique Data

The following tables describe the contents of each of the MNAV message types, presented in increasing numerical order.

4.2.2.2.1.3.2.1 Type 1 – Legacy Data Message

This message type is not supported.

4.2.2.2.1.3.2.2 Type 2 – Special Messages

Special Message has 4 subtypes: 1 – Data, 2 – Special Message, 3 – General Message, 4 – Reserved
Messages are numbered Type2.*subtype* (e.g. Type2.1)

Data	Format	Units	Description
320 Bits	hex[40]		320 MNAV bits

See classified Appendix B for additional Type 2 descriptive file content.

4.2.2.2.1.3.2.3 Type 3 – Notice Advisory to Navstar Users (NANU)

NANU has 16 subtypes:12 defined (1-12), and 4 reserved (13 – 16).
Messages are numbered Type3.*subtype* (e.g. Type3.1)

Data	Format	Units	Description
320 Bits	hex[40]		320 MNAV bits

4.2.2.2.1.3.2.4 Type 4 – Key Message

Data	Format	Units	Description
320 Bits	hex[40]		320 MNAV bits

See classified Appendix B for additional Type 4 descriptive file content.

4.2.2.2.1.3.2.5 Type 5 – Constellation Status

Constellation Status has 4 subtypes: 1 – Current Status, 2 - Change Status, 3 & 4 - Reserved.

4.2.2.2.1.3.2.5.1 Subtype 1 – Current Status

Current Constellation Status contains four pages (1-4) to transmit information for all PRNs. Messages are numbered Type5.*subtype*.*page* (e.g. Type 5.1.1)

Data	Format	Units	Description
Subtype ID	int		Subtype ID (1-4)
Page Number	int		Current page number (1-4)
Page Count	int		Number of available pages (1-4)
Reserved	hex[2]		Reserved (6 bits)
Repeat per 6-11 Status Words			
SVID	int		SV PRN (0-255)
Spot Flag	binary		Spot Beam, 0 – Off, 1 - On
L1ME Link	binary[10]		L1M Earth Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L2ME Link	binary[10]		L2M Earth Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L1MS Link	binary[10]		L1M Spot Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L2MS Link	binary[10]		L2M Spot Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
Spare	hex[5]		Spare (0 to 20 bits)

4.2.2.2.1.3.2.5.2 Subtype 2 – Change Status

Change Status contains four pages (1-4) to transmit information for all PRNs.
Messages are numbered Type5.*subtype*.*page* (e.g. Type 5.2.1)

Data	Format	Units	Description
Subtype ID	int		Subtype ID (1-4)
Page Number	int		Current page number (1-4)
Page Count	int		Number of available pages (1-4)
Reserved	hex[2]		Reserved (6 bits)
Activation Week	int		Activation week
Activation Time	int	Z-count	Activation time in Z-count
Duration	int	600 Z-count	Duration in 600 Z-count
Repeat per 5-8 Status Words			
SVID	int		SV PRN (0-255)
Spot Flag	binary		Spot Beam, 0 – Off, 1 - On
L1ME Link	binary[10]		L1M Earth Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L2ME Link	binary[10]		L2M Earth Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L1MS Link	binary[10]		L1M Spot Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
L2MS Link	binary[10]		L2M Spot Indicators: PA-code, FA-code, Health, Data, Rate, Power, Reserved Flags. (10 bits)
Spare	hex[7]		Spare (0-26 bits)

4.2.2.2.1.3.2.6 Type 6 – Military Improved Cock and Ephemeris Data Part 1 (*MICE I)*

MICE I has no subtypes.
Messages are numbered Type6.

Data	Format	Units	Description
Health	binary[6]		Health: L1ME, L2ME, L1MS, L2MS, L1PY, L2PY Status (6 bits)
AF0	double	sec	Clock Bias
AF1	double	sec/sec	Clock Drift
AF2	double	sec/sec^2	Clock Drift Rate
TGD	double	sec	Estimated Group Delay
TOC	int	sec	Clock Data Reference Time
WN_OC	int	week	Clock Data Reference Week
URA_OC	int		Clock User Range Accuracy Index
URA_DOT_OC	int		Derivative of Clock User Range Accuracy Index
TOP	int	sec	Data Predict Reference Time
DELTA_A0	double	m	Semi Major Axis Difference
ECC	double		Eccentricity
I0	double	semi-cir	Inclination Angle
OMEGA0	double	semi-cir	Right Ascension
M0	double	semi-cir	Mean Anomaly
W	double	semi-cir	Argument of Perigee
Spare	hex[3]		Spare (11 bits)

4.2.2.2.1.3.2.7 Type 7 – Military Improved Cock and Ephemeris Data Part 2 (MICE II)

MICE II has no subtypes.
Messages are numbered Type7.

Data	Format	Units	Description
TOP	int	sec	Data Predict Reference Time
TOE	int	sec	Ephemeris Data Reference Time
WN_OE	int	week	Ephemeris Data Reference Week
Reserved	hex[2]		Reserved (5 bits)
DELTA_N	double	semi-cir/sec	Mean Motion Difference
DELTA_N_DOT	double	semi-cir/sec^2	Rate of Mean Motion Difference
I_DOT	double	semi-cir/sec	Rate of Inclination Angle
DELTA_OMEGA_DOT	double	semi-cir/sec	Rate of Right Ascension
CRS	double	m	Sin Correction to Orbit Radius
CRC	double	m	Cos Correction to Orbit Radius
CUC	double	rad	Sin Correction to Argument of Latitude
CUS	double	rad	Cos Correction to Argument of Latitude
Reserved	hex[2]		Reserved (6 bits)
CIC	double	rad	Sin Correction to Angle of Inclination
CIS	double	rad	Cos Correction to Angle of Inclination
A_DOT	double	m/sec	Rate of Semi Major Axis
Reserved	hex		Reserved (2 bits)
URA_OE	int		Ephemeris User Range Accuracy Index
Spare	hex[12]		Spare (48 bits)

4.2.2.2.1.3.2.8 Type 8 – Reduced Almanac

Reduced Almanac has N pages (1-N) to transmit information for all PRNs.
Messages are numbered Type8.*page* (e.g. Type 8.1)

Data	**Format**	**Units**	**Description**
Page Number	int		Page Number (0-3)
WN_A	int	week	Almanac Week Number
TOA	int	sec	Time of Almanac
Repeat per 9 Packets			
PRN	int		PRN (0-255)
DELTA_A	int	m	Semi Major Axis Difference
OMEGA0_DOT	double	semi-cir/sec	Right Ascension Difference
PHI_0	double	semi-cir	Argument of Latitude
Health	binary[3]		Health: L1, L2, L5 Indicator
Reserved	hex		Reserved (2 bits)

4.2.2.2.1.3.2.9 *Type 9* – MNAV Message Correction Table (MMCT)

MMCT has 2 subtypes: 1 – Clock Corrections, 2 – Ephemeris Corrections.

4.2.2.2.1.3.2.9.1 Subtype 1 – Clock Corrections

Clock Corrections has N pages (1-N) to transmit information for all PRNs.
Messages are numbered Type9.*subtype*.*page* (i.e. Type 9.1.1)

Data	Format	Units	Description
Subtype ID	binary		Subtype ID (1-2)
TOP	int	sec	Data Predict Reference Time
WN_OP	int	week	Data Predict Reference Week
TOD	int	sec	Data Predict Reference Time
Packet Type	binary[8]		Type flag for 8 data packets
Repeat per 8 Packets			
PRN	int		PRN (0-255)
DELTA_AF0	double	sec	Clock Bias Correction
DELTA_AF1	double	sec/sec	Clock Drift Correction
UDRA	int		User Differential Range Accuracy Index
Spare	hex		Spare (4 bits)

4.2.2.2.1.3.2.9.2 Subtype 2 – Ephemeris Corrections

Ephemeris Corrections has N pages (1-N) to transmit information for all PRNs.
Messages are numbered Type9.*subtype*.*page* (i.e. Type 9.2.1)

Data	**Format**	**Units**	**Description**
Subtype ID	binary		Subtype ID (1-2)
TOP	int	sec	Data Predict Reference Time
WN_OP	int	week	Data Predict Reference Week
TOD	int	sec	Data Predict Reference Time
PACKET TYPE	binary[8]		Type flag for 8 data packets
Repeat per 3 Packets			
PRN	int		PRN (0-255)
DELTA_ALPHA	double		Alpha Correction
DELTA_BETA	double		Beta Correction
DELTA_GAMMA	double	semi-cir	Gamma Correction
DELTA_I	double	semi-cir	Inclination Correction
DELTA_OMEGA	double	semi-cir	Right Ascension Correction
DELTA_A	double	m	Semi Major Axis Correction
UDRA_DOT	int		Rate User Differential Range Accuracy Index

4.2.2.2.1.3.2.10 Type 10 – National Geospatial-Intelligence Agency (NGA) Updates

NGA has no subtypes.
Messages are numbered Type10.

Data	Format	Units	Description
320 Bits	hex[40]		320 MNAV bits

4.2.2.2.1.3.2.11 Type 11 – Coordinated Universal Time (UTC), Ionospheric Corrections (IC), Earth Orientation Parameters (EOP)

UTC/IC/EOP has no subtypes.
Messages are numbered Type11.

Data	Format	Units	Description
TOT	int	sec	Time Data Reference Time
WN_OT	int	week	Time Data Reference Week
A0	double	sec	UTC Bias Coefficient
A1	double	sec/sec	UTC Drift Coefficient
A2	double	sec/sec^2	UTC Drift Rate Coefficient
DELTA_T_LS	int	sec	Leap Second Count
T_LS	double	sec	Leap Second Count Reference Time
WN_LS	int	week	Leap Second Count Reference Week
Reserved	hex		Reserved (3 bits)
ALPHA_0	double	sec	Amplitude Ionosphere Coefficient – 0^{th} Order
ALPHA_1	double	sec/semi-cir	Amplitude Ionosphere Coefficient – 1^{st} Order
ALPHA_2	double	sec/semi-cir^2	Amplitude Ionosphere Coefficient – 2^{nd} Order
ALPHA_3	double	sec/semi-cir^3	Amplitude Ionosphere Coefficient – 3^{rd} Order
BETA_0	double	sec	Period Ionosphere Coefficient – 0^{th} Order
BETA_1	double	sec/semi-cir	Period Ionosphere Coefficient – 1^{st} Order
BETA_2	double	sec/semi-cir^2	Period Ionosphere Coefficient – 2^{nd} Order
BETA_3	double	sec/semi-cir^3	Period Ionosphere Coefficient – 3^{rd} Order
PM_X	double	Arc-sec	X Axis Polar Motion
PM_X_DOT	double	arc-sec/day	X Axis Polar Motion Drift
PM_Y	double	Arc-sec	Y Axis Polar Motion
PM_Y_DOT	double	arc-sec/day	Y Axis Polar Motion Drift
DELTA_UT1	double	sec	Universal Time
DELTA_UT1_DOT	double	sec/day	Universal Time Drift
Spare	hex[9]		Spare (34 bits)

4.2.2.2.1.3.2.12 Type 12 – Inter-Signal Bias

Inter-Signal Bias has no subtype.
Messages are numbered Type12.

Data	Format	Units	Description
TOC	int	sec	Clock Data Reference Time
WN_OC	int	week	Clock Data Reference Week
ISC_L1ME	double	sec	L1ME to L1PY Inter-Signal Correction
ISC_L2ME	double	sec	L2ME to L1PY Inter-Signal Correction
ISC_L1MS	double	sec	L1MS to L1PY Inter-Signal Correction
ISC_L2MS	double	sec	L2MS to L1PY Inter-Signal Correction
ISA_L2PY	int		L2PY to L1PY Inter-Signal Accuracy Index
ISA_L1ME	int		L1ME to L1PY Inter-Signal Accuracy Index
ISA_L2ME	int		L2ME to L1PY Inter-Signal Accuracy Index
ISA_L1MS	int		L1MS to L1PY Inter-Signal Accuracy Index
ISA_L2MS	int		L2MS to L1PY Inter-Signal Accuracy Index
Reserved	hex[24]		Reserved (96 bits)
Spare	hex[32]		Spare (128 bits)

4.2.2.2.1.3.2.13 Type 13 – Selective Availability/Anti-Spoofing (SA/A-S)

Data	Format	Units	Description
320 Bits	hex[40]		320 MNAV bits

See classified Appendix B for Type 13 content.

4.2.2.2.1.3.2.14 Type 14 – Authentication

This message type is not supported.

4.2.2.2.2 Category 2 Description File Format

The Category 2 Description file contains only ASCII characters. The “File Information”, “Events” and “Messages” sections of the Description file are in the format indicated by the following examples.

4.2.2.2.2.1 File Information

```
*--- Start of File Information ---*
GPS Week:                          894
GPS Time (sec):                    57600
Duration (sec):                    2400
PRN:                               1
Type:                              Satellite
Link ID:                           L1ME
*--- End of File Information ---*
```

4.2.2.2.2.2 Events

```
*--- Start of Event ---*
GPS Week:                          894
GPS Time (sec):                    57600
Key Designator:                    AES000
Data Rate:                         HI
*--- End of Event ---*
```

4.2.2.2.2.3 Messages

The file format is provided for each message type, listed in increasing numerical order.

Type2.n

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        2
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
320 Bits:                          0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
*--- End of Message ---*
```

Type3.n

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        3
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
320 Bits:                          0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
*--- End of Message ---*
```

Type4

See Appendix B.

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        4
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
320 Bits:                          0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
*--- End of Message ---*
```

Type5.1.m

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        5
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Subtype ID:                        0
Page Number:                       0
Page Count:                        0
Reserved:                          0x00
SVID:                              1
Spot Flag:                         0
L1ME Link:                         0000000000
L2ME Link:                         0000000000
SVID:                              2
Spot Flag:                         1
L1ME Link:                         0000000000
L2ME Link:                         0000000000
L1MS Link:                         0000000000
L2MS Link:                         0000000000
…
SVID:                              8
Spot Flag:                         0
L1ME Link:                         0000000000
L2ME Link:                         0000000000
Spare:                             0x00000
*--- End of Message ---*
```

Type5.2.m

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        5
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Subtype ID:                        1
Page Number:                       0
Page Count:                        0
Reserved:                          0x00
Activation Week:                   894
Activation Time (Z-count):         0
Duration (600 Z-count):            100
SVID:                              1
Spot Flag:                         0
L1ME Link:                         0000000000
L2ME Link:                         0000000000
SVID:                              2
Spot Flag:                         1
L1ME Link:                         0000000000
L2ME Link:                         0000000000
L1MS Link:                         0000000000
L2MS Link:                         0000000000
…
SVID:                              6
Spot Flag:                         0
L1ME Link:                         0000000000
L2ME Link:                         0000000000
Spare:                             0x0000000
*--- End of Message ---*
```

Type6

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        6
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Health:                            000000
AF0 (sec):                         0.00000000000e-000
AF1 (sec/sec):                     0.00000000000e-000
AF2 (sec/sec^2):                   0.00000000000e-000
TGD (sec):                         0.00000000000e-000
TOC (sec):                         3600
WN_OC:                             894
URA_OC:                            0
URA_DOT_OC:                        0
TOP (sec):                         3600
DELTA_A0 (m):                      0.00000000000e-000
ECC:                               0.00000000000e-000
I0 (semi-cir):                     0.00000000000e-000
OMEGA0 (semi-cir):                 0.00000000000e-000
M0 (semi-cir):                     0.00000000000e-000
W (semi-cir):                      0.00000000000e-000
Spare:                             0x000
*--- End of Message ---*
```

Type7

```
*--- Start of Message ---*
GPS Week:                           1100
GPS Time (sec):                     86400
*- Footer -*
Message ID:                         7
Alert Flags:                        00000
LM Config Slot 1:                   00000
LM Config Slot 2:                   00000
LM Config Slot 3:                   00000
Spare:                              0x000
TLM:                                0x00000
*- Data Block -*
TOP (sec):                          3600
TOE (sec):                          3600
WN_OE:                              894
Reserved:                           0x00
DELTA_N (semi-cir/sec):             0.00000000000e-000
DELTA_N_DOT (semi-cir/sec^2):       0.00000000000e-000
I_DOT (semi-cir/sec):               0.00000000000e-000
DELTA_OMEGA_DOT (semi-cir/sec):     0.00000000000e-000
CRS (m):                            0.00000000000e-000
CRC (m):                            0.00000000000e-000
CUC (radian):                       0.00000000000e-000
CUS (radian):                       0.00000000000e-000
Reserved:                           0x00
CIC (radian):                       0.00000000000e-000
CIS (radian):                       0.00000000000e-000
A_DOT (m/sec):                      0.00000000000e-000
Reserved:                           0x0
URA_OE:                             0
Spare:                              0x00000000
*--- End of Message ---*
```

Type8.n

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        8
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Page Number:                       0
WN_A:                              894
TOA (sec):                         3600
PRN:                               1
DELTA_A (m):                       0
OMEGA0_DOT (semi-cir):             0.00000000000e-000
PHI_0 (semi):                      0.00000000000e-000
Health:                            000
Reserved:                          0x0
PRN:                               2
DELTA_A (m):                       0
OMEGA0_DOT (semi-cir):             0.00000000000e-000
PHI_0 (semi):                      0.00000000000e-000
Health:                            000
Reserved:                          0x0
…
PRN:                               9
DELTA_A (m):                       0
OMEGA0_DOT (semi-cir):             0.00000000000e-000
PHI_0 (semi):                      0.00000000000e-000
Health:                            000
Reserved:                          0x0
*--- End of Message ---*
```

Type9.1.m

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        9
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Subtype ID:                        0
TOP (sec):                         3600
WN_OP:                             894
TOD (sec):                         3600
Packet Type:                       00000000
PRN:                               1
DELTA_AF0 (sec):                   0.00000000000e-000
DELTA_AF1 (sec/sec):               0.00000000000e-000
UDRA:                              0
PRN:                               2
DELTA_AF0 (sec):                   0.00000000000e-000
DELTA_AF1 (sec/sec):               0.00000000000e-000
UDRA:                              0
…
PRN:                               8
DELTA_AF0 (sec):                   0.00000000000e-000
DELTA_AF1 (sec/sec):               0.00000000000e-000
UDRA:                              0
Spare:                             0x0
*--- End of Message ---*
```

Type9.2.m

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        9
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
Subtype ID:                        1
TOP (sec):                         3600
WN_OP:                             894
TOD (sec):                         3600
Packet Type:                       00000000
PRN:                               1
DELTA_ALPHA:                       0.00000000000e-000
DELTA_BETA:                        0.00000000000e-000
DELTA_GAMMA (semi-cir):            0.00000000000e-000
DELTA_I (semi-cir):                0.00000000000e-000
DELTA_OMEGA (semi-cir):            0.00000000000e-000
DELTA_A (m):                       0.00000000000e-000
UDRA_DOT:                          0
PRN:                               2
DELTA_ALPHA:                       0.00000000000e-000
DELTA_BETA:                        0.00000000000e-000
DELTA_GAMMA (semi-cir):            0.00000000000e-000
DELTA_I (semi-cir):                0.00000000000e-000
DELTA_OMEGA (semi-cir):            0.00000000000e-000
DELTA_A (m):                       0.00000000000e-000
UDRA_DOT:                          0
PRN:                               3
DELTA_ALPHA:                       0.00000000000e-000
DELTA_BETA:                        0.00000000000e-000
DELTA_GAMMA (semi-cir):            0.00000000000e-000
DELTA_I (semi-cir):                0.00000000000e-000
DELTA_OMEGA (semi-cir):            0.00000000000e-000
DELTA_A (m):                       0.00000000000e-000
UDRA_DOT:                          0
*--- End of Message ---*
```

Type10

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        10
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
320 Bits:                          0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
*--- End of Message ---*
```

Type11

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        11
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
TOT (sec):                         3600
WN_OT:                             894
A0 (sec):                          0.00000000000e-000
A1 (sec/sec):                      0.00000000000e-000
A2 (sec/sec^2):                    0.00000000000e-000
DELTA_T_LS (sec):                  0
T_LS (sec):                        0.00000000000e-000
WN_LS:                             0
ALPHA_0 (sec):                     0.00000000000e-000
ALPHA_1 (sec/semi-cir):            0.00000000000e-000
ALPHA_2 (sec/semi-cir^2):          0.00000000000e-000
ALPHA_3 (sec/semi-cir^3):          0.00000000000e-000
BETA_0 (sec):                      0.00000000000e-000
BETA_1 (sec/semi-cir):             0.00000000000e-000
BETA_2 (sec/semi-cir^2):           0.00000000000e-000
BETA_3 (sec/semi-cir^3):           0.00000000000e-000
PM_X (arc-sec):                    0.00000000000e-000
PM_X_DOT (arc-sec/day):            0.00000000000e-000
PM_Y (arc-sec):                    0.00000000000e-000
PM_Y_DOT (arc-sec/day):            0.00000000000e-000
DELTA_UT1 (sec):                   0.00000000000e-000
DELTA_UT1_DOT (sec/day):           0.00000000000e-000
Spare:                             0x000000000
*--- End of Message ---*
```

Type12

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        12
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
TOC (sec):                         3600
WN_OC:                             894
ISC_L1ME (sec):                    0.00000000000e-000
ISC_L2ME (sec):                    0.00000000000e-000
ISC_L1MS (sec):                    0.00000000000e-000
ISC_L2MS (sec):                    0.00000000000e-000
ISA_L2PY:                          0
ISA_L1ME:                          0
ISA_L2ME:                          0
ISA_L1MS:                          0
ISA_L2MS:                          0
Reserved:                          0x000000000000000000000000
*--- End of Message ---*
```

Type13

See Appendix B.

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Footer -*
Message ID:                        13
Alert Flags:                       00000
LM Config Slot 1:                  00000
LM Config Slot 2:                  00000
LM Config Slot 3:                  00000
Spare:                             0x000
TLM:                               0x00000
*- Data Block -*
320 Bits:                          0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
                                   0x00000000000000000000
*--- End of Message ---*
```

4.2.3 Category 3: MNAV PSI Data

The Category 3 "MNAV PSI Data" SDS package consists of the "MNAV PSI Data" data file, and the "MNAV PSI Data" descriptive file. The data file contains a time ordered sequence of 33 byte PSI data records, each record providing the data for interleaving one MNAV message. The descriptive file defines parameter values used to derive the PSI data (e.g., time, PRN, Key Designator, Data Rate, etc.). The Key Designator or Data Rate may change on any 48-second M-code epoch.

Category 3 data files may be used to interleave or deinterleave MNAV messages. That is, they can be used to support the conversion of 400 bit MNAV messages (e.g., SDS Category 4 file messages, or 400 bit messages produced by a simulator) into the 800 symbol version, or to recreate the 400 bit message sequence from an 800 symbol MNAV message sequence (e.g., Category 2 file). Note that PSI record content is time specific, so the same 400-bit message will usually be converted into a different 800-symbol message if implemented at two different times. Also note that a given Category 3 data file will only support one data rate at a time, even though the data rate may change during the file.

4.2.3.1 Category 3 Data File

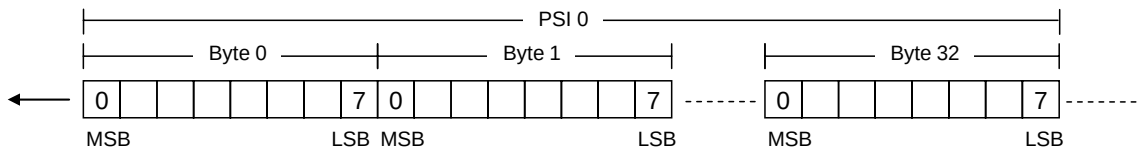
The "MNAV PSI Data" data file is a time ordered segment of the PSI data, stored in a binary file. A "MNAV PSI Data" data file contains the PSI data for only one PRN and frequency. It contains the PSI data at the 50 Hz low or 200 Hz high data rate to match the MNAV data.

4.2.3.1.1 Category 3 Data File Content

Data	Format	Description
Odd1	byte	Odd1 parameter
Row Index	byte[32]	32 Row Index parameters.

4.2.3.1.2 Category 3 Data File Format

Binary - Each record containing the parameters stored in 33 contiguous bytes. Odd1 is stored in byte 0, and Row Index 1-32 are stored in Bytes 1 to 32. The MSB is bit 0 of Byte 0, and is transmitted first



4.2.3.2 Category 3 Description File

The "MNAV PSI Data" description file is an ASCII file that provides all needed information about the data file. This information is provided in three sections: File Information, Events, and Messages. The File Information section includes start time of the file, duration, PRN, Type, and Link. This information is provided once at the beginning of the file. The Events section will include time of event, Key Designator, and Data Rate used in the generation of the PSI. This information is provided at the beginning of the file, and any other time an event occurs that changes any of these parameters. The Messages section contains the transmit time of the message, and the PSI values. The Events and Messages are interleaved in time ordered sequence. If an Event and Message have the same time tag, the Event will precede the Message.

4.2.3.2.1 Category 3 Description File Contents

4.2.3.2.1.1 File Information

Data	Format	Units	Description
--- Start of File Information ---			
GPS Week	int	week	GPS week corresponding to beginning of the data file
GPS Time	int	sec	GPS time of week corresponding to beginning of the data file
Duration	int	sec	Time interval spanned by the data file
PRN	int		PRN (1-63)
Type	string		Satellite, Pseudolite, or Simulator
Link ID	string		L1 and L2, Earth and Spot Beam (L1ME, L2ME, L1MS, L2MS)
--- End of File Information ---			

4.2.3.2.1.2 Events

Data	Format	Units	Description
--- Start of Event ---			
GPS Week	int	week	GPS week corresponding to Event
GPS Time	int	sec	GPS time of week corresponding to Event
Key Designator	string		AES Key# (AES000-999) or MNSA Key# (MNSA000-999) *** See NOTE 1 below**
Data Rate	string		MNAV data rate (HI, LO)
--- End of Event ---			

***NOTE 1**: The AES or MNSA Key Designator identifies the M-code keying material that must be loaded into equipment under test. Specific keys referenced by the Key Designators are defined separately from this document.

4.2.3.2.1.3 Messages

Data	Format	Units	Description
--- Start of Message ---			
GPS Week	int	week	Message Week Number
GPS Time	int	sec	Message Time
- Data Block -			
Odd 1	int		Interleaver variable
Row Index 1	int		Interleaver variable
Row Index 2	int		Interleaver variable
…			
Row Index 32	int		Interleaver variable
--- End of Message ---			

4.2.3.2.2 Category 3 Description File Format

The Category 3 Description file contains only ASCII characters. The “File Information”, “Events” and “Messages” sections of the Description file are in the format indicated by the following examples.

4.2.3.2.2.1 File Information

```
*--- Start of File Information ---*
GPS Week:                          894
GPS Time (sec):                    57600
Duration (sec):                    2400
PRN:                               1
Type:                              Satellite
Link ID:                           L1ME
*--- End of File Information ---*
```

4.2.3.2.2.2 Events

```
*--- Start of Event ---*
GPS Week:                          894
GPS Time (sec):                    57600
Key Designator:                    AES000
Data Rate:                         HI
*--- End of Event ---*
```

4.2.3.2.2.3 Messages

```
*--- Start of Message ---*
GPS Week:                          1100
GPS Time (sec):                    86400
*- Data Block -*
Odd1:                              0
Row Index 1:                       0
Row Index 2:                       0
…
Row Index 32:                      0
*--- End of Message ---*
```

4.2.4 Category 4: MNAV 400 Bit Message

The Category 4 “MNAV 400 Bit Messages” SDS package consists of the “MNAV 400 Bit Messages” data file, and the “MNAV 400 Bit Messages” descriptive file.

4.2.4.1 Category 4 Data File

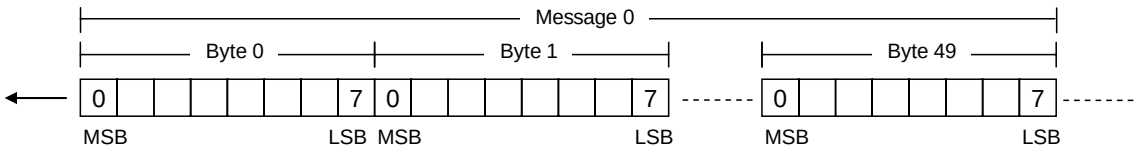
The “MNAV 400 Bit Messages” data file is a set of MNAV messages with CRC stored in a binary file. “MNAV 400 Bit Messages” data file contains the MNAV messages for only one PRN and frequency. Only one of each unique message is stored. Cutover information (i.e., recommended time to begin transmitting the message) is provided in the Description File. Data Rate and order of Message Type transmission is not provided in these files, however, messages are stored in increasing time order based on the cutover times.

4.2.4.1.1 Category 4 Data File Content

Data	Format	Description
MNAV 400	byte[50]	400 bits of MNAV data

4.2.4.1.2 Category 4 Data File Format

Binary - Each message is stored in 50 contiguous bytes, packed 8 symbols per byte. The MSB is bit 0 of Byte 0, and is transmitted first.



4.2.4.2 Category 4 Description File

The "MNAV 400 Symbol Messages" description file is an ASCII file that contains information about the data file. This information is provided in a single section: Messages. File Information and Events sections are not applicable for this category. The Messages section contains the cutover time of the message, and the description of message content. A file contains only one occurrence of each unique message.

Additional information on Category 4 description files is provided in Appendix B.

4.2.4.2.1 Category 4 Description File Content

4.2.4.2.1.1 File Information

N/A

4.2.4.2.1.2 Events

N/A

4.2.4.2.1.3 Messages

Data	Format	Units	Description
--- Start of Message ---			
GPS Week	int	week	Message Cutover Week Number
GPS Time	int	sec	Message Cutover Time
- Footer -			
Message Footer			See description 4.2.2.2.1.3.1
- Data Block -			
Message Type			See descriptions 4.2.2.2.1.3.2
--- End of Message ---			

4.2.4.2.2 Category 4 Description File Format

The Category 4 Description file contains only ASCII characters. The “Events” and “Messages” sections of the Description file are in the formats indicated below.

4.2.4.2.2.1 File Information

N/A

4.2.4.2.2.2 Events

N/A

4.2.4.2.2.3 Messages

The format of the Messages section is the same as for the MNAV 800 Symbol Description file Messages section, with the following exceptions. GPS Week and Time are used to define the cutover times, not message transmission times. The MNAV 800 Symbol Description file Messages section format is provided in paragraph 4.2.2.2.2.3.

Appendix A: Legacy Navigation Message Data Description

This appendix presents the current format and content of the three files containing the legacy Navigation Message data corresponding to the category 2 and 4 MNAV message stream. These files are identified by their extensions: .CON, .NAV, and .ALM. The formats of these files are expected to change, however the content will be maintained.

.CON file

A .CON file contains the satellite orbit and clock data used in subframes 1, 2, and 3 of the legacy Navigation Message.

General file description comments:

- Lines beginning "//" are comments, and contain no data.
- Descriptors in the format "<DEFINE_XXX>" begin a data section.
- Descriptors in the format "<END_XXX>" end a data section.
- Descriptors in the format "<XXX> #.#" define a value for a parameter.

The descriptors <DEFINE_VEHICLE_DATA> and <END_VEHICLE_DATA> bound the data for the satellite PRN specified by <ID>
The section beginning with <DEFINE_ORBITAL_PARAMETERS> and ending with <END_ORBITAL_PARAMETERS> contains one set of orbital data.
The section beginning with <DEFINE_CLOCK_DATA > and ending with <END_CLOCK_DATA > contains one set of clock data.
Both orbit and clock data contain a <DEFINE_CUTOVER_TIME> section for each set of data. This provides the initial time when the orbital and clock parameters data set are applicable.

```
//*********************************************************
//<FILE_NAME>   SV #1 sample .CON file
//<TYPE>  Vehicle orbital parameters / clock delay parameters
//<DESCRIPTION>
//
//<END_DESCRIPTION>
//*********************************************************

<DEFINE_VEHICLE_DATA>

  <ID> 1

  <DEFINE_ORBITAL_PARAMETERS>
    <DEFINE_CUTOVER_TIME>
      <GPS_TIME> 3600  <WEEK> 894  <EPOCH> 0
    <END_CUTOVER_TIME>
    <MEAN_ANOMOLY>      6.25696109304e-001   // semic
    <DELTA_N>           0.00000000000e+000   // semic/sec
    <ECCENTRICITY>      3.85475158691e-003   // unitless
    <SQRT_A>            5.15368505900e+003   // m**.5
    <OMEGA0>           -6.00456796585e-001   // semic
    <OMEGA_DOT>        -2.56113708019e-009   // semic/sec
    <I0>                3.03776550293e-001   // semic
    <I_DOT>             0.00000000000e+000   // semic/sec
```

```
    <W>                 -5.01070737838e-001    // semic
    <CUC>                0.00000000000e+000   // rad
    <CUS>                0.00000000000e+000    // rad
    <CRC>                0.00000000000e+000   // meter
    <CRS>                0.00000000000e+000   // meter
    <CIC>                0.00000000000e+000   // rad
    <CIS>                0.00000000000e+000   // radian
    <TOE>                           7200.0   // sec
    <WEEK>                             894   // week
  <END_ORBITAL_PARAMETERS>
  <DEFINE_CLOCK_DATA>
    <DEFINE_CUTOVER_TIME>
      <GPS_TIME> 3600  <WEEK> 894  <EPOCH> 0
    <END_CUTOVER_TIME>
    <TOC>                           7200.0   // sec
    <WEEK>                             894   // week
    <TGD>                0.00000000000e+000   // sec
    <AF0>                2.19345092773e-005   // sec
    <AF1>                0.00000000000e+000   // sec/sec
    <AF2>                0.00000000000e+000   // sec/sec**2
  <END_CLOCK_DATA>

  <DEFINE_ORBITAL_PARAMETERS>
    <DEFINE_CUTOVER_TIME>
      <GPS_TIME> 7200  <WEEK> 894  <EPOCH> 0
    <END_CUTOVER_TIME>
    <MEAN_ANOMOLY>       6.25696109304e-001   // semic
    <DELTA_N>            0.00000000000e+000   // semic/sec
    <ECCENTRICITY>       3.85475158691e-003   // unitless
    <SQRT_A>             5.15368505900e+003   // m**.5
    <OMEGA0>            -6.00456796585e-001   // semic
    <OMEGA_DOT>         -2.56113708019e-009   // semic/sec
    <I0>                 3.03776550293e-001   // semic
    <I_DOT>              0.00000000000e+000   // semic/sec
    <W>                 -5.01070737838e-001    // semic
    <CUC>                0.00000000000e+000   // rad
    <CUS>                0.00000000000e+000    // rad
    <CRC>                0.00000000000e+000   // meter
    <CRS>                0.00000000000e+000   // meter
    <CIC>                0.00000000000e+000   // rad
    <CIS>                0.00000000000e+000   // sec
    <TOE>                          14400.0   // sec
    <WEEK>                             894   // week
  <END_ORBITAL_PARAMETERS>
  <DEFINE_CLOCK_DATA>
    <DEFINE_CUTOVER_TIME>
      <GPS_TIME> 7200  <WEEK> 894  <EPOCH> 0
    <END_CUTOVER_TIME>
    <TOC>                          14400.0   // sec
    <WEEK>                             894   // week
    <TGD>                0.00000000000e+000   // sec
    <AF0>                2.19345092773e-005   // sec
    <AF1>                0.00000000000e+000   // sec/sec
    <AF2>                0.00000000000e+000   // sec/sec**2
  <END_CLOCK_DATA>

<END_VEHICLE_DATA>
```

.ALM file

The .ALM file contains the rough satellite orbit and clock data, and health data, to be inserted into subframes 4 and 5. The content of page 25 of subframes 4 and 5 is not included here, but can be found in the .NAV file section, which follows this section.

General file description comments:

- Lines beginning "*" are comments, and contain no data.
- "ID" is the satellite PRN

```
**** Week 894 almanac for SV-01 *************
ID:                         01
Health:                     000
Eccentricity:               3.85475158691E-03
Time of Applicability(s):   147456.000
Orbital Inclination(radian):   9.54342178733E-01
Rate of Right Ascen(r/s):  -8.04604943597E-09
SQRT(A) (m^1/2):            5153.685059
Right Ascen at TOA(radian):   -1.88751916766E+00
Argument of Perigee(radian):  -1.57416014892E+00
Mean Anom(radian):            -2.71030399319E+00
Af0(s):                     2.19345092773E-05
Af1(s/s):                   0.00000000000E+00
week:                       894

**** Week 894 almanac for SV-02 *************
ID:                         02
Health:                     000
Eccentricity:               1.67646408081E-02
Time of Applicability(s):   147456.0
Orbital Inclination(radian):   9.42477796077E-01
Rate of Right Ascen(r/s):  -8.12605276843E-09
SQRT(A) (m^1/2):            5153.630371
Right Ascen at TOA(radian):    1.40622895039E-01
Argument of Perigee(radian):  -2.36225251588E+00
Mean Anom(radian):            -6.94512423264E-01
Af0(s):                    -3.73840332031E-04
Af1(s/s):                  -3.63797880709E-12
week:                       894

**** Week 894 almanac for SV-03 *************
ID:                         03
Health:                     000
Eccentricity:               2.87532806396E-03
Time of Applicability(s):   147456.0
Orbital Inclination(radian):   9.52526568660E-01
Rate of Right Ascen(r/s):  -8.30891752834E-09
SQRT(A) (m^1/2):            5153.604004
Right Ascen at TOA(radian):    1.21908703934E+00
Argument of Perigee(radian):   2.51266689718E+00
Mean Anom(radian):             1.87687904848E+00
Af0(s):                     2.38418579102E-05
Af1(s/s):                   3.63797880709E-12
week:                       894
```

.NAV file

The .NAV file provides all the flags, and other miscellaneous parameters not provided in the .CON and .ALM files.

General file description comments:

- Lines beginning "//" are comments, and contain no data.
- Descriptors in the format "<DEFINE_XXX>" begin a data section.
- Descriptors in the format "<END_XXX>" end a data section.
- Descriptors in the format "<XXX> #.#" define a value for a parameter.
- Descriptors in the format "<XXX> "filename.txt"" defines a file with additional parameters.

The descriptors <DEFINE_BROADCAST_MESSAGE> and <END_BROADCAST_MESSAGE> bounds the navigation data set for a satellite.
The navigation data contains a <DEFINE_CUTOVER_TIME> section for each set of data. This provides the initial time when the navigation data set is applicable.

```
*******************************************************************************
//<FILE_NAME> Sample .NAV file
//<TYPE>        Navigation Message Definition File
//<DESCRIPTION>
//
//<END_DESCRIPTION>
//
*******************************************************************************

<DEFINE_BROADCAST_MESSAGE>
  <DEFINE_CUTOVER_TIME>
    <GPS_TIME> 3600  <WEEK> 894  <EPOCH> 0
  <END_CUTOVER_TIME>

  <DEFINE_ALMANAC>
   <FILE_NAME> "XXX.alm"
  <END_ALMANAC>

  <EPHEMERIS_CLOCK_DATA_FILE> "XXX.con"

  <WN> 894
  <IODC> 0
  <L2_P_DATA_FLAG> NAV_DATA
  <SV_ACCURACY> 1
  <SV_HEALTH> 0x00
  <L2_CODE> P_CODE
  <FIT_INTERVAL> 0 // 0 = 4 hrs; 1 = 6 hrs
  <IODE> 0

  <SPECIAL_MESSAGES> "Sample SDS data"

  <DEFINE_IONOSPHERIC_PARAMETERS>
    <ALPHA_0>   6.51925902231e-009   // Alpha0 (seconds)
    <ALPHA_1>   1.49011621938e-008   // Alpha1 (sec/semicircle)
    <ALPHA_2>  -5.96046457754e-008   // Alpha2 (sec/semicircle^2)
    <ALPHA_3>  -1.19209290551e-007   // Alpha3 (sec/semicircle^3)
    <BETA_0>    77824                // Beta0  (seconds)
    <BETA_1>    32768                // Beta1  (sec/semicircle)
    <BETA_2>   -65536                // Beta2  (sec/semicircle^2)
```

```
    <BETA_3>   -196608               // Beta3  (sec/semicircle^3)
  <END_IONOSPHERIC_PARAMETERS>

  <DEFINE_UTC_PARAMETERS>
    <A0>            0.000000e+000 // sec
    <A1>            0.000000e+000 // sec/sec
    <DELTA_T_ls>    0             // sec
    <DELTA_T_lsf>   0             // sec
    <TOT>           0             // sec
    <WN_t>          0             // week
    <WN_lsf>        0             // week
    <DN>            0             // days
  <END_UTC_PARAMETERS>

  <DEFINE_SV_HEALTH>
    <SV_ID>  1  0x00
    <SV_ID>  2  0x00
    <SV_ID>  3  0x00
    <SV_ID>  4  0x00
    <SV_ID>  5  0x3F
    <SV_ID>  6  0x00
    <SV_ID>  7  0x00
    <SV_ID>  8  0x3F
    <SV_ID>  9  0x00
    <SV_ID> 10  0x3F
    <SV_ID> 11  0x3F
    <SV_ID> 12  0x3F
    <SV_ID> 13  0x3F
    <SV_ID> 14  0x00
    <SV_ID> 15  0x00
    <SV_ID> 16  0x00
    <SV_ID> 17  0x00
    <SV_ID> 18  0x00
    <SV_ID> 19  0x00
    <SV_ID> 20  0x3F
    <SV_ID> 21  0x00
    <SV_ID> 22  0x3F
    <SV_ID> 23  0x00
    <SV_ID> 24  0x00
    <SV_ID> 25  0x00
    <SV_ID> 26  0x00
    <SV_ID> 27  0x00
    <SV_ID> 28  0x3F
    <SV_ID> 29  0x00
    <SV_ID> 30  0x3F
    <SV_ID> 31  0x00
    <SV_ID> 32  0x3F
  <END_SV_HEALTH>

  <DEFINE_SAAS>
    <SV_ID>  1  0x01
    <SV_ID>  2  0x01
    <SV_ID>  3  0x01
    <SV_ID>  4  0x01
    <SV_ID>  5  0x01
    <SV_ID>  6  0x01
    <SV_ID>  7  0x01
    <SV_ID>  8  0x01
    <SV_ID>  9  0x01
    <SV_ID> 10  0x01
```

```
    <SV_ID> 11  0x01
    <SV_ID> 12  0x01
    <SV_ID> 13  0x01
    <SV_ID> 14  0x01
    <SV_ID> 15  0x01
    <SV_ID> 16  0x01
    <SV_ID> 17  0x01
    <SV_ID> 18  0x01
    <SV_ID> 19  0x01
    <SV_ID> 20  0x01
    <SV_ID> 21  0x01
    <SV_ID> 22  0x01
    <SV_ID> 23  0x01
    <SV_ID> 24  0x01
    <SV_ID> 25  0x01
    <SV_ID> 26  0x01
    <SV_ID> 27  0x01
    <SV_ID> 28  0x01
    <SV_ID> 29  0x01
    <SV_ID> 30  0x01
    <SV_ID> 31  0x01
    <SV_ID> 32  0x01
  <END_SAAS>

  <DEFINE_NMC_TABLE>
    <AODO_TIME_OFFSET>   0x00  // 5 bits
    <AVAILABILITY_BITS>  0x00  // 2 bits
    <SV_ID>  2  0.0
    <SV_ID>  3  0.0
    <SV_ID>  4  0.0
    <SV_ID>  5  0.0
    <SV_ID>  6  0.0
    <SV_ID>  7  0.0
    <SV_ID>  8  0.0
    <SV_ID>  9  0.0
    <SV_ID> 10  0.0
    <SV_ID> 11  0.0
    <SV_ID> 12  0.0
    <SV_ID> 13  0.0
    <SV_ID> 14  0.0
    <SV_ID> 15  0.0
    <SV_ID> 16  0.0
    <SV_ID> 17  0.0
    <SV_ID> 18  0.0
    <SV_ID> 19  0.0
    <SV_ID> 20  0.0
    <SV_ID> 21  0.0
    <SV_ID> 22  0.0
    <SV_ID> 23  0.0
    <SV_ID> 24  0.0
    <SV_ID> 25  0.0
    <SV_ID> 26  0.0
    <SV_ID> 27  0.0
    <SV_ID> 28  0.0
    <SV_ID> 29  0.0
    <SV_ID> 30  0.0
    <SV_ID> 31  32.0
  <END_NMC_TABLE>

<END_BROADCAST_MESSAGE>
```

```
<DEFINE_BROADCAST_MESSAGE>
  <DEFINE_CUTOVER_TIME>
    <GPS_TIME> 7200  <WEEK> 894  <EPOCH> 0
  <END_CUTOVER_TIME>
  ...
<END_BROADCAST_MESSAGE>
```