**DCP Manual** **8500-0013 Revision 007**

# 3DM-GX3®-45 Data Communications Protocol

**Firmware Version 1.5.38 and higher**

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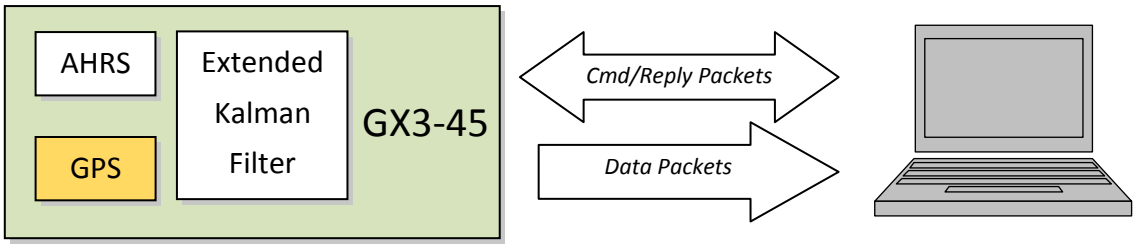
# 3DM-GX3-45 API

## API Introduction

The 3DM-GX3-45 programming interface is comprised of a compact set of setup and control commands and a very flexible user-configurable data output format. The commands and data are divided into 4 command sets and 3 data sets corresponding to the internal architecture of the device. The four command sets consist of a set of "Base" commands (a set that is common across many types of devices), a set of unified "3DM" (3D Motion) commands that are specific to the MicroStrain inertial product line, a set of "NAV" (Navigation) commands that are specific to MicroStrain navigation devices, and a set of "System" commands that are specific to sensor systems comprised of more than one internal sensor block. The three data sets represent the three types of data that the 3DM-GX3-45 is capable of producing: "AHRS" (Attitude and Heading Reference System) data, "GPS" (Global Positioning Sensor) data, and "NAV" (Navigation) data.

| | |
|---|---|
| **Base commands** | *Ping, Idle, Resume, Get ID Strings, etc.* |
| **3DM commands** | *Poll AHRS Data, Poll GPS Data, etc.* |
| **NAV commands** | *Reset Filter, Sensor to Vehicle Frame Transformation, etc.* |
| **System commands** | *Switch Communications Mode, etc.* |
| | |
| **AHRS data** | *Acceleration Vector, Gyro Vector, Euler Angles, etc.* |
| **GPS data** | *Latitude, Longitude, UTC, Satellites in view, etc.* |
| **NAV data** | *Position, Velocity, Attitude Estimates, etc.* |

The protocol is packet based. All commands, replies, and data are sent and received as fields in a message packet. The packets have a descriptor type field based on their contents, so it is easy to identify if a packet contains commands, replies, AHRS data, GPS data, or NAV data.




The 3DM-GX3-45 has an advanced mode switch that allows the device to switch into direct "AHRS" or "GPS" mode. In those modes, the device responds to the native protocols of the 3DM-GX3-25 AHRS or the u-blox5 GPS devices which are imbedded in the 3DM-GX3-45. These modes can be used to access advanced or specialized features of these devices (see the Advanced Programming section).

# Command and Data Summary

Below is a summary of the commands and data available in the programming interface. Commands and data are denoted by two values. The first value denotes the "descriptor set" that the command or data belongs to (Base command, 3DM command, AHRS data, or GPS data) and the second value denotes the unique command or data "descriptor" in that set.

## Commands

### Base Command Set (0x01)

- Ping (0x01, 0x01)
- Set To Idle (0x01, 0x02)
- Get Device Information (0x01, 0x03)
- Get Device Descriptor Sets (0x01, 0x04)
- Device Built-In Test (BIT) (0x01, 0x05)
- Resume (0x01, 0x06)
- Device Reset (0x01, 0x7E)

### 3DM Command Set (0x0C)

- Poll AHRS Data (0x0C, 0x01)
- Poll GPS Data (0x0C, 0x02)
- Poll NAV Data (0x0C, 0x03)
- Get AHRS Data Rate Base (0x0C, 0x06)
- Get GPS Data Rate Base (0x0C, 0x07)
- Get NAV Data Rate Base (0x0C, 0x0B)
- AHRS Message Format (0x0C, 0x08)
- GPS Message Format (0x0C, 0x09)
- NAV Message Format (0x0C, 0x0A)
- Enable/Disable Device Continuous Data Stream (0x0C, 0x11)
- Device Startup Settings (0x0C, 0x30)
- AHRS Signal Conditioning Settings (0x0C, 0x35)
- Change UART BAUD rate (0x0C, 0x40)
- Device Status* (0x0C, 0x64)

### Navigation Filter Command Set (0x0D)

- Reset Filter (0x0D, 0x01)
- Set Initial Attitude (0x0D, 0x02)
- Set Initial Heading (0x0D, 0x03)
- Set Initial Attitude from AHRS (0x0D, 0x04)
- Vehicle Dynamics Mode (0x0D, 0x10)
- Sensor to Vehicle Frame Transformation (0x0D, 0x11)
- Sensor to Vehicle Frame Offset (0x0D, 0x12)
- Antenna Offset (0x0D, 0x13)
- Bias Estimation Control (0x0D, 0x14)
- GPS Source Control (0x0D, 0x15)
- External GPS Update (0x0D, 0x16)

- External Heading Update (0x0D, 0x17)
- Heading Update Control (0x0D, 0x18)
- Auto-Initialization Control (0x0D, 0x19)
- Accelerometer White Noise Standard Deviation (0x0D, 0x1A)
- Gyroscope White Noise Standard Deviation (0x0D, 0x1B)
- Gyroscope Bias Model Parameters (0x0D, 0x1D)

### System Command Set (0x7F)

- Communication Mode* (0x7F, 0x10)

**Advanced Commands*

## Data

### AHRS Data Set (set 0x80)

- Scaled Accelerometer Vector (0x80, 0x04)
- Scaled Gyro Vector (0x80, 0x05)
- Scaled Magnetometer Vector (0x80, 0x06)
- Delta Theta Vector (0x80, 0x07)
- Delta Velocity Vector (0x80, 0x08)
- Orientation Matrix (0x80, 0x09)
- Quaternion (0x80, 0x0A)
- Euler Angles (0x80, 0x0C)
- GPS Correlated Timestamp (0x80, 0x12)

### GPS Data Set (set 0x81)

- LLH Position (0x81, 0x03)
- NED Velocity (0x81, 0x05)
- UTC Time (0x81, 0x08)
- GPS Time (0x81, 0x09)
- Hardware Status (0x81, 0x0D)

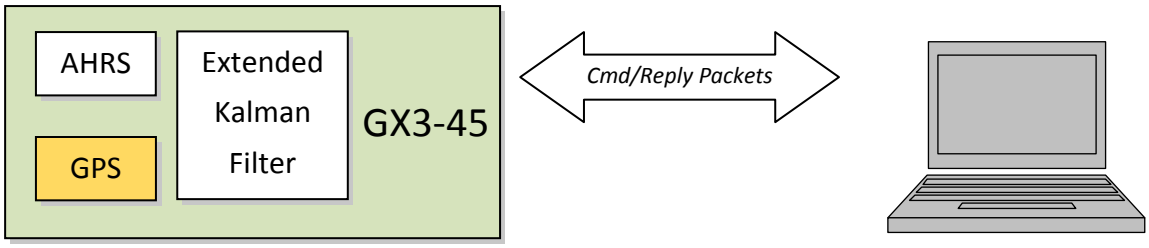
### NAV Data Set (set 0x82)

- Filter Status (0x82, 0x10)
- GPS Timestamp (0x82, 0x11)
- Estimated LLH Position (0x82, 0x01)
- Estimated NED Velocity (0x82, 0x02)
- Estimated Orientation, Quaternion (0x82, 0x03)
- Estimated Orientation, Matrix (0x82, 0x04)
- Estimated Orientation, Euler Angles (0x82, 0x05)
- Estimated Gyro Bias (0x82, 0x06)
- Estimated LLH Position Uncertainty (0x82, 0x08)
- Estimated NED Velocity Uncertainty (0x82, 0x09)
- Estimated Attitude Uncertainty, Euler Angles (0x82, 0x0A)
- Estimated Gyro Bias Uncertainty (0x82, 0x0B)

- Estimated Linear Acceleration (0x82, 0x0D)
- Estimated Angular Rate (0x82, 0x0E)
- WGS84 Local Gravity Magnitude (0x82, 0x0F)
- Estimated Attitude Uncertainty, Quaternion Elements (0x82, 0x12)
- Estimated Gravity Vector (0x82, 0x13)
- Heading Update Source State (0x82, 0x14)
- Magnetic Model Solution (0x82, 0x15)

## Basic Programming

The 3DM-GX3-45 is designed to stream NAV, AHRS, and GPS data packets over a common interface as efficiently as possible. To this end, programming the device consists of a configuration stage where the data messages and data rates are configured. The configuration stage is followed by a data streaming stage where the program starts the incoming data packet stream.




In this section there is an overview of the packet, an overview of command and reply packets, an overview of how an incoming data packet is constructed, and then an example setup command sequence that can be used directly with the 3DM-GX3-45 either through a COM utility or as a template for software development.

### MIP Packet Overview

This is an overview of the 3DM-GX3-45 packet structure. The packet structure used is the MicroStrain "MIP" packet. A reference to the general packet structure is presented in the MIP Packet Reference section. An overview of the packet is presented here.

The MIP packet "wrapper" consists of a four byte header and two byte checksum footer:

| Header | | | | Packet Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| *SYNC1 "u"* | *SYNC2 "e"* | *Descriptor Set byte* | *Payload Length byte* | *Field Length byte* | *Field Descriptor byte* | *Field Data* | *MSB* | *LSB* |
| **0x75** | **0x65** | **0x80** | **0x0E** | **0x0E** | **0x03** | **0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F** | **0x83** | **0xE1** |

Payload Length byte. This specifies the length of the packet payload. The packet payload may contain one or more fields and thus this byte also represents the sum of the lengths of all the fields in the payload.

Descriptor Set. Descriptors are grouped into different sets. The value 0x80 identifies this packet as an AHRS data packet. Fields in this packet will be from the AHRS data descriptor set.

Start of Packet (SOP) "sync" bytes. These are the same for every MIP packet and are used to identify the start of the packet.

2 byte Fletcher checksum of all the bytes in the packet.

The packet payload section contains one or more fields. Fields have a length byte, descriptor byte, and data. The diagram below shows a packet payload with a single field.

| Header | | | | Packet Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| *SYNC1 "u"* | *SYNC2 "e"* | *Descriptor Set byte* | *Payload Length byte* | *Field Length byte* | *Field Descriptor byte* | *Field Data* | *MSB* | *LSB* |
| 0x75 | 0x65 | 0x80 | 0x0E | **0x0E** | **0x06** | **0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F** | 0x86 | 0x08 |

Field Length byte. This represents a count of all the bytes in the field including the length byte, descriptor byte and field data.

Descriptor byte. This byte identifies the contents of the field data. This descriptor indicates that the data is a mag vector (set: 0x80, descriptor: 0x06)

Field data. The length of the data is Field Length – 2. This data is 12 bytes long (14 – 2) and represents the floating point magnetometer vector value from the AHRS data set.

Below is an example of a packet payload with two fields (gyro vector and mag vector). Note the payload length byte of 0x1C which is the sum of the two field length bytes 0x0E + 0x0E:

| Header | | | | Packet Payload (2 fields) | | | | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *SYNC1 "u"* | *SYNC2 "e"* | *Descriptor Set* | *Payload Length* | *Field1 Len* | *Field1 Descriptor* | *Field1 Data* | *Field2 Len* | *Field2 Descriptor* | *Field2 Data* | *MSB* | *LSB* |
| 0x75 | 0x65 | 0x80 | **0x1C** | **0x0E** | 0x05 | 0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F | **0x0E** | 0x06 | 0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F | 0xB1 | 0x1E |

## Command Overview

The basic command sequence begins with the host sending a command to the device. A command packet contains a field with the command value and any command arguments.

The device responds by sending a reply packet. The reply contains at minimum an ACK/NACK field. If any additional data is included in a reply, it appears as a second field in the packet.

### Example "Ping" Command Packet:

Below is an example of a "Ping" command packet from the Base command set. A "Ping" command has no arguments. Its function is to determine if a device is present and responsive:

| Header | | | | Packet Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| *SYNC1 "u"* | *SYNC2 "e"* | *Descriptor Set byte* | *Payload Length byte* | *Field Length byte* | *Field Descriptor byte* | *Field Data* | *MSB* | *LSB* |
| **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x01** | *N/A* | **0xE0** | **0xC6** |

*Copy-Paste version: "7565 0102 0201 E0C6"*

The packet header has the "ue" starting sync bytes characteristic of all MIP packets. The descriptor set byte (0x01) identifies the data as being from the Base command set. The length of the payload portion is 2 bytes. The payload portion of the packet consists of one field. The field starts with the length of the field which is followed by the descriptor byte (0x01) of the field. The field descriptor value *is* the command value. Here the descriptor identifies the command as the "Ping" command from the Base command descriptor set. There are no parameters associated with the ping command, so the field data is empty. The checksum is a two byte Fletcher checksum (see the MIP Packet Reference for instructions on how to compute a Fletcher two byte checksum).

### Example "Ping" Reply Packet:

The "Ping" command will generate a reply packet from the device. The reply packet will contain an ACK/NACK field. The ACK/NACK field contains an "echo" of the command byte plus an error code. An error code of 0 is an "ACK" and a non-zero error code is a "NACK":

| Header | | | | Packet Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| *SYNC1 "u"* | *SYNC2 "e"* | *Descriptor Set byte* | *Payload Length byte* | *Field Length byte* | *Field Descriptor byte* | *Field Data: 2 bytes* | *MSB* | *LSB* |
| **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo: **0x01**<br>Error code: **0x00** | **0xD5** | **0x6A** |

*Copy-Paste version: "7565 0104 04F1 0100 D56A"*

The packet header has the "ue" starting sync bytes characteristic of all MIP packets. The descriptor set byte (0x01) identifies the payload fields as being from the Base command set. The length of the payload portion is 4 bytes. The payload portion of the packet consists of one field. The field starts with the length of the field which is followed by the descriptor byte (0xF1) of the field. The field descriptor byte identifies the reply as the "ACK/NACK" from the Base command descriptor set. The field data consists of an "echo" of the original command (0x01) followed by the error code for the command (0x00). In this case the error is zero, so the field

represents an “ACK”. Some examples of non-zero error codes that might be sent are “timeout”, “not implemented”, and “invalid parameter in command”. The checksum is a two byte Fletcher checksum (see the MIP Packet Reference for instructions on how to compute a Fletcher two byte checksum).

*The ACK/NACK descriptor value (0xF1) is the same in all descriptor sets. The value belongs to a set of reserved global descriptor values.*

*The reply packet may have additional fields that contain information in reply to the command. For example, requesting Device Status will result in a reply packet that contains two fields in the packet payload: an ACK/NACK field and a device status information field.*

## Data Overview

Data packets are generated by the device. When the device is powered up, it may be configured to immediately stream data packets out to the host or it may be “idle” and waiting for a command to either start continuous data or to get data by “polling” (one data packet per request). Either way, the data packet is generated by the device in the same way.

### Example Data Packet:

Below is an example of a MIP data packet which has one field that contains the scaled accelerometer vector.

| Header | | | | Packet Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| *SYNC1 “u”* | *SYNC2 “e”* | *Descriptor Set byte* | *Payload Length byte* | *Field Length byte* | *Field Descriptor byte* | *Field Data: Accel vector (12 bytes, 3 float – X, Y, Z)* | *MSB* | *LSB* |
| **0x75** | **0x65** | **0x80** | **0x0E** | **0x0E** | **0x04** | **0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F** | **0x92** | **0xC0** |

*Copy-Paste version: “7565 800E 0E04 3E7A 63A0 BB8E 3B29 7FE5 BF7F 92C0”*

The packet header has the “ue” starting sync bytes characteristic of all MIP packets. The descriptor set byte (0x80) identifies the payload field as being from the AHRS data set. The length of the packet payload portion is 14 bytes (0x0E). The payload portion of the packet starts with the length of the field. The field descriptor byte (0x04) identifies the field data as the scaled accelerometer vector from the AHRS data descriptor set. The field data itself is three single precision floating point values of 4 bytes each (total of 12 bytes) representing the X, Y, and Z axis values of the vector. The checksum is a two byte Fletcher checksum (see the MIP Packet Reference for instructions on how to compute a Fletcher two byte checksum).

The format of the field data is fully and unambiguously specified by the descriptor. In this example, the field descriptor (0x04) specifies that the field data holds an array of three single precision IEEE-754 floating point numbers in big-endian byte order and that the values represent units of “g’s” and the order of the values is X, Y, Z vector order. Any other specification would require a different descriptor (see the Data Reference section of this manual).

*Each packet can contain any combination of data quantities from the same data descriptor set (any combination of GPS data OR any combination of AHRS data OR and combination of NAV data – you cannot combine GPS data, AHRS data, and NAV data in the same packet).*

*Data polling commands generate two individual reply packets: An ACK/NACK packet and a data packet. Enable/Disable continuous data commands generate an ACK/NACK packet followed by the continuous stream of data packets.*

*The AHR, GPS, and NAV data packets can be set up so that each data quantity is sent at a different rate. For example, you can setup continuous data to send the accelerometer vector at 100Hz and the magnetometer vector at 5Hz. This means that packets will be sent at 100Hz and each one will have the accelerometer vector but only every 20th packet will have the magnetometer vector. This helps reduce bandwidth and buffering requirements. An example of this is given in the AHRS Message Format command.*

## Example Setup Sequence

Setup involves a series of command/reply pairs. The example below demonstrates actual setup sequences that you can send directly to the 3DM-GX3-45 either programmatically or by using a COM utility. In most cases only minor alterations will be needed to adapt these examples for your application.

### Continuous Data Example Command Sequence

Most applications will operate with the 3DM-GX3-45 sending a continuous data stream. In the following example, the AHRS data format is set, followed by the NAV data format. GPS data will not be included as we will not be cross-checking against the navigation solution. To reduce the amount of streaming data, if present during the configuration, the device is placed into the idle state while performing the device initialization; when configuration is complete, the required data streams are enabled to bring the device out of idle mode. Finally, the configuration is saved so that it will be loaded on subsequent power-ups, eliminating the need to perform the configuration again.

#### *Step 1: Put the Device in Idle Mode (Disabling the AHRS, GPS, and NAV data-streams)*

Send the "Set To Idle" command to put the device in the idle state (reply is ACK/NACK). This is not required but reduces the parsing burden during initialization and makes visual confirmation of the commands easier:

| **Step 1** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Set to Idle* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x02** | N/A | **0xE1** | **0xC7** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x02**<br>Error code: **0x00** | **0xD6** | **0x6C** |

*Copy-Paste version of the command: "7565 0102 0202 E1C7"*

#### *Step 2: Configure the AHRS data-stream format*

Send a "Set AHRS Message Format" command (reply is ACK/NACK). This example requests scaled gyro, scaled accelerometer, and GPS Correlation Timestamp information at 100 Hz (100 Hz base rate, with a rate decimation of 1 on the GX3-45 = 100 Hz.) This will result in a single AHRS data packet sent at 100 Hz containing the scaled gyro field followed by the scaled accelerometer field followed by the AHRS GPS Correlation Timestamp. This is a very typical configuration for a base level of inertial data. If different rates were requested, then each packet would only contain the data quantities that fall in the same decimation frame (see the Multiple Rate Data section). If the stream was not disabled in the previous step, the AHRS data would begin stream immediately.

*Please note, this command will not append the requested descriptors to the current AHRS data-stream configuration, it will overwrite it completely:*

| **Step 2** | MIP Packet Header | Command/Reply Fields | Checksum |
|---|---|---|---|

| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
|---|---|---|---|---|---|---|---|---|---|
| *Command*<br>*New AHRS Message Format* | **0x75** | **0x65** | **0x0C** | **0x0D** | **0x0D** | **0x08** | Function: **0x01**<br>Desc count: **0x03**<br>1st Descriptor: **0x04**<br>Rate Dec: **0x0001**<br>2nd Descriptor:**0x05**<br>Rate Dec: **0x0001**<br>3rd Descriptor:**0x12**<br>Rate Dec: **0x0001** | **0x2A** | **0x35** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x08**<br>Error code: **0x00** | **0xE7** | **0xBA** |

*Copy-Paste version of the command: "7565 0C0D 0D08 0103 0400 0105 0001 1200 012A 35"*

### *Step 3: Configure the NAV data-stream format*

The following configuration command requests the Estimated LLH Position, Estimated NED Velocity, Estimated Orientation in Quaternion form, and Filter Status at 20 Hz (100Hz base rate, with a rate decimation of 5 = 20 Hz.) This will result in a single NAV packet sent at 20 Hz containing the requested fields in the requested order. If different rates were requested, the each packet would only contain the data quantities that fall in the same data rate frame (see the Multiple Rate Data section). If the stream was not disabled in the previous step, the NAV data would begin stream immediately.

*Please note, this command will not append the requested descriptors to the current NAV data-stream configuration, it will overwrite it completely.*

| **Step 3** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*New NAV Message Format* | **0x75** | **0x65** | **0x0C** | **0x10** | **0x10** | **0x0A** | Function: **0x01**<br>Desc Count: **0x04**<br>Est. Pos desc: **0x01**<br>Rate dec: **0x0005**<br>Est. Vel desc: **0x02**<br>Rate dec: **0x0005**<br>Est. Quat desc: **0x03**<br>Rate dec: **0x0005**<br>Filter Status desc: **0x10**<br>Rate dec: **0x0005** | **0x3F** | **0x31** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x0A**<br>Error code: **0x00** | **0xE9** | **0xBE** |

*Copy-Paste version of the command: "7565 0C10 100A 0104 0100 0502 0005 0300 0510 0005 3F31"*

### *Step 4: Save the AHRS and NAV MIP Message format*

To save the AHRS and NAV MIP Message format, use the "Save" function selector (0x03) in the AHRS and NAV Message Format commands. Below we've combined the two commands as two fields in the same packet. Notice that the two reply ACKs comes in one packet also. Alternatively, they could be sent as separate packets.

| **Step 4** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command field 1 Save Current AHRS Message Format* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0x08** | Function: **0x03** Desc count: **0x00** | | |
| *Command field 2 Save Current NAV Message Format* | | | | | **0x04** | **0x0A** | Function: **0x03** Desc count: **0x00** | **0x0E** | **0x31** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | Cmd echo: **0x08** Error code: **0x00** | | |
| *Reply field 2 ACK/NACK* | | | | | **0x04** | **0xF1** | Cmd echo: **0x0A** Error code: **0x00** | **0xEA** | **0x71** |

*Copy-Paste version of the command: "7565 0C08 0408 0300 040A 0300 0E31"*

### *Step 5: Enable the AHRS and NAV data-streams*

Send an "Enable/Disable Continuous Stream" command to enable the AHRS and NAV continuous streams (reply is ACK). These streams may have already been enabled by default, this step is to confirm they are enabled. These streams will begin streaming data immediately.

| **Step 5** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command field 1 Enable Continuous AHRS Message* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x05** | **0x11** | Fctn: **0x01** AHRS: **0x01** ON: **0x01** | | |
| *Command field 2 Enable Continuous NAV Message* | | | | | **0x05** | **0x11** | Fctn: **0x01** NAV: **0x03** ON: **0x01** | **0x24** | **0xCC** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | Cmd echo: **0x11** Error code: **0x00** | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Reply field 2 ACK/NACK* | | | | | **0x04** | **0xF1** | Cmd echo: **0x11** Error code: **0x00** | **0xFA** | **0xB5** |

*Copy-Paste version of the command: "7565 0C0A 0511 0101 0105 1101 0301 24 CC"*

### *Step 6 (Optional): Resume the Device*

Sending the "Resume" command is another method of re-enabling transmission of enabled data streams (reply is ACK/NACK).

| **Step 6** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Resume* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x06** | N/A | **0xE5** | **0xCB** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x06** Error code: **0x00** | **0xDA** | **0x74** |

*Copy-Paste version of the command: "7565 0102 0206 E5CB"*

### *Step 7: Initialize the Filter*

At this point in the set-up, the GX3-45 is streaming data, but the Kalman Filter is not yet initialized. For a successful initialization to occur, the GPS must have a fix and the initial orientation must be known. The orientation may be initialized in 4 different ways: Setting all of the attitude elements manually, setting only the heading and allowing the device to determine pitch and roll, using the internal AHRS solution (which requires the magnetometers) to provide the initial orientation, or via auto-initialization, which uses the chosen heading update source to initialize. In this example, we will assume the magnetometers are available and use the AHRS solution to initialize the Kalman Filter. Once the attitude is initialized and the GPS fix becomes valid, the Kalman Filter estimation will propagate:

| **Step 7** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Disable Continuous* | **0x75** | **0x65** | **0x0D** | **0x06** | **0x06** | **0x04** | Declination: 0.0 deg 0x00000000 | **0xF7** | **0xE9** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x04** Error code: **0x00** | **0xE4** | **0xB8** |

*Copy-Paste version of the command: "7565 0D06 0604 0000 0000 F7E9"*

### Polling Data Example Sequence

Polling for data is less efficient than processing a continuous data stream, but may be more appropriate for certain applications. The main difference from the continuous data example is the inclusion of the Poll data commands in the data loop:

***Step 1: Put the Device in Idle Mode (Disabling the AHRS, GPS, and NAV data-streams)***
Same as continuous streaming. See above.

***Step 2: Configure the AHRS data-stream format***
Same as continuous streaming. See above.

***Step 3: Configure the NAV data-stream format***
Same as continuous streaming. See above.

***Step 4: Save the AHRS and NAV MIP Message format***
Same as continuous streaming. See above.

***Step 5: Resume the Device***
Same as continuous streaming step 6. See above.

***Step 6: Initialize the Filter***
Same as continuous streaming step 7. See above.

***Step 7: Send individual data polling commands***
Send individual Poll AHRS Data and Poll NAV Data commands in your data collection loop. After the ACK/NACK is sent by the device, a single data packet will be sent according to the settings in the previous steps. Note that the ACK/NACK has the same descriptor set value as the command, but the data packet has the descriptor set value for the type of data (AHRS or NAV):

| **Step 5** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Poll AHRS Data* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x01** | Option: **0x00** Desc Count: **0x00** | **0xEF** | **0xDA** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | Cmd echo: **0x01** Error code: **0x00** | **0xE0** | **0xAC** |
| *AHRS Data Packet field 1 (Gyro Vector)* | **0x75** | **0x65** | **0x80** | **0x1C** | **0x0E** | **0x04** | **0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F** | | |
| *AHRS Data Packet field 2(Accel Vector)* | | | | | **0x0E** | **0x03** | **0x3E 7A 63 A0 0xBB 8E 3B 29 0x7F E5 BF 7F** | **0xAD** | **0xDC** |

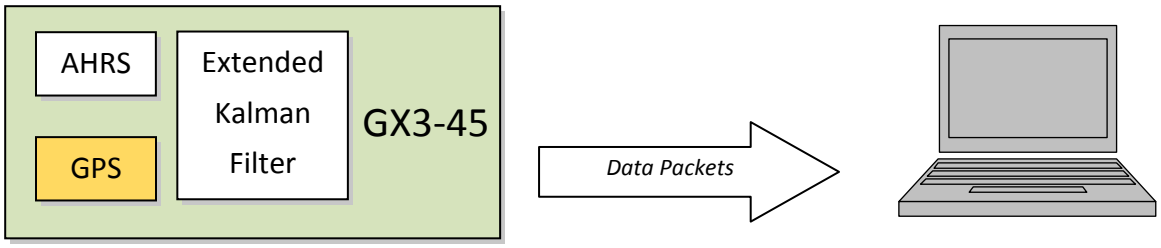
*Copy-Paste version of the command: "7565 0C04 0401 0000 EF DA"*

*You may specify the format of the data packet on a per-polling-command basis rather than using the pre-set data format (see the Poll AHRS Data and Poll NAV Data sections)*

*The polling command has an option to suppress the ACK/NACK in order to keep the incoming stream clear of anything except data packets. Set the option byte to 0x01 for this feature.*

## Parsing Incoming Packets

Setup is usually the easy part of programming the 3DM-GX3-45. Once you start continuous data streaming, parsing and processing the incoming data packet stream will become the primary focus. The stream of data from the AHRS and Kalman Filter (NAV) are usually the dominant source of data since they come in the fastest. Polling for data may seem to be a logical solution to controlling the data flow, and this may be appropriate for some applications, but if your application requires the precise delivery of inertial data, it is often necessary to have the data stream drive the process rather than having the host try to control the data stream through polling.




The "descriptor set" qualifier in the MIP packet header is a feature that greatly aids the management of the incoming packet stream by making it easy to sort the packets into logical sub-streams and route those streams to appropriate handlers. The first step is to parse the incoming character stream into packets.

It is important to take an organized approach to parsing continuous data. The basic strategy is this: parse the incoming stream of characters for the packet starting sequence "ue" and then wait for the entire packet to come in based on the packet length byte which arrives after the "ue" and descriptor set byte. Make sure you have a timeout on your wait loop in case your stream is out of sync and the starting "ue" sequence winds up being a "ghost" sequence. If you timeout, restart the parsing with the first character after the ghost "ue". Once the stream is in sync, it is rare that you will hit a timeout unless you have an unreliable communications link. After verifying the checksum, examine the "descriptor set" field in the header of the packet. This tells you immediately how to handle the packet.

Based on the value of the descriptor set field in the packet header, pass the packet to either a command handler (if it is a Base command or 3DM command descriptor set) or a data handler (if it is a GPS, AHRS, or NAV data set). Since you know beforehand that the AHRS and NAV data packets will be coming in fastest, you can tune your code to buffer or handle these packets at a high priority. Likewise, you know that the GPS packets will be coming in at a much lower rate but may have much more data to process. Again, you can tune your code to buffer or handle these slower packets appropriately. Replies to commands generally happen sequentially after a command so the incidence of these is under program control.

For multithreaded applications, it is often useful to use queues to buffer packets bound for different packet handler threads. The depth of the queue can be tuned so that no packets are dropped while waiting for their

associated threads to process the packets in the queue. See Advanced Programming Models section for more information on this topic.

Once you have sorted the different packets and sent them to the proper packet handler, the packet handler may parse the packet payload fields and handle each of the fields as appropriate for the application. For simple applications, it is perfectly acceptable to have a single handler for all packet types. Likewise, it is perfectly acceptable for a single parser to handle both the packet type and the fields in the packet. The ability to sort the packets by type is just an option that simplifies the implementation of more sophisticated applications.

## Multiple Rate Data

The message format commands (AHRS Message Format, GPS Message Format, and NAV Message Format) allow you to set different data rates for different data quantities. This is a very useful feature especially for AHRS data because some data, such as accelerometer and gyroscope data, usually requires higher data rates (100Hz) than other AHRS data such as Magnetometer (20Hz typical) data. The ability to send data at different rates reduces the parsing load on the user program and decreases the bandwidth requirements of the communications channel.

Multiple rate data is scheduled on a common sampling rate clock. This means that if there is more than one data rate scheduled, the schedules coincide periodically. For example, if you request Accelerometer data at 100Hz and Magnetometer data at 50Hz, the magnetometer schedule coincides with the Accelerometer schedule 50% of the time. When the schedules coincide, then the two data quantities are delivered in the same packet. In other words, in this example, you will receive data packets at 100Hz and every packet will have an accelerometer data field and EVERY OTHER packet will also include a magnetometer data field:

| *Packet 1* | *Packet 2* | *Packet 3* | *Packet 4* | *Packet 5* | *Packet 6* | *Packet 7* | *Packet 8* | …. |
|---|---|---|---|---|---|---|---|---|
| Accel | Accel Mag | Accel | Accel Mag | Accel | Accel Mag | Accel | Accel Mag | Accel |

If a timestamp is included at 100Hz, then the timestamp will also be included in every packet in this example. It is important to note that *the data in a packet with a timestamp is always synchronous with the timestamp.* This assures that multiple rate data is always synchronous.

| *Packet 1* | *Packet 2* | *Packet 3* | *Packet 4* | *Packet 5* | *Packet 6* | …. |
|---|---|---|---|---|---|---|
| Accel Timestamp | Accel Mag Timestamp | Accel Timestamp | Accel Mag Timestamp | Accel Timestamp | Accel Mag Timestamp | Accel Timestamp |

## Data Synchronicity

Because the MIP packet allows multiple data fields to be in a single packet, it may be assumed that a single timestamp field in the packet applies to all the data in the packet. In other words, it may be assumed that all the data fields in the packet were sampled at the same time.

AHRS, GPS, and NAV data are generated independently by three systems with different clocks. The importance of time is different in each system and the data they produce. The AHRS data requires precise microsecond resolution and perfectly regular intervals in its timestamps. GPS data produces very precise UTC interval data but it is typically delivered in a 1 second time frame. The Kalman Filter resides on a separate processor and must derive its timing information from the two data sources.

The time base difference is one of the factors that necessitate separation of the GPS, AHRS, and NAV data into separate packets. Conversely, the common time base of the different data quantities within one system is what allows grouping multiple data quantities into a single packet with a common timestamp. In other words, AHRS data is always grouped with a timestamp generated from the AHRS time base, and GPS data is always grouped with a timestamp from the GPS time base, etc.

In many applications, synchronizing the timestamps from the three system time bases is critical. MicroStrain uses an extended timestamp across its product line to allow synchronization of data sampled on different system clocks. This timestamp relies on a pulse per second (PPS) beacon signal. On the 3DM-GX3-45, this PPS signal is generated by the on board GPS. The timestamp of the AHRS data represents the interval in nanoseconds from the last PPS pulse. This allows proper time alignment of the GPS data with the AHRS data. On other systems, the PPS signal is applied externally by a system wide PPS beacon. The 3DM-GX3-45 can be the source of this beacon by picking off the PPS output on the multi-com connector.

A second form of synchronization exists which can be slightly less accurate, but easier to use in practice. All data streams (AHRS, GPS, and NAV) on the GX3-45 output a “GPS Time”-formatted timestamp. This timestamp is synchronized between the 3 devices using the GPS 1PPS hardware beacon. Due to the differences in clocks on each device, the period between two consecutive timestamp values may not be constant; this occurs because periodic corrections are applied to the AHRS and NAV timestamps when the GPS 1PPS signal is asserted.

## Communications Bandwidth Management

Because of the large amount and variety of data that is available from the 3DM-GX3-45, it is quite easy to overdrive the bandwidth of the communications channel. This can result in dropped packets. The 3DM-GX3-45 does not do analysis of the bandwidth requirements for any given output data configuration, it will simply drop a packet if its internal serial buffer is being filled faster than it is being emptied. It is up to the programmer to analyze the size of the data packets requested and the available bandwidth of the communications channel.

Often the best way to determine this is empirically by trying different settings and watching for dropped packets. Below are some guidelines on how to determine maximum bandwidth for your application.

**UART Bandwidth Calculation**

Below is an equation for the maximum theoretical UART BAUD rate for a given message configuration. Although it is possible to calculate the approximate bandwidth required for a given setup, there is no guarantee that the system can support that setup due to internal processing delays. The best approach is to try a setting based on an initial estimate and watch for dropped packets. If there are dropped packets, increase the BAUD rate, reduce the data rate, or decrease the size or number of packets.

$$\mathrm{n}(\mathrm{k} \times f_{mr}) + \mathrm{n} \sum \left(S_f \times f_{dr}\right)$$

Where

$$S_f = Size\ of\ data\ field\ in\ bytes$$
$$f_{dr} = field\ data\ rate\ in\ Hz$$
$$f_{mr} = maximum\ data\ rate\ in\ Hz$$
$$\mathrm{n} = size\ of\ UART\ word = 10bits$$
$$\mathrm{k} = Size\ of\ MIP\ wrapper = 6\ bytes$$

which becomes

$$60 f_{mr} + 10 \sum \left(S_f \times f_{dr}\right)$$

*Example:*
For an AHRS message format of Accelerometer Vector (14 byte data field) + Internal Timestamp (6 byte data field), both at 100 Hz, the theoretical minimum BAUD rate would be:

$$= 60 \times 100 + 10((14 \times 100) + (6 \times 100))$$

$$= 26000\ \mathrm{BAUD}$$

In practice, if you set the BAUD rate to 115200 the packets come through without any packet drops. If you set the BAUD rate to the next available lower rate of 19200, which is lower than the calculated minimum, you get regular packet drops. The only way to determine a packet drop is by observing a timestamp in sequential packets. The interval should not change from packet to packet. If it does change then packets were dropped.

**USB vs. UART**

The 3DM-GX3-45 has a dual communication interface: USB or UART. There is an important difference between USB and UART communication with regards to data bandwidth. The USB "virtual COM port" that the 3DM-GX3-45 implements runs at USB "full-speed" setting of 12Mbs (megabits per second). However, USB is a polled master-slave system and so the slave (3DM-GX3-45) can only communicate when polled by the master. This results in inconsistent data streaming – that is, the data comes in spurts rather than at a constant rate and, although rare, sometimes data can be dropped if the host processor fails to poll the USB device in a timely manner.

With the UART the opposite is true. The 3DM-GX3-45 operates without UART handshaking which means it streams data out at a very consistent rate without stopping. Since the host processor has no handshake method of pausing the stream, it must instead make sure that it can process the incoming packet stream non-stop without dropping packets.

In practice, USB and UART communications behave similarly on a Windows based PC, however, UART is the preferred communications system if consistent, deterministic communications timing behavior is required. USB is preferred if you require more data than is possible over the UART and you can tolerate the possibility of variable latency in the data delivery and very occasional packet drops due to host system delays in servicing the USB port.

# Command Reference

## Base Commands

The Base command set is common to many MicroStrain devices. With the Base command set it is possible to identify many properties and do basic functions on a device even if you do not recognize its specialized functionality or data. The commands work the same way on all devices that implement this set.

### Ping (0x01, 0x01)

| **Description** | Send a "Ping" command | | |
|---|---|---|---|
| **Notes** | Device responds with ACK/NACK packet if present. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x01 | N/A |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, non-zero: NACK) |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Ping* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x01** | | **0xE0** | **0xC6** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo: **0x01**<br>Error code: **0x00** | **0xD5** | **0x6A** |

*Copy-Paste version of the command: "7565 0102 0201 E0C6"*

### Set To Idle (0x01, 0x02)

| **Description** | Place device into idle mode. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | Command has no parameters. Device responds with ACK if successfully placed in idle mode. This command will suspend streaming (if enabled) or wake the device from sleep (if sleeping) to allow it to respond to status and setup commands. You may restore the device mode by issuing the Resume command. | | | | | | | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* | | | | | | |
| *Command* | 0x02 | 0x02 | N/A | | | | | | |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0: ACK, non-zero: NACK) | | | | | | |
| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Set To Idle* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x02** | | **0xE1** | **0xC7** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo: **0x02**<br>Error code: **0x00** | **0xD6** | **0x6C** |

*Copy-Paste version of the command: "7565 0102 0202 E1C7"*

### Resume (0x01, 0x06)

| **Description** | Place device back into the mode it was in before issuing the Set To Idle command. If the Set To Idle command was not issued, then the device is placed in default mode. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | Command has no parameters. Device responds with ACK if stream successfully enabled. | | | | | | | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* | | | | | | |
| *Command* | 0x02 | 0x06 | N/A | | | | | | |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0: ACK, non-zero: NACK) | | | | | | |
| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Set To Idle* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x06** | | **0xE5** | **0xCB** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo: **0x06**<br>Error code: **0x00** | **0xDA** | **0x74** |

*Copy-Paste version of the command: "7565 0102 0206 E5CB"*

### Get Device Information (0x01, 0x03)

| **Description** | Get the device ID strings and firmware version | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | Reply has two fields: “ACK/NACK” and “Device Info Field” | | | | | | | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* | | | | | | |
| *Command* | 0x02 | 0x03 | N/A | | | | | | |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0: ACK, non-zero: NACK) | | | | | | |
| *Reply field 2*<br>*Device Info Field* | 0x54 | 0x81 | *Binary Offset* | *Description* | *Data Type* | *Units* | | | |
| | | | 0 | Firmware Version | U16 | N/A | | | |
| | | | 2 | Model Name | String(16) | N/A | | | |
| | | | 18 | Model Number | String(16) | N/A | | | |
| | | | 34 | Serial Number | String(16) | N/A | | | |
| | | | 50 | Lot Number | String(16) | N/A | | | |
| | | | 66 | Device Options | String(16) | N/A | | | |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Get Device Info* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x03** | | **0xE2** | **0xC8** |
| *Reply Field 1*<br>*ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x58** | **0x04** | **0xF1** | Command echo: **0x03**<br>Error code: **0x00** | | |
| *Reply Field 2*<br>*Device Info Field* | | | | | **0x54** | **0x81** | FW Version: **0x05FE**<br>“ 3DM-GX3-45”<br>“ 6226-4220”<br>“ 6226-01319”<br>“ I042Y”<br>“ 5g, 300d/s” | **0x##** | **0x##** |

*Copy-Paste version of the command: “7565 0102 0203 E2C8”*

### Get Device Descriptor Sets (0x01, 0x04)

| **Description** | Get the set of descriptors that this device supports | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | Reply has two fields: "ACK/NACK" and "Descriptors". The "Descriptors" field is an array of 16 bit values. The MSB specifies the descriptor set and the LSB specifies the descriptor. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x02 | | 0x04 | | N/A | | | | |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command byte<br>U8 – error code (0: ACK, non-zero: NACK) | | | | |
| *Reply field 2*<br>*Array of Descriptors* | 2 x <Number of descriptors> + 2 | | 0x82 | | *Binary Offset* | *Description* | | *Data Type* | |
| | | | | | 0 | MSB: Descriptor Set<br>LSB: Descriptor | | U16 | |
| | | | | | 1 | MSB: Descriptor Set<br>LSB: Descriptor | | U16 | |
| | | | | | … | *<etc>* | | … | |
| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Get Device Info* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x04** | | **0xE3** | **0xC9** |
| *Reply Field 1*<br>*ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo:<br>**0x04**<br>Error code: **0x00** | | |
| *Reply Field 2*<br>*Array of Descriptors* | | | | | ***<n*2>+2*** | **0x82** | **0x0101**<br>**0x0102**<br>**0x0103**<br>**…**<br>**0x0C01**<br>**0x0C02**<br>**…**<br>*nth descriptor:*<br>**0x0C72** | **0x##** | **0x##** |

*Copy-Paste version of the command: "7565 0102 0204 E3C9"*

### Device Built-In Test (0x01, 0x05)

| | |
|---|---|
| **Description** | Run the device Built-In Test (BIT). The Built-In Test command always returns a 32 bit value. A value of 0 means that all tests passed. A non-zero value indicates that not all tests passed. The failure flags are device dependent. The flags for the 3DM-GX3-45 are defined below. |
| **Notes** | The BIT will take approximately 5 seconds to complete on the 3DM-GX3-45. The GPS power will be cycled during the test resulting in the temporary loss and subsequent recalculation of the position solution.<br><br>**3DM-GX3-45 BIT Error Flags:** |

| Byte | Byte 1 (LSB) | Byte 2 | Byte 3 | Byte 4 (MSB) |
|---|---|---|---|---|
| Device | AP-1 Processor | AHRS | GPS | Reserved |
| *Bit 1 (LSB)* | I2C Hardware Error | Communication Error | Communication Error | Reserved |
| *Bit 2* | I2C EEPROM Error | Reserved | 1PPS Signal Error | Reserved |
| *Bit 3* | Reserved | Reserved | 1 PPS Inhibit Error | Reserved |
| *Bit 4* | Reserved | Reserved | Power Control Error | Reserved |
| *Bit 5* | Reserved | Reserved | Reserved | Reserved |
| *Bit 6* | Reserved | Reserved | Reserved | Reserved |
| *Bit 7* | Reserved | Reserved | Reserved | Reserved |
| *Bit 8 (MSB)* | Reserved | Reserved | Reserved | Reserved |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x02 | 0x05 | N/A |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, non-zero: NACK) |
| *Reply field 2*<br>*BIT Error Flags* | 0x06 | 0x83 | U32 – BIT Error Flags |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Built-In Test* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x05** | N/A | **0xE4** | **0xCA** |
| *Reply field 1*<br>*ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x0A** | **0x04** | **0xF1** | *Echo cmd:* **0x05**<br>*Error code:* **0x00** | | |
| *Reply field 2*<br>*BIT Error Flags* | | | | | **0x06** | **0x83** | *BIT Error Flags:*<br>**0x00000000** | **0x68** | **0x7D** |

*Copy-Paste version of the command: "7565 0102 0205 E4CA"*

### Device Reset (0x01, 0x7E)

| **Description** | Resets the 3DM-GX3-45. | | |
|---|---|---|---|
| Notes | Device responds with ACK if it recognizes the command and then immediately resets. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x7E | N/A |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0: ACK, non-zero: NACK) |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Set Reset* | **0x75** | **0x65** | **0x01** | **0x02** | **0x02** | **0x7E** | *N/A* | **0x5D** | **0x43** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x01** | **0x04** | **0x04** | **0xF1** | Command echo: **0x7E**<br>Error code: **0x00** | **0x52** | **0x64** |

*Copy-Paste version of the command: "7565 0102 027E 5D43"*

## 3DM Commands

The 3DM command set is common to the MicroStrain Inertial sensors that support the MIP packet protocol. Because of the unified set of commands, it is easy to migrate code from one inertial sensor to another.

### Poll AHRS Data (0x0C, 0x01)

| **Description** | Poll the 3DM-GX3-45 for an AHRS message with the specified format | | |
|---|---|---|---|
| **Notes** | This function polls for an AHRS message using the provided format. The resulting message will maintain the order of descriptors sent in the command and any unrecognized descriptors are ignored. If the format is not provided, the device will attempt to use the stored format (set with the Set AHRS Message Format command.) If no format is provided and there is no stored format, the device will respond with a NACK. The reply packet contains an ACK/NACK field. The polled data packet is sent separately as an AHRS Data packet.<br><br>*Possible Option Selector Values:*<br>0x00 – Normal ACK/NACK Reply.<br>0x01 – Suppress the ACK/NACK reply. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 4 + 3*N | 0x01 | U8 – Option Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 Reserved) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Poll AHRS data (use stored format)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x01** | Option: **0x00**<br>Desc count: **0x00** | **0xEF** | **0xDA** |
| *Command*<br>*Poll AHRS data (use specified format)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x01** | Option: **0x00**<br>Desc count: **0x02**<br>1st Descriptor: **0x04**<br>Reserved: **0x0000**<br>2nd Descriptor:**0x05**<br>Reserved: **0x0000** | **0x06** | **0x27** |
| *Reply*<br>*ACK/NACK (Data packet is sent separately if ACK)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x01**<br>*Error code:* **0x00** | **0xE0** | **0xAC** |

*Copy-Paste versions of the commands:*
*Stored format: "7565 0C04 0401 0000 EFDA"*
*Specified format: "7565 0C0A 0A01 0002 0400 0005 0000 0627"*

### Poll GPS Data (0x0C, 0x02)

| **Description** | Poll the 3DM-GX3-45 for a GPS message with the specified format | | |
|---|---|---|---|
| **Notes** | This function polls for a GPS message using the provided format. The resulting message will maintain the order of descriptors sent in the command and any unrecognized descriptors are ignored. If the format is not provided, the device will attempt to use the stored format (set with the Set GPS Message Format command.) If no format is provided and there is no stored format, the device will respond with a NACK. The reply packet contains an ACK/NACK field. The polled data packet is sent separately as a GPS Data packet.<br><br>*Possible Option Selector Values:*<br>0x00 – Normal ACK/NACK Reply.<br>0x01 – Suppress the ACK/NACK reply. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 4 + 3*N | 0x02 | U8 – Option Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 Reserved) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Poll GPS data (use stored format)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x02** | Option: **0x00**<br>Desc count: **0x00** | **0xF0** | **0xDD** |
| *Command*<br>*Poll GPS data (use specified format)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x02** | Option: **0x00**<br>Desc count: **0x02**<br>1st Descriptor: **0x03**<br>Reserved: **0x0000**<br>2nd Descriptor:**0x05**<br>Reserved: **0x0000** | **0x06** | **0x2A** |
| *Reply*<br>*ACK/NACK (Data packet is sent separately if ACK)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x02**<br>*Error code:* **0x00** | **0xE1** | **0xAE** |

*Copy-Paste versions of the commands:*
*Stored format: "7565 0C04 0402 0000 F0DD"*
*Specified format: "7565 0C0A 0A02 0002 0300 0005 0000 062A"*

### Poll NAV Data (0x0C, 0x03)

| **Description** | Poll the 3DM-GX3-45 for a NAV message with the specified format | | |
|---|---|---|---|
| **Notes** | This function polls for a NAV message using the provided format. The resulting message will maintain the order of descriptors sent in the command and any unrecognized descriptors are ignored. If the format is not provided, the device will attempt to use the stored format (set with the Set NAV Message Format command.) If no format is provided and there is no stored format, the device will respond with a NACK. The reply packet contains an ACK/NACK field. The polled data packet is sent separately as a NAV Data packet.<br><br>*Possible Option Selector Values:*<br>0x00 – Normal ACK/NACK Reply.<br>0x01 – Suppress the ACK/NACK reply. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 4 + 3*N | 0x03 | U8 – Option Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 Reserved) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Poll NAV data (use stored format)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x03** | Option: **0x00**<br>Desc count: **0x00** | **0xF1** | **0xE0** |
| *Command*<br>*Poll NAV data (use specified format)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x03** | Option: **0x00**<br>Desc count: **0x02**<br>1st Descriptor: **0x01**<br>Reserved: **0x0000**<br>2nd Descriptor:**0x02**<br>Reserved: **0x0000** | **0x02** | **0x1E** |
| *Reply*<br>*ACK/NACK (Data packet is sent separately if ACK)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x03**<br>*Error code:* **0x00** | **0xE2** | **0xB0** |

*Copy-Paste versions of the commands:*
*Stored format: "7565 0C04 0403 0000 F1E0"*
*Specified format: "7565 0C0A 0A03 0002 0100 0002 0000 021E"*

### Get AHRS Data Rate Base(0x0C, 0x06)

| **Description** | Get the decimation base for the AHRS Data rate calculations | | |
|---|---|---|---|
| **Notes** | Returns the value used for data rate calculations. See the AHRS Message Format command.<br><br>*Most models of 3DM-GX3-45 have an AHRS Base Data Rate of 100. This is used for all the examples in this document. For a given device, this value stays constant.* | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x06 | *none* |
| *Reply field 1 ACK/NACK Field* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 Communications Mode* | 0x04 | 0x83 | U16-AHRS data rate decimation base |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | MSB | LSB |
| *Command Get Communications Mode* | **0x75** | **0x65** | **0x0C** | **0x02** | **0x02** | **0x06** | | **0xF0** | **0xF7** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | *Echo cmd:* **0x06**<br>*Error code:* **0x00** | | |
| *Reply field 2 Communication Mode* | | | | | **0x04** | **0x83** | Rate decimation base: **0x0064** | **0xD4** | **0x6B** |

*Copy-Paste version of the command: "7565 0C02 0206 F0F7"*

### Get GPS Data Rate Base(0x0C, 0x07)

| **Description** | Get the decimation base for the GPS Data rate calculations | | |
|---|---|---|---|
| **Notes** | Returns the value used for data rate calculations. See the GPS Message Format command.<br><br>*Most models of 3DM-GX3-45 have a GPS Base Data Rate of 4. This is used for all the examples in this document. For a given device, this value stays constant.* | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x07 | *none* |
| *Reply field 1 ACK/NACK Field* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 Communications Mode* | 0x04 | 0x84 | U16-GPS data rate decimation base |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | MSB | LSB |
| *Command Get Communications Mode* | **0x75** | **0x65** | **0x0C** | **0x02** | **0x02** | **0x07** | | **0xF1** | **0xF8** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | *Echo cmd:* **0x07**<br>*Error code:* **0x00** | | |
| *Reply field 2 Communication Mode* | | | | | **0x04** | **0x84** | Rate decimation base: **0x0004** | **0x76** | **0x14** |

*Copy-Paste version of the command: "7565 0C02 0207 F1F8"*

### Get NAV Data Rate Base (0x0C, 0x0B)

| **Description** | Get the decimation base for the NAV Data rate calculations | | |
|---|---|---|---|
| **Notes** | Returns the value used for data rate calculations. See the NAV Message Format command.<br><br>*Most models of 3DM-GX3-45 have a NAV Base Data Rate of 100. This is used for all the examples in this document. For a given device, this value stays constant.* | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x0B | *none* |
| *Reply field 1 ACK/NACK Field* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 Communications Mode* | 0x04 | 0x8A | U16- NAV data rate decimation base |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | MSB | LSB |
| *Command Get Communications Mode* | **0x75** | **0x65** | **0x0C** | **0x02** | **0x02** | **0x0B** | *N.A.* | **0xF5** | **0xFC** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | *Echo cmd:* **0x0B**<br>*Error code:* **0x00** | | |
| *Reply field 2 Communication Mode* | | | | | **0x04** | **0x8A** | Rate decimation base: **0x0064** | **0xE0** | **0x9E** |

*Copy-Paste version of the command: "7565 0C02 020B F5FC"*

### AHRS Message Format (0x0C, 0x08)

| | |
|---|---|
| **Description** | Set, read, or save the format of the AHRS message packet. This command sets the format for the AHRS data packet when in standard mode. The resulting data messages will maintain the order of descriptors sent in the command. The command has a function selector and a descriptor array as parameters. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>The rate decimation field is calculated as follows for AHRS messages:<br><br>Data Rate = 100Hz / Rate Decimation<br><br>The GX3-45 checks that all descriptors are valid prior to executing this command. If any of the descriptors are invalid for the AHRS descriptor set, a NACK will be returned and the message format will be unchanged. The descriptor array only needs to be provided if the function selector is = 1 (Use new settings). For all other functions it may be empty (Number of Descriptors = 0). |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 4 + 3*N | 0x08 | U8 - Function Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 3 + 3*N | 0x80 | U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command AHRS Message Format (use new settings)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x08** | Function: **0x01**<br>Desc count: **0x02**<br>1st Descriptor: **0x04**<br>Rate Dec: **0x000A**<br>2nd Descriptor:**0x05** | **0x22** | **0xA0** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Rate Dec: **0x000A** | | |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x08**<br>*Error code:* **0x00** | **0xE7** | **0xBA** |
| *Command*<br>*AHRS Message Format (read back current settings)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x08** | Function: **0x02**<br>Desc count: **0x00** | **0xF8** | **0xF3** |
| *Reply field 1*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x0D** | **0x04** | **0xF1** | *Echo cmd:* **0x08**<br>*Error code:* **0x00** | | |
| *Reply field 2*<br>*Current AHRS Message Format* | | | | | **0x09** | **0x80** | Desc count: **0x02**<br>1st Descriptor: **0x03**<br>Rate Dec: **0x000A**<br>2nd Descriptor:**0x04**<br>Rate Dec: **0x000A** | **0x98** | **0x0F** |

*Copy-Paste version of the commands:*
*Use New Settings: "7565 0C0A 0A08 0102 0400 0A05 000A 22A0"*
*Read Current Settings: "7565 0C04 0408 0200 F8F3"*

### GPS Message Format (0x0C, 0x09)

| | |
|---|---|
| **Description** | Set, read, or save the format of the GPS message packet. This function sets the format for the GPS MIP data packet when in standard mode. The resulting message will maintain the order of descriptors sent in the command. The command has a function selector and a descriptor array as parameters. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>The rate decimation field is calculated as follows for GPS messages:<br><br>*Data Rate = 4Hz / Rate Decimation*<br><br>The GX3-45 checks that all descriptors are valid prior to executing this command. If any of the descriptors are invalid for the GPS data descriptor set, a NACK will be returned and the message format will be unchanged. The descriptor array only needs to be provided if the function selector is = 1 (Use new settings). For all other functions it may be empty (Number of Descriptors = 0). |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 4 + 3*N | 0x09 | U8 - Function Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |
| *Reply field 1 ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 3 + 3*N | 0x81 | U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command GPS Message Format (use new settings)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x09** | Function: **0x01**<br>Desc count: **0x02**<br>1st Descriptor: **0x03**<br>Data rate: **0x0004**<br>2nd Descriptor:**0x05** | **0x16** | **0x85** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Data rate: **0x0004** | | |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x09**<br>*Error code:* **0x00** | **0xE8** | **0xBC** |
| *Command GPS Message Format (read back current settings)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x09** | Function: **0x02**<br>Desc count: **0x00** | **0xF9** | **0xF6** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x0D** | **0x04** | **0xF1** | *Echo cmd:* **0x09**<br>*Error code:* **0x00** | | |
| *Reply field 2 Current GPS Message Format* | | | | | **0x09** | **0x81** | Desc count: **0x02**<br>1st Descriptor: **0x03**<br>Data rate: **0x0004**<br>2nd Descriptor:**0x05**<br>Datarate: **0x0004** | **0x8D** | **0xFE** |

*Copy-Paste version of the commands:*
*Use New Settings: "7565 0C0A 0A09 0102 0300 0405 0004 1685"*
*Read Current Settings: "7565 0C04 0409 0200 F9F6"*

### NAV Message Format (0x0C, 0x0A)

| | |
|---|---|
| **Description** | Set, read, or save the format of the NAV message packet. This function sets the format for the NAV MIP data packet when in standard mode. The resulting message will maintain the order of descriptors sent in the command. The command has a function selector and a descriptor array as parameters. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>The rate decimation field is calculated as follows for NAV messages:<br><br>*Data Rate = 100Hz / Rate Decimation*<br><br>The GX3-45 checks that all descriptors are valid prior to executing this command. If any of the descriptors are invalid for the NAV data descriptor set, a NACK will be returned and the message format will be unchanged. The descriptor array only needs to be provided if the function selector is = 1 (Use new settings). For all other functions it may be empty (Number of Descriptors = 0). |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 4 + 3*N | 0x0A | U8 - Function Selector<br>U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |
| *Reply field 1 ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 3 + 3*N | 0x82 | U8 – Number of Descriptors (N),<br>N*(U8 – Descriptor, U16 – Rate Decimation) |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command NAV Message Format (use new settings)* | **0x75** | **0x65** | **0x0C** | **0x0A** | **0x0A** | **0x0A** | Function: **0x01**<br>Desc count: **0x02**<br>1st Descriptor: **0x01**<br>Data rate: **0x0001**<br>2nd Descriptor:**0x02** | **0x0C** | **0x6A** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Data rate: **0x0001** | | |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x0A**<br>*Error code:* **0x00** | **0xE9** | **0xBE** |
| *Command*<br>*NAV Message Format (read back current settings)* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0x0A** | Function: **0x02**<br>Desc count: **0x00** | **0xFA** | **0xF9** |
| *Reply field 1*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x0D** | **0x04** | **0xF1** | *Echo cmd:* **0x0A**<br>*Error code:* **0x00** | | |
| *Reply field 2*<br>*Current NAV Message Format* | | | | | **0x09** | **0x82** | Desc count: **0x02**<br>1st Descriptor: **0x01**<br>Data rate: **0x0001**<br>2nd Descriptor:**0x02**<br>Datarate: **0x0001** | **0x84** | **0xED** |

*Copy-Paste version of the commands:*
*Use New Settings: "7565 0C0A 0A0A 0102 0100 0102 0C6A"*
*Read Current Settings: "7565 0C04 040A 0200 FAF9"*

### Enable/Disable Continuous Data Stream (0x0C, 0x11)

| | |
|---|---|
| **Description** | Control the streaming of AHRS, GPS, and NAV data. If disabled, the data from the selected device is not continuously transmitted. Upon enabling, the most current data will be transmitted (i.e. no stale data is transmitted.) The default for the device is all streams enabled. For all functions except 0x01 (use new setting), the new enable flag value is ignored. |
| **Notes** | Possible function selector values:<br><br>0x01 – Apply new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Load factory default settings<br><br>*The device selector can be:*<br><br>0x01 – AHRS<br>0x02 – GPS<br>0x03 – NAV<br><br>*The enable flag can be either:*<br><br>0x00 – disable the selected stream.<br>0x01 – enable the selected stream. *(default)* |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x05 | 0x11 | U8 – Function Selector<br>U8 – Device Selector<br>U8 – New Enable Flag |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2*<br>*(function = 2)* | 0x04 | 0x85 | U8 – Device Selector<br>U8 – Current Device Enable Flag |

| **Examples** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*AHRS Stream ON* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (AHRS): **0x01**<br>Stream (ON): **0x01** | **0x04** | **0x1A** |
| *Command*<br>*AHRS Stream OFF* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (AHRS): **0x01**<br>Stream (OFF): **0x00** | **0x03** | **0x19** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Command*<br>*GPS Stream ON* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (GPS): **0x02**<br>Stream (ON): **0x01** | **0x05** | **0x1C** |
| *Command*<br>*GPS Stream OFF* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (GPS): **0x02**<br>Stream (OFF): **0x00** | **0x04** | **0x1B** |
| *Command*<br>*NAV Stream ON* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (NAV): **0x03**<br>Stream (ON): **0x01** | **0x06** | **0x1E** |
| *Command*<br>*NAV Stream OFF* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x11** | Function(Apply):**0x01**<br>Device (NAV): **0x03**<br>Stream (OFF): **0x00** | **0x05** | **0x1D** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0xF1** | *Echo cmd:* **0x11**<br>*Error code:* **0x00** | **0xEF** | **0xCA** |

*Copy-Paste version of the 1st command: "7565 0C05 0511 0101 0104 1A"*

**Device Startup Settings (0x0C, 0x30)**

| | |
|---|---|
| **Description** | Save, Load, or Reset to Default the values for all device settings. This is the equivalent of sending the same function selector to each of the following settings commands:<br><br>AHRS Message Format<br>GPS Message Format<br>NAV Message Format<br><br>Enable/Disable Continuous Data Stream<br>UART BAUD Rate<br>Communications Mode<br>AHRS Signal Conditioning Settings<br><br>Vehicle Dynamics Mode<br>Sensor to Vehicle Rotation<br>Sensor to Vehicle Offset<br>Antenna Offset<br>Bias Estimation Control<br>GPS Source Control<br>Heading Update Control<br>Auto-Initialization Control<br>Accel White Noise<br>Gyro White Noise<br>Gyro Bias Model |
| **Notes** | *Possible function selector values:*<br><br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Load factory default settings |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| Command | 0x02 | 0x30 | U8 –Function Selector |
| Reply<br>ACK/NACK | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Startup Settings*<br>*(Save All)* | **0x75** | **0x65** | **0x0C** | **0x03** | **0x03** | **0x30** | *Fctn(Save):***0x03** | **0x1F** | **0x45** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x30** *Error code:* **0x00** | **0x0F** | **0x0A** |

*Copy-Paste version of the command: "7565 0C03 0330 031F 45"*

### AHRS Signal Conditioning Settings (0x0C, 0x35)

| | |
|---|---|
| **Description** | Set, read, or save the AHRS signal conditioning parameters. This function sets the AHRS signal conditioning parameters for all communications and streaming modes. For all functions except 0x01 (use new settings), the new parameter values are ignored. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Apply new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Load factory default settings<br><br>*Possible Orientation Calculation Decimation values:*<br><br>0x0002 to 0x03E8 (2 to 1000): This value divided into 1000 will determine the rate at which coning & sculling integration, and orientation calculations are made (including Matrix, Euler, and Quaternion). For example, a value of 10 results in 1000/10 = 100Hz calculation rate. **Always o*verwritten to"0x000A" (10) on the GX3-45.***<br><br>*Possible Data Conditioning Flags:*<br><br>0x0001 – Enables Orientation Calculation (Matrix/Euler). **Always o*verwritten to"1"on the GX3-45.***<br>0x0002 – Enables Coning & Sculling. *Default is "1".* **Always o*verwritten to"1"on the GX3-45.***<br>0x0040 – Enables finite size correction. *Default is "0"*<br>0x0100 – Disables Magnetometer. *Default is "0"*<br>0x0400 – Disables "North" compensation. *Default is "0"*<br>0x0800 – Disables "Up" compensation. *Default is "0"*<br>0x1000 – Enables Quaternion calculation. **Always o*verwritten to"1"on the GX3-45.***<br><br>*Possible Gyro/Accel and Mag Filter Width values:*<br><br>0x01 to 0x20 (1 to 32): This value divided into 1000 determines the bandwidth of the adjustable filter. See the section on "AHRS Filtering" for more information. *Default is 15 for Accel/Gyro, 17 for Mag.* |

| | |
|---|---|
| | *Possible Up and North compensation values:*<br><br>0x0001 to 0x03E8 (1 to 1000): This value represents how quickly (in seconds) the gravitational /magnetometer vectors correct the inertial attitude/yaw orientation results. *Default is 10 (seconds) for both values.*<br><br>*Possible Mag Power/Bandwidth values:*<br><br>0: High bandwidth, highest power consumption<br>1: Bandwidth is coupled to Data Rate; low power consumption.<br>*Default is "1"* |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x10 | 0x35 | U8 – Function Selector<br>U16 – New Orientation Calc Decimation Value<br>U16 – New Data Conditioning Flags<br>U8 – New Accel/Gyro Filter Width<br>U8 – New Mag Filter Width<br>U16 – New Up Compensation<br>U16 – New North Compensation<br>U8 – New Mag Bandwidth/Power<br>U16 - *Reserved* |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2*<br>*( function = 2)* | 0x0F | 0x86 | U16 – Current Orientation Decimation Value<br>U16 – Current Data Conditioning Flags<br>U8 – Current Accel/Gyro Filter Width<br>U8 – Current Mag Filter Width<br>U16 – Current Up Compensation<br>U16 – Current North Compensation<br>U8 – Current Mag Bandwidth/Power<br>U16 - *Reserved* |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*GPS Settings* | **0x75** | **0x65** | **0x0C** | **0x10** | **0x10** | **0x35** | *Fctn (Apply):* **0x01**<br>*Calc Decimation (100Hz):* **0x000A**<br>*Flags(def):***0x0003**<br>*Acc/GyroFilt:***0x0E**<br>*Mag Filter:* **0x11**<br>*Up Comp:* **0x000A**<br>*N Comp:* **0x000A**<br>*Mag BW:***0x01**<br>*Reserved:***0x0000** | **0x7D** | **0xB7** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x35**<br>*Error code:* **0x00** | **0x14** | **0x14** |

*Copy-Paste version of the command: "7565 0C10 1035 0100 0A00 030E 1100 0A00 0A01 0000 7DB7"*

### UART BAUD Rate (0x0C, 0x40)

| | | | |
|---|---|---|---|
| **Description** | Change, read, or save the BAUD rate of the main communication channel (UART1).<br>For all functions except 0x01 (use new settings), the new BAUD rate value is ignored. | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>*Supported BAUD rates are:*<br><br>9600, 19200, 115200 *(default)*, 230400, 460800, 921600 | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x07 | 0x40 | U8 – Function Selector<br>U32 –New BAUD rate |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2*<br>*(function = 2)* | 0x06 | 0x87 | U32 – Current BAUD rate |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command*<br>*Set BAUD Rate Command* | **0x75** | **0x65** | **0x0C** | **0x07** | **0x07** | **0x40** | *Fctn(USE):***0x01**<br>*BAUD (115200)*:<br>**0x0001C200** | **0xF8** | **0xDA** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x40**<br>*Error code:* **0x00** | **0x1F** | **0x2A** |

*Copy-Paste version of the command: "7565 0C07 0740 0100 01C2 00F8 DA"*

### Device Status (0x0C, 0x64)

| | | | |
|---|---|---|---|
| **Description** | Get the device-specific status for the 3DM-GX3-45 | | |
| **Notes** | Reply has two fields: "ACK/NACK" and "Device Status Field". The device status field may be one of two selectable formats – basic and diagnostic.<br><br>The reply data for this command is device specific. The reply is specified by two parameters in the command. The first parameter is the model number (which for the 3DM-GX3-45 is always = 6228 (0x1854)). That is followed by a status selector byte which determines the type of data structure returned. In the case of the 3DM-GX3-45, there are two selector values – one to return a basic status structure and a second to return an extensive diagnostics status structure. A list of available values for the selector values and specific fields in the data structure are as follows:<br><br>*Possible Status Selector Values:*<br><br>0x01 – Basic Status Structure<br><br>*Possible Communication Mode Values:*<br><br>0x01 – Standard MIP Mode<br>0x02 – Advanced AHRS Direct Mode<br>0x03 – Advanced GPS Direct Mode<br><br>*Possible Communication Device Values:*<br><br>0x01 - Com1 (Serial)<br>0x02 - USB<br><br>*Possible Settings Flags:*<br><br>0x00000001 – AHRS Continuous Stream Enabled<br>0x00000100 – GPS Continuous Stream Enabled<br>0x00010000 – NAV Continuous Stream Enabled<br><br>*Possible Com1 State, USB State, GPS Driver State, GPS Port State, AHRS Driver State, AHRS Port State Values:*<br><br>0x00 – Not Initialized<br>0x01 – Initialized | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x02 | 0x64 | U16-Device Model Number: set = 6228 (0x1854)<br>U8-Status Selector |
| *Reply field 1* | 0x04 | 0xF1 | U8 – echo the command byte |

| *ACK/NACK Field* | | | U8 – error code (0:ACK, not 0:NACK) | | | |
|---|---|---|---|---|---|---|
| | 0x11 | 0x90 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Echo of the Device Model Number | U16 | N/A |
| | | | 2 | Echo of the selector byte | U8 | N/A |
| | | | 3 | Communication Mode | U8 | See Notes |
| | | | 4 | Communication Device | U8 | See Notes |
| | | | 5 | Settings Flags | U32 | See Notes |
| | | | 9 | Com 1 State | U16 | See Notes |
| | | | 11 | Com1 Baudrate | U32 | Baud |

| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | MSB | LSB |
| *Command Get Device Status (return Basic Status structure: selector = 1)* | **0x75** | **0x65** | **0x0C** | **0x05** | **0x05** | **0x64** | Model # (6228): **0x1854** Status Selector (basic status): **0x01** | **0xC1** | **0x51** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x15** | **0x04** | **0xF1** | *Echo cmd:* **0x64** *Error code:* **0x00** | | |
| *Reply field 2 Device Status (Basic Status structure)* | | | | | **0x11** | **0x90** | Echo Model#: **0x1854** Echo Selector: **0x01** U8: U8: U32: U16: U32: | **0x##** | **0x##** |

*Copy-Paste version of the command: "7565 0C05 0564 1852 01BF 4D"*

## Navigation Filter Commands

The Navigation Filter command set is specific to MicroStrain Inertial Navigation sensors.

### Reset Filter (0x0D, 0x01)

| **Description** | Reset the filter to the initialize state. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | If the auto-initialization feature is disabled, the initial attitude or heading must be set in order to enter the run state after a reset. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x02 | | 0x01 | | N/A | | | | |
| *Reply*<br>*ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command byte<br>U8 – error code (0:ACK, non-zero: NACK) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x02** | **0x02** | **0x01** | | **0xEC** | **0xF6** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x01**<br>*Error code:* **0x00** | **0xE1** | **0xB2** |

*Copy-Paste version of the command: "7565 0D02 0201 ECF6"*

### Set Initial Attitude (0x0D, 0x02)

| **Description** | Set the initial attitude. | | |
|---|---|---|---|
| **Notes** | This command can only be issued in the "INIT" state and should be used with a good estimate of the vehicle attitude. The Euler Angles are the sensor body frame with respect to the local NED frame. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x0E | 0x02 | Float – Roll (radians)<br>Float – Pitch (radians)<br>Float – Heading (radians) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0E** | **0E** | **02** | *Roll:* 0x00000000 (**0.0f)**<br>*Pitch:* 0x00000000 (**0.0f)**<br>*Heading:* 0x00000000 (**0.0f)** | **0x05** | **0x6F** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x02**<br>*Error code:* **0x00** | **0xE2** | **0xB4** |

*Copy-Paste version of the command: "7565 0D0E 0E02 0000 0000 0000 0000 0000 0000 0000 0000 056F"*

### Set Initial Heading (0x0D, 0x03)

| **Description** | Set the initial heading angle. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | This command can only be issued in the "INIT" state and should be used with a good estimation of Heading. The GX3-45 will use this value in conjunction with the output of the accelerometers to determine the initial attitude estimate. The Euler Angles are the sensor body frame with respect to the local NED frame. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x06 | | 0x03 | | Float – Heading (radians) | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x06** | **0x06** | **0x03** | *Heading:* 0x00000000 (**0.0f)** | **0xF6** | **0xE4** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x03**<br>*Error code:* **0x00** | **0xE3** | **0xB6** |

*Copy-Paste version of the command: "7565 0D06 0603 0000 0000 F6E4"*

### Set Initial Attitude From AHRS (0x0D, 0x04)

| **Description** | Set the initial attitude using the embedded AHRS. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | This command can only be issued in the "INIT" state. The GX3-45 will use the on-board AHRS unit to initialize the attitude. The user must supply a declination angle for the local magnet field conditions<br><br>***Special Note:*** The AHRS uses a magnetometer to determine heading. In the presence of significant magnetic interference, this value can be wildly off, causing the filter to go unstable. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x06 | | 0x04 | | Float – Declination Angle (radians) | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x06** | **0x06** | **0x04** | *Declination:* 0x00000000 (**0.0f)** | **0xF7** | **0xE9** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x04**<br>*Error code:* **0x00** | **0xE4** | **0xB8** |

*Copy-Paste version of the command: "7565 0D06 0604 0000 0000 F7E9"*

### Vehicle Dynamics Mode (0x0D, 0x10)

| | |
|---|---|
| **Description** | Set, read, or save the vehicle dynamics mode. For all functions except 0x01 (use new settings), the new dynamics mode value is ignored. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Apply new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Load factory default settings<br><br>*Possible Modes:* |

| Mode | Use | Altitude Limits | Velocity Limits |
|---|---|---|---|
| 0x01 – Portable (default) | Applications with low acceleration | 12,000 m | Horizontal - 310 m/s<br>Vertical - 50 m/s |
| 0x02 – Automotive | Low vertical acceleration, wheeled-vehicle dynamics | 6000 m | Horizontal - 84 m/s<br>Vertical - 15 m/s |
| 0x03 – Airborne | Typical airborne application | 50,000 m | Horizontal - 250 m/s<br>Vertical - 100 m/s |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x04 | 0x10 | U8 – Function Selector<br>U8 – New Dynamics Mode |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 3 | 0x80 | U8 –Current Dynamics Mode |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command Dynamics Mode* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0x10** | *Fctn (Apply):* **0x01**<br>*Mode (Portable):* **0x01** | **0x01** | **0x10** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x10**<br>*Error code:* **0x00** | **0xF0** | **0xD0** |

*Copy-Paste version of the command: "7565 0C04 0410 0101 0110"*

### Sensor to Vehicle Frame Transformation (0x0D, 0x11)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Set the sensor to vehicle frame transformation matrix using Roll, Pitch, and Yaw Euler angles. These angles define the rotation *from* the sensor body frame *to* the fixed vehicle frame. Please reference the GX3-45 Theory of Operation for more information. | | | | | | | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>This transformation affects the following output quantities:<br><br>NAV:<br>Estimated Orientation, Quaternion<br>Estimated Orientation, Matrix<br>Estimated Orientation, Euler Angles<br>Estimated Linear Acceleration<br>Estimated Angular Rate<br>Estimated Gravity Vector | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x0F | | 0x11 | | U8 – Function Selector<br>Float – Roll Angle (radians)<br>Float – Pitch Angle (radians)<br>Float – Yaw Angle (radians) | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| *Reply field 2 (function = 2)* | 0x0E | | 0x81 | | Float – Roll Angle (radians)<br>Float – Pitch Angle (radians)<br>Float – Yaw Angle (radians) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x0F** | **0x11** | *Fctn (Apply):* **0x01**<br>*Roll:* 0x00000000 (**0.0f**)<br>*Pitch:* 0x00000000 | **0x17** | **0x72** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (**0.0f)**<br>*Yaw:* 0x00000000<br>(**0.0f)** | | |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x11**<br>*Error code:* **0x00** | **0xF1** | **0xD2** |

*Copy-Paste version of the command: "7565 0D0F 0F11 0100 0000 0000 0000 0000 0000 0017 72"*

### Sensor to Vehicle Frame Offset (0x0D, 0x12)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Set the sensor to vehicle frame offset, expressed in the sensor frame. Please reference the GX3-45 Theory of Operation for more information. | | | | | | | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>This offset affects the following output quantities:<br>Estimated LLH Position<br><br>The maximum value for any axis is +-100 meters. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x0F | | 0x12 | | U8 – Function Selector<br>Float – X (meters, sensor body frame)<br>Float – Y (meters, sensor body frame)<br>Float – Z (meters, sensor body frame) | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| *Reply field 2 (function = 2)* | 0x0E | | 0x82 | | Float – X (meters, sensor body frame)<br>Float – Y (meters, sensor body frame)<br>Float – Z (meters, sensor body frame) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x0F** | **0x12** | *Fctn (Apply):* **0x01**<br>*X:* 0x00000000 (**0.0f)**<br>*Y:* 0x00000000 (**0.0f)**<br>*Z:* 0x00000000 (**0.0f)** | **0x18** | **0x80** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x12**<br>*Error code:* **0x00** | **0xF2** | **0xD4** |

*Copy-Paste version of the command: "7565 0D0F 0F12 0100 0000 0000 0000 0000 0000 0018 80"*

### Antenna Offset (0x0D, 0x13)

| **Description** | Set the sensor to antenna offset, expressed in the sensor frame. |
|---|---|
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>This offset affects the following output quantities:<br>Estimated LLH Position<br><br>A maximum value of +-10 meters for any axis is recommended. |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x0F | 0x13 | U8 – Function Selector<br>Float – X (meters, sensor body frame)<br>Float – Y (meters, sensor body frame)<br>Float – Z (meters, sensor body frame) |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 0x0E | 0x83 | Float – X (meters, sensor body frame)<br>Float – Y (meters, sensor body frame)<br>Float – Z (meters, sensor body frame) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x0F** | **0x13** | *Fctn (Apply):* **0x01**<br>*X:* 0x00000000 (**0.0f)**<br>*Y:* 0x00000000 (**0.0f)**<br>*Z:* 0x00000000 (**0.0f)** | **0x19** | **0x8E** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x13**<br>*Error code:* **0x00** | **0xF3** | **0xD6** |

*Copy-Paste version of the command: "7565 0D0F 0F13 0100 0000 0000 0000 0000 0000 0019 8E"*

**Bias Estimation Control (0x0D, 0x14)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Control the calculation of sensor biases. | | | | | | | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>*Possible control bitfield values:*<br><br>Bit 0 (0x00000001) – Gyro bias estimate (1 – enable, 0 – disable) | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x05 | | 0x14 | | U8 – Function Selector<br>U16 – Control Bitfield | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| *Reply field 2 (function = 2)* | 0x04 | | 0x84 | | U16 – Control Bitfield | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x05** | **0x05** | **0x14** | *Fctn (Apply):* **0x01**<br>*X:* 0x0001 (**Enable Gyro Bias Estimation)** | **0x07** | **0x2B** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x14**<br>*Error code:* **0x00** | **0xF4** | **0xD8** |

*Copy-Paste version of the command: "7565 0D05 0514 0100 0107 2B"*

### GPS Source Control (0x0D, 0x15)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Control the source of GPS information used to update the Kalman Filter. | | | | | | | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>*Possible GPS Source values:*<br><br>0x01 – Internal GPS<br>0x02 – External GPS (Requires user to provide GPS information via the "External GPS Update" command)<br><br>Changing the GPS source while the sensor is in the "running" state will temporarily place it back in the "init" state until the new source of GPS data is received. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x04 | | 0x15 | | U8 – Function Selector<br>U8 – GPS Source | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| *Reply field 2 (function = 2)* | 0x03 | | 0x86 | | U8 – GPS Source | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0x15** | *Fctn (Apply):* **0x01**<br>*Source:* 0x02<br>(**External GPS)** | **0x07** | **0x20** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x15**<br>*Error code:* **0x00** | **0xF5** | **0xDA** |

*Copy-Paste version of the command: "7565 0D04 0415 0102 0720"*

### External GPS Update (0x0D, 0x16)

| **Description** | Trigger a filter update step using external GPS information. | | |
|---|---|---|---|
| **Notes** | GPS source control must be set to external for this command to update the filter; it will be ignored/NACK'd otherwise. | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x48 | 0x16 | Double – GPS Time of Week (seconds)<br>U16 – GPS Week Number<br>Double – Latitude (deg)<br>Double – Longitude (deg)<br>Double – Altitude above WGS84 Ellipsoid (m)<br>Float – North Velocity (m/s)<br>Float – East Velocity (m/s)<br>Float – Down Velocity (m/s)<br><br>Float – North Position Uncertainty (m, 1-sigma)<br>Float – East Position Uncertainty (m, 1-sigma)<br>Float – Down Position Uncertainty (m, 1-sigma)<br><br>Float – North Velocity Uncertainty (m/s, 1-sigma)<br>Float – East Velocity Uncertainty (m/s, 1-sigma)<br>Float – Down Velocity Uncertainty (m/s, 1-sigma) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **48** | **48** | **16** | *GPS Tow:* **0.0d**<br>*GPS Week: 0x0000*<br>*Latitude:* **0.0d**<br>*Longitude:* **0.0d**<br>*Height:* **0.0d**<br>*Vel North:* **0.0f**<br>*Vel East:* **0.0f**<br>*Vel Down:* **0.0f**<br>*Pos Sigma (N)* **0.0f**<br>*Pos Sigma (E)* **0.0f**<br>*Pos Sigma (D)* **0.0f**<br>*Vel Sigma (N)* **0.0f**<br>*Vel Sigma (E)* **0.0f**<br>*Vel Sigma (D)* **0.0f** | **0xXX** | **0xXX** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x16**<br>*Error code:* **0x00** | **0xF6** | **0xDC** |

*Copy-Paste version of the command: N/A*

### External Heading Update (0x0D, 0x17)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Trigger a filter update step using external heading information<br><br>***The heading must be the sensor frame with respect to the NED frame.*** | | | | | | | | |
| **Notes** | Angle uncertainties of 0.0 will be NACK'd.<br><br>Possible Heading Type Commands:<br><br>0x01 – True Heading<br>0x02 – Magnetic Heading*<br><br>*Note: if the GPS is unavailable, magnetic heading updates will be NACK'd. This happens because the on-board magnetic model cannot be run without GPS updates. | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x0B | | 0x16 | | Float – Heading Angle (radians, true north, +- PI)<br>Float – Heading Angle Uncertainty (radians, 1-sigma)<br>U8 – Heading type (1 – true, 2 – magnetic) | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command byte<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0B** | **0B** | **17** | *Angle:* **0.0f**<br>*Angle Sigma:* **0.01f**<br>Heading Type: **0x01** (True) | **0xXX** | **0xXX** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x17**<br>*Error code:* **0x00** | **0xF7** | **0xDE** |

*Copy-Paste version of the command: N/A*

### Heading Update Control (0x0D, 0x18)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | Select the source for heading updates to the Kalman Filter. | | | | | | | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>*Possible Enable Flag values:*<br><br>0x00 – Disable Heading Updates<br>0x01 – Use the Magnetometer for Heading Updates*<br>0x02 – Use the Internal GPS Velocity Vector for Heading Updates**<br>0x03 – Use external heading updates<br><br>*The magnetometer inclination angle (dip angle) is calculated and tested against the World Magnetic Model value. When an error of 30 degrees or more is detected, the heading is marked as invalid and is not used by the filter.<br><br>**To use the Internal GPS velocity vector for heading updates, the target application must have no (or minimal) side-slip; this is true in most ground vehicle applications. *Additionally, when this option is selected, the X-axis must be co-aligned with the direction of travel of the vehicle.* | | | | | | | | |
| **Field Format** | *Field Length* | | *Field Descriptor* | | *Field Data* | | | | |
| *Command* | 0x04 | | 0x18 | | U8 – Function Selector<br>U8 – Enable Flag | | | | |
| *Reply ACK/NACK* | 0x04 | | 0xF1 | | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) | | | | |
| *Reply field 2 (function = 2)* | 0x03 | | 0x87 | | U8 – Enable Flag | | | | |
| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0x18** | *Fctn (Apply):* **0x01**<br>*Enable:* 0x01<br>(**Enable Mag. Updates)** | **0x09** | **0x28** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x18**<br>*Error code:* **0x00** | **0xF8** | **0xE0** |

*Copy-Paste version of the command: "7565 0D04 0418 0101 0928"*

### Auto-Initialization Control (0x0D, 0x19)

| | |
|---|---|
| **Description** | Enable/Disable automatic initialization upon device startup. |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>*Possible Enable Flag values:*<br><br>0x00 – Disable auto-initialization<br>0x01 – Enable auto-initialization*<br><br>*A heading update source must be selected in order for the sensor to auto-initialize. The filter will initialize the roll and pitch angles using the AHRS estimation, heading from the heading update source, and position and velocity from the selected GPS source. Attitude initialization takes approximately 5 seconds; whereas, GPS initialization can be shorter or longer, depending on the state of the GPS during initialization. |

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x04 | 0x19 | U8 – Function Selector<br>U8 – Enable Flag |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 0x03 | 0x88 | U8 – Enable Flag |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0x19** | *Fctn (Apply):* **0x01**<br>*Enable:* 0x01<br>**(Enable auto-initialization)** | **0x0A** | **0x2B** |
| *Reply* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x19** | **0xF9** | **0xE2** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *ACK/NACK* | | | | | | | *Error code:* **0x00** | | |

*Copy-Paste version of the command: "7565 0D04 0419 0101 0A2B"*

### Accelerometer White Noise Standard Deviation (0x0D, 0x1A)

| **Description** | Set the expected accelerometer white noise 1-sigma values. This function can be used to tune the filter performance in the target application. | | |
|---|---|---|---|
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>Each of the noise values must be greater than 0.0 | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x0F | 0x1A | U8 – Function Selector<br>Float – X Accel Noise 1-sigma (meters/second^2)<br>Float – Y Accel Noise 1-sigma (meters/second^2)<br>Float – Z Accel Noise 1-sigma (meters/second^2) |
| *Reply ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2 (function = 2)* | 0x0E | 0x89 | Float – X Accel Noise 1-sigma (meters/second^2)<br>Float – Y Accel Noise 1-sigma (meters/second^2)<br>Float – Z Accel Noise 1-sigma (meters/second^2) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x0F** | **0x1A** | *Fctn (Apply):* **0x01**<br>*X:* (**0.02f)**<br>*Y:* (**0.02f)**<br>*Z:* (**0.02f)** | **0x60** | **0xA3** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x1A**<br>*Error code:* **0x00** | **0xFA** | **0xE4** |

*Copy-Paste version of the command: "7565 0D0F 0F01 1A01 3CA3 D70A 3CA3 D70A 3CA3 D760 A3"*

### Gyroscope White Noise Standard Deviation (0x0D, 0x1B)

| | | | |
|---|---|---|---|
| **Description** | Set the expected gyroscope white noise 1-sigma values. This function can be used to tune the filter performance in the target application. | | |
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>Each of the noise values must be greater than 0.0 | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x0F | 0x1B | U8 – Function Selector<br>Float – X Gyro Noise 1-sigma (rad/second)<br>Float – Y Gyro Noise 1-sigma (rad/second)<br>Float – Z Gyro Noise 1-sigma (rad/second) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2*<br>*(function = 2)* | 0x0E | 0x8A | Float – X Gyro Noise 1-sigma (rad/second)<br>Float – Y Gyro Noise 1-sigma (rad/second)<br>Float – Z Gyro Noise 1-sigma (rad/second) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x0F** | **0x1B** | *Fctn (Apply):* **0x01**<br>*X:* (**0.0000539f)**<br>*Y:* (**0.0000539f)**<br>*Z:* (**0.0000539f)** | **0xDE** | **0xE8** |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x1B**<br>*Error code:* **0x00** | **0xFB** | **0xE6** |

*Copy-Paste version of the command: "7565 0D0F 0F1B 013A 0D4B AD3A 0D4B AD3A 0D4B ADDE E8"*

### Gyroscope Bias Model Parameters (0x0D, 0x1D)

| **Description** | Set the gyroscope bias model parameters. | | |
|---|---|---|---|
| **Notes** | *Possible function selector values:*<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>Each of the noise values must be greater than 0.0 | | |
| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
| *Command* | 0x1B | 0x1D | U8 – Function Selector<br>Float – X Gyro Bias Beta (1/second)<br>Float – Y Gyro Bias Beta (1/second)<br>Float – Z Gyro Bias Beta (1/second)<br>Float – X Gyro Bias Noise 1-sigma (rad /second)<br>Float – Y Gyro Bias Noise 1-sigma (rad /second)<br>Float – Z Gyro Bias Noise 1-sigma (rad /second) |
| *Reply*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |
| *Reply field 2*<br>*(function = 2)* | 0x1A | 0x8C | Float – X Gyro Bias Beta (1/second)<br>Float – Y Gyro Bias Beta (1/second)<br>Float – Z Gyro Bias Beta (1/second)<br>Float – X Gyro Bias Noise 1-sigma (rad /second)<br>Float – Y Gyro Bias Noise 1-sigma (rad /second)<br>Float – Z Gyro Bias Noise 1-sigma (rad /second) |

| **Example** | *MIP Packet Header* | | | | *Fields* | | | *Checksum* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command* | **0x75** | **0x65** | **0x0D** | **0x0F** | **0x1B** | **0x1D** | *Fctn (Apply):* **0x01**<br>*X Beta:* (**0.01f)**<br>*Y Beta:* (**0.01f)**<br>*Z Beta:* (**0.01f)**<br>*X Noise:* (**0.00016f)**<br>*Y Noise:* (**0.00016f)**<br>*Z Noise:* (**0.** | **0xXX** | **0xXX** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **00016f)** | | |
| *Reply*<br>*ACK/NACK* | **0x75** | **0x65** | **0x0D** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x1D**<br>*Error code:* **0x00** | **0xFD** | **0xEA** |

*Copy-Paste version of the command: N/A*

## System Commands

The System Command set provides a set of advanced commands that are specific to devices such as the 3DM-GX3-35 that have multiple intelligent internal sensor blocks. These commands allow special mode such as talking directly to the native protocols of the embedded sensor blocks. For example, with the 3DM-GX3-35, you may switch into a mode that talks directly to the internal u-blox chip or directly to the embedded 3DM-GX3-25 AHRS. This allows you to use code or utilities written specifically for the native u-blox protocols (NMEA or UBX) and 3DM-GX3-25 protocols (original single byte commands or ASPP packet protocol).

### Communication Mode (0x7F, 0x10)

Advanced

<table>
<tr><td>Description</td><td>Set, read, or save the device communication mode. This will change the communications protocol to and from “NAV” mode to “AHRS Direct” (3DM-GX3-25 protocols) or “GPS Direct” (u-blox5 protocols). This command is always active, even when switched to the direct modes. This command responds with an ACK/NACK just prior to switching to the new protocol. For all functions except 0x01 (use new settings), the new communications mode value is ignored.</td></tr>
<tr><td>Notes</td><td>Possible function selector values:<br><br>0x01 – Use new settings<br>0x02 – Read back current settings.<br>0x03 – Save current settings as startup settings<br>0x04 – Load saved startup settings<br>0x05 – Reset to factory default settings<br><br>Possible Communications Modes:<br><br><table><tr><th>Value</th><th>Mode</th><th>Protocol(s)</th></tr><tr><td>0x01</td><td>NAV</td><td>3DM-GX3-45 MIP Packet (default)</td></tr><tr><td>0x02</td><td>AHRS Direct</td><td>3DM-GX3-25 Single Byte, ASPP</td></tr><tr><td>0x03</td><td>GPS Direct</td><td>NMEA, UBX</td></tr></table><br>IMPORTANT: GPS message settings are automatically reloaded (see Advanced GPS Startup Settings) when switching from direct modes back into standard mode.<br><br>Note: Switching to and from GPS Direct Mode takes longer than most commands to complete due to the amount of GPS setup data that needs to be stored/retrieved.</td></tr>
</table>

| **Field Format** | *Field Length* | *Field Descriptor* | *Field Data* |
|---|---|---|---|
| *Command* | 0x04 | 0x10 | U8 –Function Selector<br>U8 –New Communications Mode |
| *Reply field 1*<br>*ACK/NACK* | 0x04 | 0xF1 | U8 – echo the command descriptor<br>U8 – error code (0:ACK, not 0:NACK) |

| *Reply field 2 ( function = 2)* | 0x03 | | 0x90 | | U8 –Current Communications Mode | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Example** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Field Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command COM Mode* | **0x75** | **0x65** | **0x7F** | **0x04** | **0x04** | **0x10** | *Fctn(USE)*:**0x01** New mode (*AHRS Direct)*: **0x02** | **0x74** | **0xBD** |
| *Reply ACK/NACK* | **0x75** | **0x65** | **0x7F** | **0x04** | **0x04** | **0xF1** | *Echo cmd:* **0x10** *Error code:* **0x00** | **0x62** | **0x7C** |

*Copy-Paste version of the command: "7565 7F04 0410 0102 74BD"*

# Data Reference

## AHRS Data

### Scaled Accelerometer Vector (0x80, 0x04)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Scaled Accelerometer Vector | | | | | |
| **Notes** | This is a vector quantifying the direction and magnitude of the acceleration that the 3DM-GX3® is exposed to. This quantity is derived from Raw Accelerometer, but is fully temperature compensated and scaled into physical units of *g* (1 *g* = 9.80665 m/sec^2). It is expressed in terms of the 3DM-GX3®'s local coordinate system. | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x04 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Accel | float | g |
| | | | 4 | Y Accel | float | g |
| | | | 8 | Z Accel | float | g |

### Scaled Gyro Vector (0x80, 0x05)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Scaled Gyro Vector | | | | | |
| **Notes** | This is a vector quantifying the rate of rotation (angular rate) of the 3DM-GX3®. This quantity is derived from the Raw Angular Rate quantities, but is fully temperature compensated and scaled into units of radians/second. It is expressed in terms of the 3DM-GX3®'s local coordinate system in units of radians/second. | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x05 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Gyro | float | Radians/second |
| | | | 4 | Y Gyro | float | Radians/second |
| | | | 8 | Z Gyro | float | Radians/second |

### Scaled Magnetometer Vector (0x80, 0x06)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Scaled Mag Vector | | | | | |
| **Notes** | This is a vector which gives the instantaneous magnetometer direction and magnitude. It is fully temperature compensated and is expressed in terms of the 3DM-GX3®'s local coordinate system in units of Gauss. | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x06 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Mag | float | Gauss |
| | | | 4 | Y Mag | float | Gauss |
| | | | 8 | Z Mag | float | Gauss |

### Delta Theta Vector (0x80, 0x07)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Time integral of angular rate. | | | | | |
| **Notes** | This is a vector which gives the time integral of Angular Rate where the limits of integration are the beginning and end of the calculation cycle at 100Hz. It is expressed in terms of the 3DM-GX3®'s local coordinate system in units of radians. | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x07 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Delta Theta | float | radians |
| | | | 4 | Y Delta Theta | float | radians |
| | | | 8 | Z Delta Theta | float | radians |

### Delta Velocity Vector (0x80, 0x08)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Time integral of velocity. | | | | | |
| **Notes** | This is a vector which gives the time integral of *Accel* where the limits of integration are the beginning and end of the calculation cycle at 100Hz. It is expressed in terms of the 3DM-GX3®'s local coordinate system in units of g*second where g is the standard gravitational constant. To convert Delta Velocity into the more conventional units of m/sec, simply multiply by the standard gravitational constant, 9.80665 m/sec^2 | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x08 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Delta Velocity | float | g*seconds |
| | | | 4 | Y Delta Velocity | float | g*seconds |
| | | | 8 | Z Delta Velocity | float | g*seconds |

### Orientation Matrix (0x80, 0x09)

<table>
<tr><td>Description</td><td colspan="5">3 x 3 Orientation Matrix M</td></tr>
<tr><td>Notes</td><td colspan="5">This is a 9 component coordinate transformation matrix which describes the orientation of the 3DM-GX3® with respect to the fixed earth coordinate system.<br><br>$$M = \begin{bmatrix} M_{1,1} & M_{1,2} & M_{1,3} \\ M_{2,1} & M_{2,2} & M_{2,3} \\ M_{3,1} & M_{3,2} & M_{3,3} \end{bmatrix}$$<br><br>M satisfies the following equation:<br><br>$V\_IL_i = M_{ij} \cdot V\_E_j$<br><br>Where: V_IL is a vector expressed in the 3DM-GX3®'s local coordinate system.<br>V_E is the same vector expressed in the stationary, earth-fixed coordinate system</td></tr>
<tr><td rowspan="11">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="10">38 (0x26)</td><td rowspan="10">0x09</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>$M_{11}$</td><td>float</td><td>n/a</td></tr>
<tr><td>4</td><td>$M_{12}$</td><td>float</td><td>n/a</td></tr>
<tr><td>8</td><td>$M_{13}$</td><td>float</td><td>n/a</td></tr>
<tr><td>12</td><td>$M_{21}$</td><td>float</td><td>n/a</td></tr>
<tr><td>16</td><td>$M_{22}$</td><td>float</td><td>n/a</td></tr>
<tr><td>20</td><td>$M_{23}$</td><td>float</td><td>n/a</td></tr>
<tr><td>24</td><td>$M_{31}$</td><td>float</td><td>n/a</td></tr>
<tr><td>28</td><td>$M_{32}$</td><td>float</td><td>n/a</td></tr>
<tr><td>32</td><td>$M_{33}$</td><td>float</td><td>n/a</td></tr>
</table>

### Orientation Quaternion (0x80, 0x0A)

<table>
<tr><td>Description</td><td colspan="5">4 x 1 quaternion Q.</td></tr>
<tr><td>Notes</td><td colspan="5">This is a 4 component quaternion which describes the orientation of the 3DM-GX3 with respect to the fixed earth coordinate quaternion.<br><br>$$Q = \begin{bmatrix} q0 \\ q1 \\ q2 \\ q3 \end{bmatrix}$$<br><br>Q satisfies the following equation:<br><br>V_ILi = Q • V_E • Q-1<br><br>Where: V_IL is a vector expressed in the 3DM-GX3®'s local coordinate system.<br>V_E is the same vector expressed in the stationary, earth-fixed coordinate system</td></tr>
<tr><td rowspan="6">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="5">18 (0x12)</td><td rowspan="5">0x0A</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>$q_0$</td><td>float</td><td>n/a</td></tr>
<tr><td>4</td><td>$q_1$</td><td>float</td><td>n/a</td></tr>
<tr><td>8</td><td>$q_2$</td><td>float</td><td>n/a</td></tr>
<tr><td>12</td><td>$q_3$</td><td>float</td><td>n/a</td></tr>
</table>

### Euler Angles (0x80, 0x0C)

<table>
<tr><td>Description</td><td colspan="5">Pitch, Roll, and Yaw (aircraft) values</td></tr>
<tr><td>Notes</td><td colspan="5">This is a 3 component vector containing the Roll, Pitch and Yaw angles in radians. It is computed by the AHRS from the orientation matrix M.<br>$Euler = \begin{bmatrix} Roll \\ Pitch \\ Yaw \end{bmatrix}$ (radians)</td></tr>
<tr><td rowspan="5">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="4">14 (0x0E)</td><td rowspan="4">0x0C</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Roll</td><td>float</td><td>radians</td></tr>
<tr><td>4</td><td>Pitch</td><td>float</td><td>radians</td></tr>
<tr><td>8</td><td>Yaw</td><td>float</td><td>radians</td></tr>
</table>

### GPS Correlation Timestamp (0x80, 0x12)

<table>
<tr><td>Description</td><td>GPS correlation timestamp.</td></tr>
<tr><td>Notes</td><td>This timestamp has three fields:<br><br>Double GPS TOW<br>U16 GPS Week number<br>U16 Timestamp flags<br><br>Timestamp Status Flags:<br>Bit0 – PPS Beacon Good If set, GPS PPS signal is present<br>Bit1 – GPS Time Refresh (toggles with each refresh)<br>Bit2 – GPS Time Initialized (set with the first GPS Time Refresh)<br><br>This timestamp correlates the AHRS packets with the GPS packets. It is identical to the GPS Time record except the flags are defined specifically for the AHRS. When the GPS Time Initialized flag is asserted, the GPS Time and AHRS GPS Timestamp are correlated. This flag is only set once upon the first valid GPS Time record. After that, each time the GPS Time becomes invalid (from a lack of signal) and then valid again (regains signal) the GPS Time Refresh flag will toggle. The GPS Time Initialized will remain set.<br><br>The “PPS Beacon Good” flag in the Timestamp flags byte indicates if the PPS beacon coming from the GPS is present. If this flag is not asserted, it means that the AHRS internal clock is being used for the PPS. The fractional portion of the GPS TOW represents the amount of time that has elapsed from the last PPS.<br><br>If the GPS loses signal, the GPS and AHRS timestamps become free running and will slowly drift</td></tr>
</table>

<table>
<tr><td></td><td colspan="5">away from each other. If the timestamp clocks have drifted apart, then there will be a jump in the timestamp when the PPS Beacon Good reasserts, reflecting the amount of drift of the clocks.<br><br>See the Data Synchronicity section of this manual for more information on timestamps.</td></tr>
<tr><td rowspan="4">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="3">14 (0x0E)</td><td rowspan="3">0x12</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>GPS Time of Week</td><td>Double</td><td>Seconds</td></tr>
<tr><td>8</td><td>GPS Week Number</td><td>U16</td><td></td></tr>
<tr><td></td><td>10</td><td>Timestamp Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

## GPS Data

### LLH Position (0x81, 0x03)

<table>
<tr><td>Description</td><td colspan="5">Position Data in the Geodetic Frame</td></tr>
<tr><td>Notes</td><td colspan="5">Valid Flag Mapping:<br><br>0x0001 – Latitude & Longitude Valid<br>0x0002 – Ellipsoid Height Valid<br>0x0004 – MSL Height Valid<br>0x0008 – Horizontal Accuracy Valid<br>0x0010 – Vertical Accuracy Valid</td></tr>
<tr><td rowspan="9">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="8">44 (0x2C)</td><td rowspan="8">0x03</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Latitude</td><td>Double</td><td>Decimal Degrees</td></tr>
<tr><td>8</td><td>Longitude</td><td>Double</td><td>Decimal Degrees</td></tr>
<tr><td>16</td><td>Height above Ellipsoid</td><td>Double</td><td>Meters</td></tr>
<tr><td>24</td><td>Height above MSL</td><td>Double</td><td>Meters</td></tr>
<tr><td>32</td><td>Horizontal Accuracy</td><td>Float</td><td>Meters</td></tr>
<tr><td>36</td><td>Vertical Accuracy</td><td>Float</td><td>Meters</td></tr>
<tr><td>40</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

### NED Velocity (0x81, 0x05)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Velocity Data in the North-East-Down Frame | | | | | |
| **Notes** | Valid Flag Mapping:<br><br>0x0001 – NED Velocity Valid<br>0x0002 – Speed Valid<br>0x0004 – Ground Speed Valid<br>0x0008 – Heading Valid<br>0x0010 – Speed Accuracy Valid<br>0x0020 – Heading Accuracy Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 36(0x24) | 0x05 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | North | Float | Meters / Sec |
| | | | 4 | East | Float | Meters / Sec |
| | | | 8 | Down | Float | Meters / Sec |
| | | | 12 | Speed | Float | Meters / Sec |
| | | | 16 | Ground Speed | Float | Meters / Sec |
| | | | 20 | Heading | Float | Decimal Degrees |
| | | | 24 | Speed Accuracy | Float | Meters / Sec |
| | | | 28 | Heading Accuracy | Float | Decimal Degrees |
| | | | 32 | Valid Flags | U16 | See Notes |

### UTC Time (0x81, 0x08)

| **Description** | Coordinated Universal Time Data | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0001 – Date Valid<br>0x0002 – Time Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 15 (0x0F) | 0x08 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Year | U16 | Years (1999-2099) |
| | | | 2 | Month | U8 | Months (1-12) |
| | | | 3 | Day | U8 | Days (1-31) |
| | | | 4 | Hour | U8 | Hours (0-23) |
| | | | 5 | Minute | U8 | Minutes (0-59) |
| | | | 6 | Second | U8 | Seconds (0-59) |
| | | | 7 | Millisecond | U32 | Milliseconds |
| | | | 11 | Valid Flags | U16 | See Notes |

### GPS Time (0x81, 0x09)

| **Description** | Global Positioning System Time Data | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0001 – TOW Valid<br>0x0002 – Week Number Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x09 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Time of Week | Double | Seconds |
| | | | 8 | Week Number | U16 | |
| | | | 10 | Valid Flags | U16 | See Notes |

### Hardware Status (0x81, 0x0D)

<table>
<tr><td>Description</td><td colspan="5">GPS Hardware Status Information</td></tr>
<tr><td>Notes</td><td colspan="5">Hardware status is only available at 1 Hz. Setting the rate higher than 1 Hz has no effect.<br><br>Valid Flag Mapping:<br><br>0x0001 – Sensor State Valid<br>0x0002 – Antenna State Valid<br>0x0004 – Antenna Power Valid<br><br>Possible Sensor State values:<br><br>0x00 – Sensor Off<br>0x01 – Sensor On<br>0x02 – Sensor State Unknown<br><br>Possible Antenna State values:<br><br>0x01 – Antenna Init<br>0x02 – Antenna Short<br>0x03 – Antenna Open<br>0x04 – Antenna Good<br>0x05 – Antenna State Unknown.<br><br>Possible Antenna Power values:<br><br>0x00 – Antenna Off<br>0x01 – Antenna On<br>0x02 – Antenna Power Unknown</td></tr>
<tr><td rowspan="6">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="5">7(0x07)</td><td rowspan="5">0x0D</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Sensor State</td><td>U8</td><td>See Notes</td></tr>
<tr><td>1</td><td>Antenna State</td><td>U8</td><td>See Notes</td></tr>
<tr><td>2</td><td>Antenna Power</td><td>U8</td><td>See Notes</td></tr>
<tr><td>3</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

## NAV Data

### Filter Status (0x82, 0x10)

<table>
<tr><td>Description</td><td colspan="5">Kalman Filter Status</td></tr>
<tr><td>Notes</td><td colspan="5">Possible Filter States:<br><br>0x00 – Startup<br>0x01 – Initialization (see status flags)<br>0x02 – Running, Solution Valid<br>0x03 – Running, Solution Error (see status flags)<br><br>Possible Dynamics Modes:<br><br>0x01 – Portable<br>0x02 – Automotive<br>0x03 – Airborne<br><br>Possible Status Flags:<br><br>Filter State = Initialization:<br><br>0x1000 – Attitude not initialized<br>0x2000 – Position & Velocity not initialized<br><br>Filter State = Running:<br><br>0x0001 – IMU Unavailable<br>0x0002 – GPS Unavailable<br>0x0008 – Matrix Singularity in calculation<br><br>0x0010 – Position Covariance High Warning*<br>0x0020 – Velocity Covariance High Warning*<br>0x0040 – Attitude Covariance High Warning*<br>0x0080 – NAN in Solution<br><br>*Note: The covariance high warnings are triggered when any axis of the covariance vector exceeds normal operating limits. If more information is required, please inspect the relevant uncertainty packet to determine which axis is in error.</td></tr>
<tr><td rowspan="3">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="2">08 (0x08)</td><td rowspan="2">0x10</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Filter State</td><td>U16</td><td>See Notes</td></tr>
<tr><td></td><td></td><td>2</td><td>Dynamics Mode</td><td>U16</td><td>See Notes</td></tr>
<tr><td></td><td></td><td>4</td><td>Status Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

### GPS Timestamp (0x82, 0x11)

| **Description** | Kalman Filter Calculated Value Timestamp Data | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Time Invalid<br>0x0001 – Time Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 14 (0x0E) | 0x11 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Time of Week | Double | Seconds |
| | | | 8 | Week Number | U16 | |
| | | | 10 | Valid Flags | U16 | See Notes |

### Estimated LLH Position (0x82, 0x01)

| **Description** | INS Estimated Position Data expressed in the Geodetic Frame | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Latitude, Longitude, & Height are Invalid<br>0x0001 – Latitude, Longitude, & Height Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 28 (0x1C) | 0x01 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Latitude | Double | Decimal Degrees |
| | | | 8 | Longitude | Double | Decimal Degrees |
| | | | 16 | Height above Ellipsoid | Double | Meters |
| | | | 24 | Valid Flags | U16 | See Notes |

### Estimated NED Velocity (0x82, 0x02)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | INS Estimated Velocity Data expressed in the Local-Level Frame | | | | | |
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – NED Velocity is Invalid<br>0x0001 – NED Velocity Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x02 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | North | Float | Meters / Sec |
| | | | 4 | East | Float | Meters / Sec |
| | | | 8 | Down | Float | Meters / Sec |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Orientation, Quaternion (0x82, 0x03)

<table>
<tr><td>Description</td><td colspan="5">INS Estimated Orientation in quaternion form.</td></tr>
<tr><td>Notes</td><td colspan="5">This is a 4 component quaternion which describes the orientation of the 3DM-GX3-45 with respect to the fixed earth coordinate quaternion.<br><br>$$Q = \begin{bmatrix} q0 \\ q1 \\ q2 \\ q3 \end{bmatrix}$$<br><br>Q satisfies the following equation:<br><br>V_E = Q • V_IL • Q-1<br><br>Where: V_IL is a vector expressed in the 3DM-GX3®'s local coordinate system.<br>V_E is the same vector expressed in the stationary, earth-fixed coordinate system<br><br>Valid Flag Mapping:<br><br>0x0000 – Quaternion is Invalid<br>0x0001 – Quaternion Valid</td></tr>
<tr><td rowspan="7">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="6">20 (0x14)</td><td rowspan="6">0x03</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>$q_0$</td><td>float</td><td>n/a</td></tr>
<tr><td>4</td><td>$q_1$ * i</td><td>float</td><td>n/a</td></tr>
<tr><td>8</td><td>$q_2$ * j</td><td>float</td><td>n/a</td></tr>
<tr><td>12</td><td>$q_3$ * k</td><td>float</td><td>n/a</td></tr>
<tr><td>16</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

### Estimated Orientation, Matrix (0x82, 0x04)

**Description**

INS Estimated Orientation in Matrix form.

**Notes**

This is a 9 component coordinate transformation matrix which describes the orientation of the 3DM-GX3® with respect to the fixed earth coordinate system.

$$M = \begin{bmatrix} M_{1,1} & M_{1,2} & M_{1,3} \\ M_{2,1} & M_{2,2} & M_{2,3} \\ M_{3,1} & M_{3,2} & M_{3,3} \end{bmatrix}$$

*M* satisfies the following equation:

$V\_IL_i = M_{ij} \cdot V\_E_j$

*Where: V_IL is a vector expressed in the 3DM-GX3®'s local coordinate system.*
*V_E is the same vector expressed in the stationary, earth-fixed coordinate system*

Valid Flag Mapping:

0x0000 – Orientation Matrix is Invalid
0x0001 – Orientation Matrix Valid

**Field Format**

| *Field Length* | *Data Descriptor* | *Message Data* | | | |
|---|---|---|---|---|---|
| | | *Binary Offset* | *Description* | *Data Type* | *Units* |
| 40 (0x28) | 0x04 | 0 | $M_{11}$ | float | *n/a* |
| | | 4 | $M_{12}$ | float | *n/a* |
| | | 8 | $M_{13}$ | float | *n/a* |
| | | 12 | $M_{21}$ | float | *n/a* |
| | | 16 | $M_{22}$ | float | *n/a* |
| | | 20 | $M_{23}$ | float | *n/a* |
| | | 24 | $M_{31}$ | float | *n/a* |
| | | 28 | $M_{32}$ | float | *n/a* |
| | | 32 | $M_{33}$ | float | *n/a* |
| | | 36 | Valid Flags | U16 | See Notes |

### Estimated Orientation, Euler Angles (0x82, 0x05)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Pitch, Roll, and Yaw (aircraft) values | | | | | |
| **Notes** | This is a 3 component vector containing the Roll, Pitch and Yaw angles in radians. It is computed by the INS from the orientation quaternion Q.<br><br>$Euler = \begin{bmatrix} Roll \\ Pitch \\ Yaw \end{bmatrix}$ (radians)<br><br>Valid Flag Mapping:<br><br>0x0000 – Euler Angles are Invalid<br>0x0001 – Euler Angles Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x05 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Roll | float | radians |
| | | | 4 | Pitch | float | radians |
| | | | 8 | Yaw | float | radians |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Gyro Bias (0x82, 0x06)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Estimated Gyro Biases expressed in the Sensor Body Frame. | | | | | |
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Gyro Bias are Invalid<br>0x0001 – Gyro Bias Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x06 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X Gyro Bias | float | radians/sec |
| | | | 4 | Y Gyro Bias | float | radians/sec |
| | | | 8 | Z Gyro Bias | float | radians/sec |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated LLH Position Uncertainty (0x82, 0x08)

| **Description** | INS Estimated Position Data expressed in the Geodetic Frame | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Position Uncertainties are Invalid<br>0x0001 – Position Uncertainties Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x08 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Local-Level, 1-Sigma Position Uncertainty (North) | Float | Meters |
| | | | 4 | Local-Level, 1-Sigma Position Uncertainty (East) | Float | Meters |
| | | | 8 | Local-Level, 1-Sigma Position Uncertainty (Down) | Float | Meters |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated NED Velocity Uncertainty (0x82, 0x09)

| **Description** | INS Estimated Velocity Data expressed in the Local-Level Frame | | | | | |
|---|---|---|---|---|---|---|
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – NED Velocity Uncertainties are Invalid<br>0x0001 – NED Velocity Uncertainties Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x09 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Local-Level, 1-Sigma Velocity Uncertainty (North) | Float | Meters / Sec |
| | | | 4 | Local-Level, 1-Sigma Velocity Uncertainty (East) | Float | Meters / Sec |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 8 | Local-Level, 1-Sigma Velocity Uncertainty (Down) | Float | Meters / Sec |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Attitude Uncertainty, Euler Angles (0x82, 0x0A)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | 1-sigma attitude uncertainty expressed in Pitch, Roll, and Yaw (aircraft) elements. | | | | | |
| **Notes** | This is a 3 component vector containing the Roll, Pitch and Yaw angle uncertainties in radians.<br><br>**IMPORTANT:** These values are derived from the quaternion elements and become increasingly inaccurate as the pitch angle approaches +-90 degrees. To compensate for this limitation, these values will be marked as invalid when the pitch angle exceeds +-70 degrees.<br><br>Valid Flag Mapping:<br><br>0x0000 – Attitude Uncertainties are Invalid<br>0x0001 – Attitude Uncertainties Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x0A | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | 1-Sigma Attitude Uncertainty (Roll) | float | radians |
| | | | 4 | 1-Sigma Attitude Uncertainty (Pitch) | float | radians |
| | | | 8 | 1-Sigma Attitude Uncertainty (Yaw) | float | radians |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Gyro Bias Uncertainty (0x82, 0x0B)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Estimated Gyro Bias Uncertainty expressed in the Sensor Body Frame. | | | | | |
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Gyro Bias Uncertainties are Invalid<br>0x0001 – Gyro Bias Uncertainties Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x0B | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | 1-Sigma Gyro Bias Uncertainty (X) | float | radians/sec |
| | | | 4 | 1-Sigma Gyro Bias Uncertainty (Y) | float | radians/sec |
| | | | 8 | 1-Sigma Gyro Bias Uncertainty (Z) | float | radians/sec |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Linear Acceleration (0x82, 0x0D)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | INS Estimated Linear Acceleration Data expressed in:<br>1) The Sensor Frame, if no sensor to body rotation has been defined.<br>2) The Vehicle Frame, if a sensor to body rotation has been defined. | | | | | |
| **Notes** | Valid Flag Mapping:<br><br>0x0000 – Linear Accelerations are Invalid<br>0x0001 – Linear Accelerations are Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x0D | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X | Float | Meters / Sec^2 |
| | | | 4 | Y | Float | Meters / Sec^2 |
| | | | 8 | Z | Float | Meters / Sec^2 |
| | | | 12 | Valid Flags | U16 | See Notes |

### Estimated Angular Rate (0x82, 0x0E)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | INS Estimated Angular Rate Data expressed in:<br>1) The Sensor Frame, if no sensor to body rotation has been defined.<br>2) The Vehicle Frame, if a sensor to body rotation has been defined. | | | | | |
| **Notes** | The estimated gyro bias has been removed from these angular rate values.<br><br>Valid Flag Mapping:<br><br>0x0000 – Angular Rates are not Valid<br>0x0001 – Angular Rates are Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 16 (0x10) | 0x0E | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | X | Float | Radians / Sec |
| | | | 4 | Y | Float | Radians / Sec |
| | | | 8 | Z | Float | Radians / Sec |
| | | | 12 | Valid Flags | U16 | See Notes |

### WGS84 Local Gravity Magnitude (0x82, 0x0F)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Local Magnitude of Earth's gravity using the WGS84 gravity model. | | | | | |
| **Notes** | The GX3-45 implements the WGS84 gravity model, valid for altitudes of 20km or less.<br><br>Valid Flag Mapping:<br><br>0x0000 – Gravity value is Invalid<br>0x0001 – Gravity value is Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 08 (0x08) | 0x0F | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | Gravity Magnitude | Float | meters / sec^2 |
| | | | 4 | Valid Flags | U16 | See Notes |

### Estimated Attitude Uncertainty, Quaternion Elements (0x82, 0x12)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | 1-sigma attitude uncertainty expressed in quaternion components. | | | | | |
| **Notes** | This is a 4 component vector containing the attitude uncertainty expressed in quaternion elements.<br><br>Valid Flag Mapping:<br><br>0x0000 – Attitude uncertainties are Invalid<br>0x0001 – Attitude uncertainties are Valid | | | | | |
| **Field Format** | *Field Length* | *Data Descriptor* | *Message Data* | | | |
| | 20 (0x14) | 0x12 | *Binary Offset* | *Description* | *Data Type* | *Units* |
| | | | 0 | 1-Sigma Attitude Uncertainty (q0) | float | |
| | | | 4 | 1-Sigma Attitude Uncertainty (q1) | float | |
| | | | 8 | 1-Sigma Attitude Uncertainty (q2) | float | |
| | | | 12 | 1-Sigma Attitude Uncertainty (q3) | float | |
| | | | 16 | Valid Flags | U16 | See Notes |

### Estimated Gravity Vector (0x82, 0x13)

<table>
<tr><td>Description</td><td colspan="5">INS Estimated Gravity Data expressed in:<br>1) The Sensor Frame, if no sensor to body rotation has been defined.<br>2) The Vehicle Frame, if a sensor to body rotation has been defined.</td></tr>
<tr><td>Notes</td><td colspan="5">Valid Flag Mapping:<br><br>0x0000 – Gravity vector is Invalid<br>0x0001 – Gravity vector is Valid</td></tr>
<tr><td rowspan="6">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="5">16 (0x10)</td><td rowspan="5">0x13</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>X</td><td>Float</td><td>Meters / Sec^2</td></tr>
<tr><td>4</td><td>Y</td><td>Float</td><td>Meters / Sec^2</td></tr>
<tr><td>8</td><td>Z</td><td>Float</td><td>Meters / Sec^2</td></tr>
<tr><td>12</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

### Heading Update Source State (0x82, 0x14)

<table>
<tr><td>Description</td><td colspan="5">Heading Update Source information expressed in the sensor frame.</td></tr>
<tr><td>Notes</td><td colspan="5">Heading updates can be applied from a number of sources (listed below.)<br><br>The heading value is always relative to true north.<br><br>Possible Sources:<br><br>0x0000 – No source, heading updates disabled<br>0x0001 – Internal Magnetometer<br>0x0002 – Internal GPS Velocity Vector<br>0x0003 – External Heading Update Command<br><br>Valid Flag Mapping:<br><br>0x0000 – No heading update received in 2 seconds.<br>0x0001 – The heading update source has provided data within 2 seconds.</td></tr>
<tr><td rowspan="6">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="5">14 (0x0E)</td><td rowspan="5">0x14</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Heading (True)</td><td>Float</td><td>Radians</td></tr>
<tr><td>4</td><td>Heading 1-sigma Uncertainty</td><td>Float</td><td>Radians</td></tr>
<tr><td>8</td><td>Source</td><td>U16</td><td>See Notes</td></tr>
<tr><td>10</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

### Magnetic Model Solution (0x82, 0x15)

<table>
<tr><td>Description</td><td colspan="5">Magnetic model solution expressed in the NED frame.</td></tr>
<tr><td>Notes</td><td colspan="5">The World Magnetic Model 2010 is used. A valid GPS location is required for the model to be valid.<br><br>Valid Flag Mapping:<br><br>0x0000 – Magnetic model solution is invalid (note: this will be the state when the magnetic model is recalculating for the current time and location as well as when GPS is unavailable)<br>0x0001 – Magnetic model solution is valid</td></tr>
<tr><td rowspan="8">Field Format</td><td>Field Length</td><td>Data Descriptor</td><td colspan="3">Message Data</td></tr>
<tr><td rowspan="7">24 (0x18)</td><td rowspan="7">0x15</td><td>Binary Offset</td><td>Description</td><td>Data Type</td><td>Units</td></tr>
<tr><td>0</td><td>Intensity (North)</td><td>Float</td><td>Gauss</td></tr>
<tr><td>4</td><td>Intensity (East)</td><td>Float</td><td>Gauss</td></tr>
<tr><td>8</td><td>Intensity (Down)</td><td>Float</td><td>Gauss</td></tr>
<tr><td>12</td><td>Inclination</td><td>Float</td><td>Radians</td></tr>
<tr><td>16</td><td>Declination</td><td>Float</td><td>Radians</td></tr>
<tr><td>20</td><td>Valid Flags</td><td>U16</td><td>See Notes</td></tr>
</table>

# MIP Packet Reference

## Structure

Commands and Data are sent and received as fields in the MicroStrain "MIP" packet format. Below is the general definition of the structure:

| Header | | | | Payload | | | Checksum | |
|---|---|---|---|---|---|---|---|---|
| SYNC1 "u" | SYNC2 "e" | Descriptor Set byte | Payload Length byte | Fields | | | MSB | LSB |
| 0x75 | 0x65 | <desc set selector> | $k_1+k_2+\ldots k_n$ | MIP Field 1 length = $k_1$ | ... | MIP Field *n* length = $k_n$ | 0x*MM* | 0x*LL* |

| Field Header | | Field Data |
|---|---|---|
| Field Length byte | Field Descriptor byte | Field Data |
| $k_n$ | <descriptor> | <$k_n$-2 bytes of data> |

The packet always begins with the start-of-packet sequence "ue" (0x75, 0x65). The "Descriptor Set" byte in the header specifies which command or data set is contained in fields of the packet. The payload length byte specifies the sum of all the field length bytes in the payload section.

### Payload Length Range

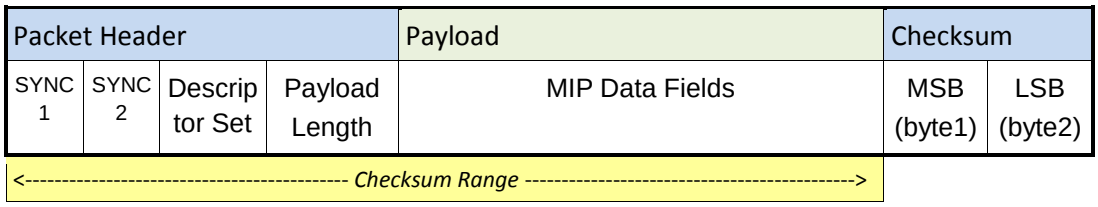
| Packet Header | | | | Payload | Checksum | |
|---|---|---|---|---|---|---|
| SYNC 1 | SYNC 2 | Descript or Set | Payload Length | MIP Data Fields | MSB | LSB |
| | | | | <----------*Payload Length Range* ----------> | | |

The payload section can be empty or can contain one or more fields. Each field has a length byte and a descriptor byte. The field length byte specifies the length of the entire field including the field length byte and field descriptor byte. The descriptor byte specifies the command or data that is contained in the field data. The descriptor can only be from the set of descriptors specified by the descriptor set byte in the header. The field data can be anything but is always rigidly defined. The definition of a descriptor is fundamentally described in a ".h" file that corresponds to the descriptor set that the descriptor belongs to.

MicroStrain provides a “MIP Packet Builder” utility to simplify the construction of a MIP packet. Most commands will have a single field in the packet, but multiple field packets are possible. Extensive examples complete with checksums are given in the command reference section.

### Checksum Range

The checksum is a 2 byte Fletcher checksum and encompasses all the bytes in the packet:




### 16-bit Fletcher Checksum Algorithm (C language)

```
for(i=0; i<checksum_range; i++)
{
 checksum_byte1 += mip_packet[i];
 checksum_byte2 += checksum_byte1;
}

checksum = ((u16) checksum_byte1 << 8) + (u16) checksum_byte2;
```

# Advanced Programming

## Multiple Commands in a Single Packet

MIP packets may contain one or more individual commands. In the case that multiple commands are transmitted in a single MIP packet, the GX3-45 will respond with a single packet containing multiple replies. As with any packet, all commands must be from the same descriptor set (you cannot mix Base commands with 3DM commands in the same packet).

Below is an example that shows how you can combine the commands from step 2 and 3 of the Example Setup Sequence into a single packet. The commands are from the 3DM set. The command packet has two fields as does the reply packet (the fields are put on separate rows for clarity):

| **Step 2 and 3** | MIP Packet Header | | | | Command/Reply Fields | | | Checksum | |
|---|---|---|---|---|---|---|---|---|---|
| | *Sync1* | *Sync2* | *Desc Set* | *Payload Length* | *Field Length* | *Cmd Desc.* | *Field Data* | *MSB* | *LSB* |
| *Command field 1 Set AHRS Message Format* | **0x75** | **0x65** | **0x0C** | **0x14** | **0x0A** | **0x08** | Function: **0x00**<br>Desc count: **0x02**<br>1st Descriptor: **0x03**<br>Rate Dec: **0x000A**<br>2nd Descriptor:**0x04**<br>Rate Dec: **0x000A** | | |
| *Command field 2 Set GPS Message Format* | | | | | **0x0A** | **0x09** | Function: **0x00**<br>Desc Count: **0x02**<br>ECEF pos desc: **0x04**<br>Rate dec: **0x0004**<br>ECEF vel desc: **0x06**<br>Rate dec: **0x0004** | **0x50** | **0x98** |
| *Reply field 1 ACK/NACK* | **0x75** | **0x65** | **0x0C** | **0x08** | **0x04** | **0xF1** | Cmd echo: **0x08**<br>Error code: **0x00** | | |
| *Reply field 2 ACK/NACK* | | | | | **0x04** | **0xF1** | Cmd echo: **0x09**<br>Error code: **0x00** | **0xE9** | **0x6F** |

*Copy-Paste version of the command: "7565 0C14 0A08 0002 0300 0A04 000A 0A09 0002 0400 0406 0004 5098"*

*Note that the only difference in the packet headers of the single command packets compared to the multiple command packets is the payload length. Parsing multiple fields in a single packet involves subtracting the field length of the next field from the payload length until the payload length is less than or equal to zero.*

## Direct Modes

The GX3-45 has special "direct" modes that switch the device into a "GX3-25" AHRS or a "u-blox" GPS device. The Device Communications Mode command is used to switch between modes. When in these modes, the GX3-45 acts just like a GX3-25 AHRS or a u-blox GPS sensor respectively. Any code or tools developed for these devices may be used in these modes. For example, when in the "u-blox" direct mode, the u-blox "u-center" application works perfectly with the GPS chip embedded in the GX3-45.

These modes can be used to access advanced (native) data of the individual sensors, data that isn't represented in the 3DM command sets of the GX3-45.

*IMPORTANT: When you switch modes, you are switching to a new device protocol EXCEPT for two commands: the Device Communications Mode and Device Status commands. Those commands are always available regardless of which mode you are in. For example, if you switch to GPS direct mode, then the protocol recognized by the device is NMEA and UBX protocol, however the GX3-45 is still "listening" for mode switch or device status commands and will respond to them. It will not respond to any other 3DM-GX3-45 Basic or 3DM commands until switched back to the "Standard Mode".*

*IMPORTANT: The GPS message settings required for Kalman Filter execution are automatically reloaded when switching from direct modes back in to standard mode.*

## Internal Diagnostic Functions

The 3DM-GX3-45 supports two device specific internal functions used for diagnostics and system status. These are Device Built In Test and Device Status. These commands are defined generically but the implementation is very specific to the hardware implemented on this device. Other MicroStrain devices will have their own implementations of these functions depending on the internal hardware of the devices.

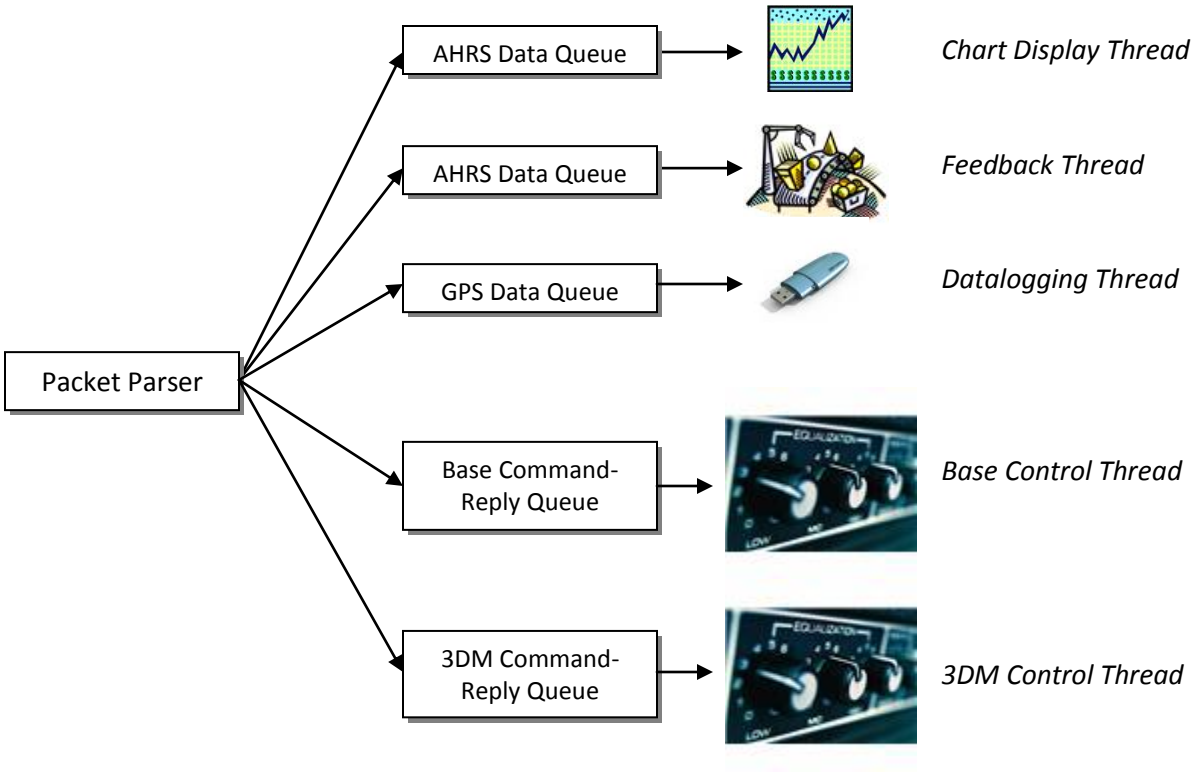
3DM-GX3-45 INTERNAL DIAGNOSTIC COMMANDS

- Device Built In Test (0x01, 0x05)
- Device Status (0x0C, 0x64)

## Advanced Programming Models

Many applications will only require a single threaded programming model which is simple to implement using a single program loop that services incoming packets. In other applications, advanced techniques such as multithreading or event based processes are required. The MIP packet design simplifies implementation of these models. It does this by limiting the packet size to a maximum of 261 bytes and it provides the "descriptor set" byte in the header. The limited packet size makes scalable packet buffers possible even with limited memory space. The descriptor set byte aids in sorting an incoming packet stream into one or more command-reply packet queues and/or data packet queues. A typical multithreaded environment will have a command/control thread and one or more data processing threads. Each of these threads can be fed with individual incoming packet queues, each containing packets that only pertain to that thread – sorted by descriptor set. Packet queues can easily be created dynamically as threads are created and destroyed. All

packet queues can be fed by a single incoming packet parser that runs continuously independent of the queues. The packet queues are individually scaled as appropriate to the process; smaller queues for lower latency and larger queues for more efficient batch processing of packets.




*Multithreaded application with multiple incoming packet queues*