MIDG II Message Specification for Firmware V2.2.XXXX

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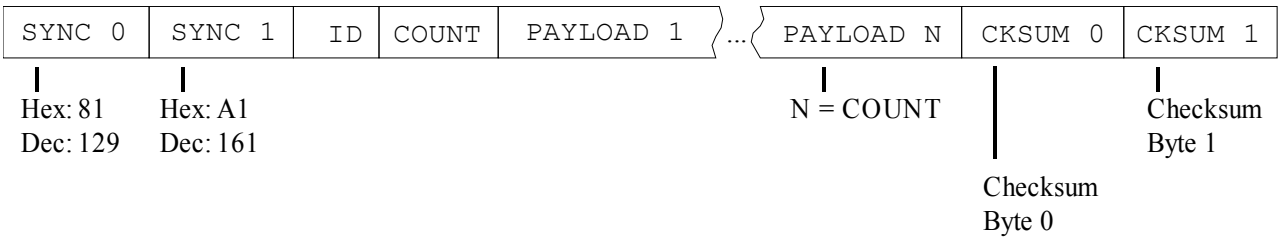
1 Software Interface

This section defines the MIDG II software interface. The MIDG II uses the Microbotics binary protocol, defined in the following section, to communication with the host computer. The defined messages provide sensor data transfer between the host and the MIDG II and facilitate MIDG II configuration.

1.1 Microbotics Binary Protocol

Communication with the MIDG II occurs over the selected primary communication port using the Microbotics binary protocol, herein referred to as mBin. The mBin protocol is a standard binary packet format that has the following structure.



mBin Packet Frame

The checksum is a Fletcher checksum as defined in internet RFC 1145. It is computed over the bytes between the head and checksum. In other words, it includes the message ID, Count byte, and the payload bytes. The basic algorithm is as follows:

```
cksum0 = 0                                    <- unsigned character
cksum1 = 0                                    <- unsigned character
for each byte from ID to Payload_N (inclusive)
  cksum0 = cksum0 + byte                      <- only 8 bits preserved
  cksum1 = cksum1 + cksum 0                   <- only 8 bits preserved
```

The payload is composed of a sequence of bytes that represent values within a message. In the section that follows, the application messages will be defined using the nomenclature shown below to indicate the type of value represented in the payload. All payload values are big endian, meaning that the most significant byte of a multi-byte value is sent first. In bit fields, bit zero represents the least significant bit.

Type	Description
U1	Unsigned, 8 bit integer
U2	Unsigned, 16 bit integer
U4	Unsigned, 32 bit integer
B*x*	String of *x* bytes
BN	Variable length string of bytes

Type	Description
I1	Signed, 8 bit integer
I2	Signed, 16 bit integer
I4	Signed, 32 bit integer
R4	IEEE 754 single precision
R8	IEEE 754 double precision

1.2 MIDG II Messages

The MIDG II messages are divided into several groups: data sent from the MIDG II to the host, data and commands sent from the host to the MIDG II, handshaking messages, and configuration messages.

1.2.1 MIDG II Output

Currently, the following messages are provided from the MIDG II. Any of these messages may be configured to be transmitted from the MIDG II at a user selectable rate from once every 5 seconds to 50Hz. When a message is disabled (its output rate is set to zero), it may be polled by sending a message of the same ID to the MIDG II, but with no payload, so that the message payload length is zero. Rates for these messages are set using the configuration-set message MSG_DIV. See section 1.3.1 for details.
Supported output messages (message IDs):

- (1) STATUS MIDG II Status
- (2) IMU_DATA IMU Data
- (3) IMU_MAG Magnetometer Data
- (10) NAV_SENSOR Navigation Sensor Data
- (12) NAV_PV Navigation Position/Velocity Data
- (13) NAV_HDG Navigation Heading Data
- (15) NAV_ACC Navigation Accuracy Estimate
- (20) GPS_PV GPS Position/Velocity Data
- (21) GPS_SVI GPS Satellite Vehicle Data
- (22) GPS_RAW GPS Raw Measurement Data
- (23) GPS_CLK GPS Clock Data
- (24) GPS_EPH Ephemeris Data (poll only, payload of poll is SVID)
- (25) TIM_UTC UTC Time
- (26) TIM_ERR Time Error
- (27) TIM_PPS Time at 1 PPS
- (28) TIM_TM Time at Time Mark pulse

Message	STATUS	**Description**	Status Information		
Message ID	1	**Payload Length**	8 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		ts	msec	Timestamp
4	U2	1	status		System Status: bits 8-15: reserved bit 7: NV configuration valid bit 6: Timestamp is GPS time bit 5: DGPS bit 4: reserved bits 0-3: Current Mode 1 = IMU Mode 2 = VG Initialization 3 = VG Fast 4 = VG Medium 5 = VG Slow 6 = VG SE 7 = INS Mode
6	I2		Temperature	0.01 °C	Internal temperature

Notes:
1. VG is Vertical Gyro Mode. SE means slow, eligible for INS mode.

Message	IMU_DATA	**Description**	Inertial Measurements		
Message ID	2	**Payload Length**	23 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		ts	msec	Timestamp
4	I2		p	1e-2 deg/s	X Axis Angular Rate
6	I2		q	1e-2 deg/s	Y Axis Angular Rate
8	I2		r	1e-2 deg/s	Z Axis Angular Rate
10	I2		ax	milli-g	X Axis Acceleration
12	I2		ay	milli-g	Y Axis Acceleration
14	I2		az	milli-g	Z Axis Acceleration
16	I2	1	mx		X Axis Magnetic Field
18	I2		my		Y Axis Magnetic Field
20	I2		mz		Z Axis Magnetic Field
22	U1		Flags	bitfield	Flags bit 7: GPS 1PPS flag bit 6: Timestamp is GPS time

Notes:
1. The magnetometer outputs are scaled so that the magnitude of the local field at calibration is 5000 counts.

Message	IMU_MAG	**Description**	Magnetometer Measurements		
Message ID	3	**Payload Length**	11 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		ts	msec	Timestamp
4	I2	1	mx		X Axis Magnetic Field
6	I2		my		Y Axis Magnetic Field
8	I2		mz		Z Axis Magnetic Field
10	U1		Flags	bitfield	Flags bit 6: Timestamp is GPS time

Notes:
1. The magnetometer outputs are scaled so that the magnitude of the local field at calibration is 5000 counts.

Message	NAV_SENSOR	**Description**	Navigation Sensor Data		
Message ID	10	**Payload Length**	39 Bytes	**Applicable Modes**	VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		ts	msec	Timestamp
4	I2		p	1e-2deg/s	X Axis Angular Rate
6	I2		q	1e-2deg/s	Y Axis Angular Rate
8	I2		r	1e-2deg/s	Z Axis Angular Rate
10	I2		ax	milli-g	X Axis Acceleration
12	I2		ay	milli-g	Y Axis Acceleration
14	I2		az	milli-g	Z Axis Acceleration
16	I2		yaw	0.01deg	Yaw
18	I2		pitch	0.01deg	Pitch
20	I2		roll	0.01deg	Roll
22	I4	1	Qw	2^{-30}	Orientation Quaternion
26	I4		Qx	2^{-30}	Orientation Quaternion
30	I4		Qy	2^{-30}	Orientation Quaternion
34	I4		Qz	2^{-30}	Orientation Quaternion
38	U1		Flags	bitfield	Flags bit 7: INS Mode bit 6: Timestamp is GPS time bit 5: DGPS bit 4: Magnetometer measurement applied bit 3: External heading measurement applied bit 2: External position measurement applied bit 1: External velocity measurement applied bit 0: External air data measurement applied

Notes:

1. The elements of the quaternion must be multiplied by 2^{-30} (i.e., 9.31322574615 x 10^{-10}) to get a unit quaternion.

Message	NAV_PV	**Description**	Navigation Position and Velocity Solution		
Message ID	12	**Payload Length**	29 Bytes	**Applicable Modes**	VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		ts	msec	Timestamp
4	I4	1	PosX		X Axis Position (ECEF X, East, or Longitude)
8	I4	1	PosY		Y Axis Position (ECEF Y, North, or Latitude)
12	I4	1	PosZ		Z Axis Position (ECEF Z, Up, or Altitude)
16	I4	2	VelX	cm/s	X Axis Velocity (ECEF Vx or Veast)
20	I4	2	VelY	cm/s	Y Axis Velocity (ECEF Vy or Vnorth)
24	I4	2	VelZ	cm/s	Z Axis Velocity (ECEF Vz or Vup)
28	U1	3	Details	bitfield	Solution Status: bit 7: Position estimate invalid bit 6: Timestamp is GPS time bit 5: DGPS bit 4: Velocity estimate invalid bits 2-3: Position Format 0=ECEF 1=ENU 2,3=LLA bit 1: Velocity Format 0=ECEF 1=ENU bit 0: ENU position relative to first fix

Notes:

1. Units are output-dependent: cm for ECEF and ENU relative; $1e^{-7}$deg for Lon/Lat, with cm for Alt
2. Format is either ECEF or ENU
3. If position is reported in ENU coordinates, the position will be relative to either the first GPS fix since reset or a location specified in configuration.

Message	NAV_HDG [1]	**Description**	Navigation Heading Information		
Message ID	13	**Payload Length**	17 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		ts	msec	Timestamp
4	I2		MHdg	0.01 deg	Magnetic heading
6	I2	2	MDec	0.01 deg	Magnetic declination
8	I2	2	MDip	0.01 deg	Magnetic dip
10	I2	3	COG	0.01 deg	Course over ground
12	U2	3	SOG	cm/s	Speed over ground
14	I2	3	Vup	cm/s	Vertical velocity
16	U1		Flags	bitfield	Flags bit 7: Declination and dip valid bit 6: Timestamp is GPS time

Notes:
1. Message included in MIDG II firmware version 2.1.102 and higher.
2. The magnetic declination and magnetic dip are taken from a world magnetic model, which requires initialization with the current location. As a result, these values are not valid until position is known and Flags bit 7 is set.
3. Course over ground, speed over ground, and vertical velocity are calculated from the navigation solution data and correspond to the velocities presented in the NAV_PV message.

Message	NAV_ACC	**Description**	Navigation Solution Accuracy Estimate		
Message ID	15	**Payload Length**	17 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		ts	msec	Timestamp
4	U2	1	HPos	cm	Horizontal position accuracy estimate
6	U2	1	VPos	cm	Vertical position accuracy estimate
8	U2	1	HVel	cm/s	Horizontal velocity accuracy estimate
10	U2	1	VVel	cm/s	Vertical velocity accuracy estimate
12	U2	1	Att	0.01 deg	Tilt accuracy estimate
14	U2	1	Hdg	0.01 deg	Heading accuracy estimate
16	U1		Flags	bitfield	Flags bit 7: Content valid bit 6: Timestamp is GPS time bit 5: DGPS

Notes:
1. Value represents the probable standard deviation of error.

Message	GPS_PV	**Description**	GPS Position and Velocity Solution		
Message ID	20	**Payload Length**	38 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		GPS_ts	msec	GPS Time
4	U2		GPS_week		GPS week
6	U2	2	Details	bitfield	Solution Details: bits 12-15: Number of SVs used in solution bits 8-11: GPS Fix Type 0 = No Fix 1 = Dead reckoning only 2 = 2D Fix 3 = 3D Fix 4 = GPS + dead reckoning combined bit 7: Time of week valid bit 6: Week number valid bit 5: Differential solution bit 4: GPS Fix valid bits 2-3: Position Format 0=ECEF 1=ENU 2,3=LLA bit 1: Velocity Format 0=ECEF 1=ENU bit 0: ENU position relative to first fix
8	I4	3	GPS_PosX		X Axis Position (ECEF X, East, or Longitude)
12	I4	3	GPS_PosY		Y Axis Position (ECEF Y, North, or Latitude)
16	I4	3	GPS_PosZ		Z Axis Position (ECEF Z, Up, or Altitude)
20	I4		GPS_VelX	cm/s	X Axis Velocity (ECEF Vx or Veast)
24	I4		GPS_VelY	cm/s	Y Axis Velocity (ECEF Vy or Vnorth)
28	I4		GPS_VelZ	cm/s	Z Axis Velocity (ECEF Vz or Vup)
32	U2		PDOP	0.01	Position DOP
34	U2	4	PAcc	cm	Position Accuracy
36	U2	4	SAcc	cm/s	Speed Accuracy

Notes:

1. This message is provided at the selected rate only if data is produced by the GPS receiver.
2. If position is reported in ENU coordinates, the position will be relative to either the first GPS fix since reset or a location specified in configuration.
3. Units are output-dependent: cm for ECEF and ENU relative; $1e^{-7}$deg for Lon/Lat, with cm for Alt
4. Accuracy is the root of the variance in the filtered estimate

Message	GPS_SVI		**Description**	GPS Satellite Vehicle Information		
Message ID	21		**Payload Length**	8*NCh + 6	**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	U4		GPS_ts	msec	GPS Time	
4	U1		reserved		Reserved	
5	U1		NCh		Number of SVs to follow	
The following block is repeated NCh times.						
$8*ChN_i + 6$	U1	2	ChN		Receiver channel number	
$8*ChN_i + 7$	U1		SVID		SV on this receiver channel	
$8*ChN_i + 8$	U1		CNo	dbHz	Carrier to Noise ratio	
$8*ChN_i + 9$	U1		Flags	bitfield	Information regarding the SV bit 4: SV is unhealthy, will not be used bit 3: Orbit info is Ephemeris bit 2: Orbit info available for this SV bit 1: DGPS data available for this SV bit 0: SV used for navigation	
$8*ChN_i + 10$	I1		QI	value	Information regarding the receiver channel 7: Code/carrier locked, receiving 50bps data 5,6: Code and carrier locked 4: Code locked 3: Signal detected but unusable 1,2: Channel is searching 0: Channel is idle	
$8*ChN_i + 11$	I1		Elev	deg	SV elevation	
$8*ChN_i + 12$	I2		Az	deg	SV azimuth	

Notes:
1. This message is provided at the selected rate only if data is produced by the GPS receiver.
2. ChN_i goes from zero to NCh-1

Message	GPS_RAW	**Description**	GPS Raw Measurement Data		
Message ID	22	**Payload Length**	24*nSVs + 8	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		GPS_ts	msec	GPS Time
4	U2		GPS_week		GPS week
6	U1		reserved		reserved
7	U1		nSVs		Number of SVs to follow (upto 10)
The following block is repeated nSVs times.					
$24*nSVs_i + 8$	R8		CP	cycles	Carrier Phase
$24*nSVs_i + 16$	R8		PR	m	Pseudo Range
$24*nSVs_i + 24$	R4		Doppler	Hz	Doppler Measurement
$24*nSVs_i + 28$	U1		SVID		SV number
$24*nSVs_i + 29$	I1		QI	bitfield	Information regarding the receiver channel bit 7: Code/carrier locked, receiving 50bps data bit 5,6: Code and carrier locked bit 4: Code locked bit 3: Signal detected but unusable bit 1,2: Channel is searching bit 0: Channel is idle
$24*nSVs_i + 30$	U1		CNo	dbHz	Carrier to Noise ratio
$24*nSVs_i + 31$	U1		LLI		Loss of link indicator (RINEX definition)

Notes:
1. This message is provided at the selected rate only if data is produced by the GPS receiver.
2. This message is available in MIDG II firmware versions 2.0.8 and higher.

Message	GPS_CLK	**Description**	GPS Receiver Clock Solution		
Message ID	23	**Payload Length**	20 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		GPS_ts	msec	Timestamp
4	I4		CLKB	ns	Clock bias
8	I4		CLKD	ns/s	Clock drift
12	U4		TAcc	ns	Time accuracy estimate
16	U4		FAcc	ps/s	Frequency accuracy estimate

Notes:

Message	GPS_EPH	**Description**	GPS Satellite Ephemeris Data		
Message ID	24	**Payload Length**	77	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U1		SVID		SV number
1	U4		HOW		GPS Handover word
The following element is repeated 24 times. Each element is a 24 bit word of the GPS Navigation Msesage (see ICD-GPS-200). The 8 words following the telemetry and handover words of sub-frames 1 through 3 are included. Each word is arranged most significant byte first (big-endian).					
5+word*3	U3		Nav_word		Navigation word from subframes 1 through 3

Notes:

1. This message does not have a configurable message rate. Ephemeris data is polled for an SV by sending a message to the MIDG II with ID=24 (GPS_EPH) and a single payload byte which is the SV for which ephemeris data is being requested. In order to prevent overrunning the MIDG II output queue, requests are cached and ephemeris messages are sent at a rate of one ephemeris message per second.
2. Since the navigation words require significant byte splitting and parsing, no effort is made to align the 24 bit words on 4 byte boundaries.
3. If no valid ephemeris data is available for an SV, this message will have a single byte payload, the SVID, and the Handover word and navigation words will not be included.
4. This message is available in MIDG II firmware versions 2.1.109 and higher.

Message	TIM_UTC	**Description**	UTC Time		
Message ID	25	**Payload Length**	16 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		GPS_ts	msec	GPS Time
4	I4		Nano	ns	Nanoseconds of Second (-5e8 to 5e8)
8	U2		Year		Year (1999..2099)
10	U1		Month		Month (1..12)
11	U1		Day		Day of Month (1..31)
12	U1		Hour		Hour of Day (0..23)
13	U1		Min		Minute of Hour (0..59)
14	U1		Sec		Second of Minute (0..59)
15	U1		Valid	bitfield	Time information validity bit 2: Valid UTC (leap seconds known) bit 1: Week number valid bit 0: Time of week valid

Notes:

1. This message is provided at the selected rate only if data is produced by the GPS receiver.

Message	TIM_ERR	**Description**	Time Error Information		
Message ID	26	**Payload Length**	7 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		ts	msec	Timestamp
4	I1		TTB	counts	Time timer bias
5	I1		DTB	counts	Data timer bias
6	U1		Flags	bitfield	Flags bit 6: Timestamp is GPS time

Notes:

Message	TIM_PPS[1]	**Description**	Time Pulse Information		
Message ID	27	**Payload Length**	16 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4		TOW	msec	GPS time of next pulse
4	U4		Frac	msec/2^32	Fractional millisecond of next pulse
8	I4	2	QErr	ps	Quantization error of next pulse
12	U2		Week		GPS week number of next pulse
14	U1		Flags	bitfield	Flags bit 1: UTC is available bit 0: Time base is (0=GPS, 1=UTC)
15	U1		res		Reserved

Notes:

1. This message indicates the estimated time of the next GPS time pulse. The time pulse signal is available externally as an order option. The pulse signal is present only when the receiver is able to calculate a position solution. Accuracy of the pulse is 50ns RMS, <100ns 99%.
2. The time pulse signal is aligned to a 23.104 MHz clock, which results in a resolution of 43ns. The resulting quantization is considered in the time accuracy estimation of the receiver.

Message	TIM_TM[1]	**Description**	Time Mark Information		
Message ID	28	**Payload Length**	8 Bytes	**Applicable Modes**	IMU, VG, INS

Payload Contents

Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U4		TOW	msec	GPS time of received pulse rising edge
4	U2		Week		GPS week number of received pulse rising edge
6	U2		res		Reserved

Notes:

1. This message is only available on specially built MIDG II units that have a pulse input in place of the inverted 1PPS output (pin 8). This message reports the GPS time of the rising edge of the received pulse. This message is generated any time the pulse is received at up to 50Hz. If multiple pulses are received in a 50Hz period, the time of the most recent rising edge is reported.

1.2.2 External Measurements

The MIDG II messages defined in this section provide a mechanism for aiding the MIDG II Kalman filter with external measurements, including heading, magnetic vector, position, velocity, and air data.

- (31) HDG_MEAS Heading Measurement
- (32) AID_MAG Magnetometer vector aiding.
- (37) AID_POS Position aiding in ECEF, or LLA. Altitude can be WGS-84 or biased (e.g. barometric).
- (38) AID_VEL Velocity aiding.
- (39) AID_AIR Airspeed, angle of attack, angle of slip

NOTE: AID_POS and AID_AIR are not implemented as of 2.1.105.

Message	HDG_MEAS				
Description	Heading measurements			**Message Rate**	
Message ID	31	**Payload Length**	8 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4	1	ts	msec	Time
4	U2	2	dev		Details and vertical position standard deviation bit 15: Time value format 1 = GPS Time 0 = Estimated delay bits 14-12: (reserved) bits 11-0: heading standard dev (unit = 0.1 deg)
6	I2	3	hdg	0.1 deg	Heading measurement. Valid range is –1800 to 3600.

Notes:

1. The time value is either the GPS Time of Week of the measurement, or the estimated delay of the measurement from the time it is valid. The convention used depends on a bit in the Details field. If time delay is used, then the delay value is taken from the least significant byte of the ts field for a maximum delay of 255 milliseconds.
2. Bit 15 is described in note 1.
3. The heading measurement should be true heading with North at 0 degrees, East at 90 degrees, etc.

Message	AID_MAG	**Description**	Magnetometer Vector		
Message ID	32	**Payload Length**	12 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4	1	ts	msec	Time
4	U2	2	det		Details bit 15: Time value format 1 = GPS Time 0 = Estimated delay bits 14-0: (reserved)
6	I2	3	mx		X magnetic component
8	I2		my		Y magnetic component
10	I2		mz		Z magnetic component

Notes:

4. The time value is either the GPS Time of Week of the measurement, or the estimated delay of the measurement from the time it is valid. The convention used depends on a bit in the Details field. If time delay is used, then the delay value is taken from the least significant byte of the ts field for a maximum delay of 255 milliseconds.
5. Bit 15 is described in note 1.
6. Units for the magnetic components may be selected arbitrary. The maximum vector value should be high enough to provide good resolution, but low enough to avoid saturating the 16 bit signed integer field. A scaled range of +-10000 counts would be a good choice. Internally, the MIDG II will convert the vector components to a normalized unit vector for use as a measurement.

Message	AID_POS	**Description**	Position aiding		
Message ID	37	**Payload Length**	20 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4	1	ts	msec	Time
4	U2	2,3	vdev		Details and vertical position standard deviation bit 15: Time value format 1 = GPS Time 0 = Estimated delay bit 14: Measurement reference coordinates 1 = ECEF 0 = Lon/Lat/Altitude bit 13: Calculate altitude bias bit 12: (reserved) bits 11-0: vertical standard deviation (unit = 0.1 m)
6	U2	3	hdev	0.1 m	Horizontal position standard deviation
8	I4	4	X/Alt	1e-2 m	ECEF X or Altitude
12	I4	5	Y/Lon	1e-2 m 1e-7 deg	ECEF Y or Longitude
16	I4	5	Z/Lat	1e-2 m 1e-7 deg	ECEF Z or Latitude

Notes:

2. The time value is either the GPS Time of Week of the measurement, or the estimated delay of the measurement from the time it is valid. The convention used depends on a bit in the Details field. If time delay is used, then the delay value is taken from the least significant byte of the ts field for a maximum delay of 255 milliseconds.
3. Bit 15 is described in note 1. If bit 14 is set, the message must be full length. If it is cleared, then a short message that ends with the X/Alt field is accepted. If bit 13 is set, then the MIDG II assumes that it must calculate a bias for the altitude measurement when internal GPS data is available. Currently, a single bias is maintained inside the MIDG II for this measurement message, corresponding to a single external biased altitude sensor. The use of multiple biased external altitude measurements is not supported at this time.
4. The deviation fields indicate the expected standard deviation of the measurement. If a deviation field is zero, it indicates that the associated direction should not receive an update. For example, a packet that updates the latitude and longitude, but not the altitude, would set vdev bits 11-0 to zero.
5. If the measurement is LLA and hdev is zero, the message can end after the X/Alt field. The payload length in this case is 12 bytes.
6. In ECEF, the units are 1e-2 meters. In LLA, Lon and Lat have units 1e-7 degrees. All measurements are referenced to WGS-84 coordinates.

Message	AID_VEL	**Description**	Velocity		
Message ID	38	**Payload Length**	14 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4	1	ts	msec	Time
4	U2	2,3,4	vdev		Details and speed standard deviation bit 15: Time value format 1 = GPS Time 0 = Estimated delay bit 14: Speed only bits 13-12: (reserved) bits 11-0: Vertical speed standard deviation (unit = 0.1 m/s)
6	I2	4	Vu	1e-2 m/s	Up velocity (or velocity magnitude if vdev bit 14 is set)
8	I2		Ve	1e-2 m/s	East Velocity
10	I2		Vn	1e-2 m/s	North Velocity
12	U2		hdev	0.1 m/s	Horizontal speed standard deviation

Notes:

1. The time value is either the GPS Time of Week of the measurement, or the estimated delay of the measurement from the time it is valid. The convention used depends on a bit in the Details field. If time delay is used, then the delay value is taken from the least significant byte of the ts field for a maximum delay of 255 milliseconds.
2. Bit 15 is described in note 1.
3. The deviation field indicates the expected standard deviation of the measurement. If vdev bits 11-0 are zero, then the vertical component of velocity is not used in the measurement update.
4. Bit 14 indicates that (the absolute value of) Vu is the total speed through space, and vdev bits 11-0 are the standard deviation of the speed measurement. If bit 14 is cleared, then all elements of the message after Vu are ignored, and may be omitted by the sender.

Message	AID_AIR	**Description**	Air data (airspeed, angle of attack, angle of slip)		
Message ID	39	**Payload Length**	12 Bytes	**Applicable Modes**	INS

Payload Contents

Byte Offset	Number Format	Notes	Name	Unit	Purpose / Comment
0	U4	1	ts	msec	Time
4	U2	2,3	dev		Details and airspeed standard deviation bit 15: Time value format 1 = GPS Time 0 = Estimated delay bits 14-12: (reserved) bits 11-0: True Airspeed standard deviation (unit = 0.1 m/s)
6	U2	6	aspd	0.1 m/s	True Airspeed
8	U2	4,5	aoa		Angle of attack bits 15-12: deviation bits 11-0: angle of attack
10	U2	4,5	aos		Angle of attack bits 15-12: deviation bits 11-0: angle of slip

Notes:

1. The time value is either the GPS Time of Week of the measurement, or the estimated delay of the measurement from the time it is valid. The convention used depends on a bit in the Details field. If time delay is used, then the delay value is taken from the least significant byte of the ts field for a maximum delay of 255 milliseconds.
2. Bit 15 is described in note 1.
3. The deviation field indicates the expected standard deviation of the measurement.
4. Deviation represents the standard deviation of the angle measurement. The actual deviation applied with the measurement is the deviation 4 bit value times 2 plus 1. For example, 0 = 1 degree, 1 = 3 degrees, 2 = 5 degrees, … 15 = 31 degrees.
5. The angle is represented as a 12 bit scaled signed integer that represents approximately +- 90 degrees. The scale factor is 90/2048, which gives slightly better than 0.05 degree resolution. For example, 123 = 5.4 degrees.
6. The provided airspeed is expected to be the ground speed plus the current wind, so that if the wind is estimated and removed from this measurement, it will be equivalent to the ground speed.

1.2.3 Miscellaneous MIDG II Input

Several message are provided for commanding and providing information to the MIDG II.
Supported input messages (message IDs):

- (30) RTCM RTCM differential correction data
- (99) RESET System reset

Message	RTCM					
Description	RTCM DGPS corrections				**Message Rate**	
Message ID	30	**Payload Length**	variable		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	BN	1	RTCM		RTCM data for differential GPS corrections	
Notes: 1. RTCM corrections are provided to the MIDG II as a stream of bytes. Typically, GPS ground stations that create differential GPS corrections provide a serial stream of these corrections to the user. The contents of this stream must be encapsulated in this packet and provided to the MIDG II. The MIDG II accepts RTCM message types 1, 2, 3, and 9.						

Message	RESET					
Description	Soft reset command				**Message Rate**	
Message ID	99	**Payload Length**	n Bytes		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	U4		code		Value must be 0x01310655 for reset to occur	
Notes:						

1.2.4 Configuration

Configuration messages provide access to the setup information of the MIDG II. This includes the selected mode of operation, message rates, output formats, etc. All configuration takes place through only two packets that allow for setting and querying the configuration information. Of course, the handshaking packets are used as well. The set and query packets are defined below, but the actual configuration items are described in a separate section that is applicable to the mBin protocol and legacy protocols (MIDG) with which the MIDG II is compatible.

- (35) CFG_SET Configuration Set
- (36) CFG_QUERY Configuration Query

Message	CFG_SET					
Description	Sets configuration items				**Message Rate**	
Message ID	35	**Payload Length**	variable		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	BN	1	data		Zero or more bytes that are configuration item specific	
Notes: 1. The possible payloads for configuration are described in a separate section of this document. If configuration change is successful, the MIDG II will reply with an ACK message. If configuration change is not successful, the MIDG II will reply with a NACK message indicating the reason for failure.						

Message	CFG_QUERY					
Description	Queries configuration items				**Message Rate**	
Message ID	36	**Payload Length**	variable		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	BN	1	data		Zero or more bytes that are configuration item specific	
Notes: 1. See note 1 for the CFG_SET message.						

1.2.5 Handshaking

Handshaking messages provide a method by which the MIDG II and host can acknowledge requests and commands.
Supported messages (message IDs):

- (40) ACK Acknowledge
- (41) NACK Negative Acknowledge

Message	ACK					
Description	Message acknowledgement				**Message Rate**	
Message ID	40	**Payload Length**	variable		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	U1		to		Message ID to which this is a reply	
1	BN		data		Zero or more bytes that are reply specific	
Notes:						

Message	NACK					
Description	Message negative acknowledgement				**Message Rate**	
Message ID	41	**Payload Length**	variable		**Applicable Modes**	IMU, VG, INS
Payload Contents						
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**	
0	U1		to		Message ID to which this is a reply	
1	BN		data		Zero or more bytes that are reply specific	
Notes:						

1.3 Configuration Subsystem

The MIDG II provides configuration options to ensure that it is flexible to meet a wide variety of customer applications. This section deals with the configuration messages that are accepted and the replies that are generated. There are two classes of configuration request: configuration-set requests, and configuration-query requests.

1.3.1 Configuration-Set Requests

Configuration-set requests are sent to the MIDG II using the CFG_SET message. The payload of the CFG_SET message determines the specific configuration change that is requested. In all cases, the first byte indicates the configuration item being addressed. The remaining byes contain the details of the change request. The following tables describe the payload of each possible configuration-set request.

Item	BAUD				
Description	Sets the serial interface baud rate			**Bytes**	2
Item ID	1				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1	1	baud		Baud rate select value 0 = 115200 1 = 57600 2 = 38400 3 = 19200 4 = 9600
Notes: 1. Changes take effect on reset.					

Item	PROTOCOL				
Description	Sets the serial interface protocol			**Bytes**	2
Item ID	2				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1	1	protocol		Protocol select value 0 = Microbotics Binary Protocol
Notes: 1. Changes take effect on reset. Currently, the only valid protocol is Microbotics Binary Protocol.					

Item	FORMAT				
Description	Output format for position and velocity			**Bytes**	2
Item ID	3				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1	1	format	bitfield	Solution Status: bits 4-7: Reserved bits 2-3: Position Format 0=ECEF 1=ENU 2,3=Lon,Lat,Alt bit 1: Velocity Format 0=ECEF 1=ENU bit 0: ENU position relative to first fix
Notes: 1. If ENU position format is selected, the position will be relative to either the first GPS fix since reset or a location specified in configuration, depending on bit 0.					

Item	MODE				
Description	Sets the desired run mode			**Bytes**	2
Item ID	4				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1		mode		Mode select value 0 = IMU 1 = VG (Vertical Gyro) 2 = INS
Notes:					

Message	MSG_DIV				
Description	Sets message divisor			**Bytes**	3
Item ID	5				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1		msg		Message for which the divisor is to be changed
2	U1		divisor		The message rate for the specified message will be 50/divisor. If divisor is zero, the message will be disabled, although it may still be queried.
Notes:					

Message	POS_REF				
Description	Sets position reference for relative position			**Bytes**	16
Item ID	6				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1		res1		reserved
2	U2		res2		reserved
4	I4	1	POS_X	cm	X Position, ECEF coordinates
8	I4		POS_Y	cm	Y Position, ECEF coordinates
12	I4		POS_Z	cm	Z Position, ECEF coordinates

Notes:

1. The specified location is used as the reference point against which relative ENU position is calculated, assuming that bit 0 of the FORMAT configuration message is cleared.

Message	XFORM				
Description	Sets the output transform			**Bytes**	8
Item ID	10				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1		res		reserved
2	I2	1	yaw	0.01 deg	Transform yaw
4	I2		pitch	0.01 deg	Transform pitch
6	I2		roll	0.01 deg	Transform roll

Notes:

2. The yaw, pitch, and roll indicated in this packet are the Euler angles that define a rotation from the MIDG II sensor coordinates to the vehicle coordinates. In other words, the resulting direction cosine matrix would be able to transform vectors from vehicle coordinates to MIDG II sensor coordinates.

Message	HDG				
Description	Heading measurement configuration			**Bytes**	8
Item ID	11				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1	1	cfg		Magnetometer operation settings: bit 7: (reserved) bits 6-4: Internal mag aiding threshold bit 3: Use velocity vector for heading even when turning bit 2: Use velocity vector for heading bit 1: Enable internal mag in VG mode bit 0: Enable internal mag in INS mode
2	I2	2	X bias		X axis magnetometer bias
4	I2	2	Y bias		Y axis magnetometer bias
6	I2	2	Z bias		Z axis magnetometer bias

Notes:

1. Further description of the configuration bit field values:
   Bits 4-6 specify the aiding threshold used when applying internal magnetometer measurements. The internal magnetometer will not be used if the current heading accuracy is better than the selected threshold. The default threshold in previous versions of the MIDG II firmware was level 4 (8 degrees). The threshold values correspond to 1 sigma error estimates as follows:

Threshold	Measurement (1 sigma)
0	0.5 degree
1	1.0 degree
2	2.0 degrees
3	4.0 degrees
4	8.0 degrees
5	12.0 degrees
6	20.0 degrees
7	30.0 degrees

   Bit 2 allows the velocity vector, from GPS or external measurement, to be used as a heading measurement. This assumes that the MIDG II is aligned with the vehicle such that heading is equivalent to direction of motion, and is generally applicable for ground vehicles. If the velocity vector is different from heading when turning, select bit 3 also. This can happen when, for example, when the GPS antenna is not mounted above the rear axle of a car.

   Bits 1 and 2 allow the internal magnetometer to be disabled in either INS or VG mode.

2. The provided bias values are subtracted from the magnetometer data. They are estimated biases, not bias corrections.

Message	CFG_SAVE				
Description	Stores configuration in non-volatile memory			**Bytes**	1
Item ID	100				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID

Notes:
This configuration message must be issued for any configuration changes to be preserved across resets.

Message	CFG_LOAD				
Description	Reloads configuration from NV memory			**Bytes**	1
Item ID	101				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
Notes: This configuration message resets the configuration information to stored values.					

Message	CFG_ERASE				
Description	Stores configuration in non-volatile memory			**Bytes**	1
Item ID	102				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
Notes: This configuration message erases non-volatile memory. If non-volatile configuration memory does not contain valid configuration information upon reset, default values are used.					

1.3.2 Configuration-Set Replies

The MIDG II will respond to each configuration set request with either an ACK or a NACK message. The formats for these replies are as follows:

Payload of ACK reply to CFG_SET Message					
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		CFG_SET		Value is 35, indicating that this is a reply to CFG_SET
1	U1		item		Configuration item number that was successfully changed

Payload of NACK reply to CFG_SET Message					
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		CFG_SET		Value is 35, indicating that this is a reply to CFG_SET
1	U1		item		Configuration item number that was successfully changed
2	U1		code		Failure codes 1 wrong number of parameters 2 bad configuration item number 3 invalid request 4 change would exhaust the serial port bandwidth 5 subsystem busy, please retry

1.3.3 Configuration-Query Requests

Configuration-query requests are sent to the MIDG II using the CFG_QUERY message. The payload of CFG_QUERY messages from the host consist of a single unsigned character which is the information item that is being requested. See section 1.3.1, Configuration-Set Requests, to get a list of configuration items that can be queried. In addition to querying configuration information, the configuration-query requests are also used to retrieve general information from the MIDG II such as part number, serial number, and installed firmware version. Information requests are formulated in the same way as configuration requests; the structure is as follows:

Message	INFO				
Description	Retrieves information			**Bytes**	2
Item ID	20				
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Item ID
1	U1		info		Info ID 0 = Manufacturer 1 = Product 2 = Part number 3 = Serial number 4 = Support key 5 = Firmware version
Notes:					

The response to an information query will be the same as the response to a configuration query (see section 1.3.4, Configuration-Query Replies). It will include the item ID (20 in this case), the info ID, and a null terminated string. If the requested info ID is not recognized, the reply will be a null string.

1.3.4 Configuration-Query Replies

Replies to configuration-query requests are not issued in ACK packets, although NACK packets are used to indicate a failed query. Configuration-query replies have the same ID as the configuration-query packet, and the content is identical to the corresponding configuration-set message.

Payload of CFG_QUERY reply to CFG_QUERY Message					
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		item		Configuration item number that was successfully queried
…	*The remaining bytes match the configuration-set request (section 1.3.1) corresponding to the item number.*				

Payload of NACK reply to CFG_QUERY Message					
Byte Offset	**Number Format**	**Notes**	**Name**	**Unit**	**Purpose / Comment**
0	U1		CFG_QUERY		Value is 36, indicating this is a reply to CFG_QUERY
1	U1		item		Configuration item number that was successfully changed
2	U1		code		Failure codes 2 bad configuration item number

Revision History

June 18, 2007	Added GPS_EPH message definition. GPS_SVI: Updated QI field documentation. QI is a value, not a bitfield.
December 14, 2006	Redefined HDG_MEAS external heading aid message to be more consistent with the other aiding messages. Removed option for tilt aiding from magnetometer. Removed bit 7 from HDG Configuration set request. Bit 7 is now reserved.
September 20, 2006	Corrected the TIM_UTC Nano field type from U4 to I4.
September 12, 2006	Added NAV_HDG message.
August 29, 2006	Updated notes of HDG_MEAS message. Changed MAG configuration message name to HDG and added new configuration bits and more detailed notes. Replaced deprecated TAcc field of TIM_UTC message with nanoseconds of second. Removed DEBUG configuration message. Changed PROTOCOL configuration message. The only supported protocol is now Microbotics binary protocol. New measurement flags added to the NAV_SENSOR message. Changed NAV_PV message flags to correspond to new behavior. The source and GPS valid flags have been replaced by position and velocity estimate invalid flags.
March 17, 2006	Added TIM_TP (28) message.
September 7, 2005	Corrected Payload Length field in GPS_RAW (22) message table.
May 26, 2005	Added GPS_CLK message. NAV_PV: Added Details bit 4 to indicate valid GPS position and velocity. TIM_UTC: Deprecated TAcc field of message. TIM_PPS: Updated notes for message.
November 30, 2004	Added GPS_RAW message.
October 27, 2004	Specified payload byte order and bit field order.
September 2, 2004	Fixed STATUS message, NV valid bit (previously read NV invalid).
July 19, 2004	Updated for firmware 2.0.3. New TIM_PPS message.
June 18, 2004	Fixed length and byte offset error in NAV_ACC message specification.
March 11, 2004	First release document