MICROBOTICS, INC.

MIDG Series INS/GPS Application Note
AN001 - Operating Mode
January 9, 2012

1 MIDG Series INS/GPS. The MIDG Series INS/GPS has three distinct modes of operation: At power-on, the MIDG Series INS/GPS attempts to load the user's configuration data which was stored in non-volatile memory. If user's configuration data is not present, the default configuration is used. The *"Run Mode"* is the configuration option which determines, in part, how the mode transitions occur. The default value for Run Mode is INS.

1.1 Alignment Modes The MIDG Series INS/GPS has four distinct alignment modes. These alignment modes are the stages of sensor alignment. These modes do not provide full navigational data. The MIDG Series INS/GPS should be allowed to transition to an operational mode before relying on outputted data. Alignment time is about two minutes. The Figure 1 outlines the transitions between states. The alignment modes are as follows:

A. **Initialize Alignment -** At power-on, the alignment procedure begins.

B. **Coarse Alignment -** Applies any stored sensor biases to the sensor alignment.

C. **Medium Alignment -** Applies GPS readings being received to the sensor alignment.

D. **Fine Alignment -** Tunes the sensor alignment for a formal operational mode.

1.2 Operational Modes The MIDG Series INS/GPS has three distinct modes of operation: These modes are mutually exclusive and the active mode is determined based on the user's configuration and internal operating criteria. The operational modes are as follows:

A. **IMU** - Inertial Measurement Unit

B. **VG** - Vertical Gyro

C. **INS** - Inertial Navigation System

2 IMU mode. The IMU mode is the most basic of the operating modes. In this mode, the MIDG Series INS/GPS provides calibrated values for angular rate, acceleration, and magnetic field. Measurements from the GPS receiver are also available at rates up to 4Hz; however, none of the position/velocity/attitude estimation algorithms are executed and as a result, attitude is also not available.

3 VG mode. The VG mode provides the basic attitude estimation to IMU mode. In VG mode, the data from the rate sensors is accumulated to provide an estimate of attitude. Of course, the residual errors in angular rates causes the attitude estimate to drift away from the true attitude. To compensate for this drift, the gravity vector (as measured by the accelerometers) is used as an indication of whether the MIDG Series INS/GPS is level. Additionally, the
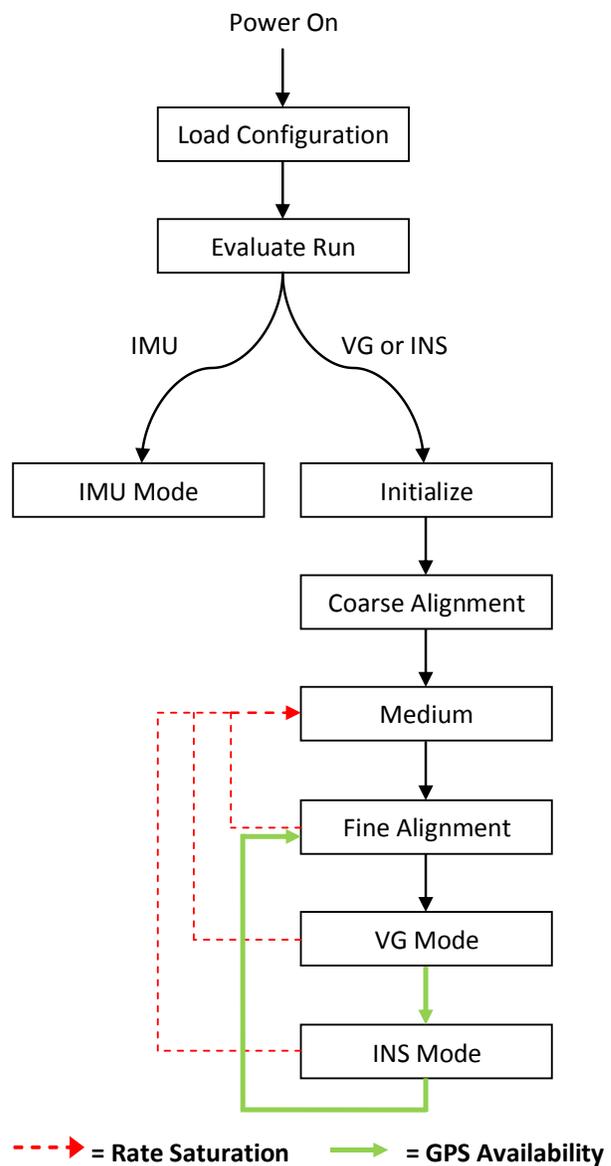
Figure 1. MIDG Series INS/GPS mode transitions.

magnetometer data is used as an indication of North direction. The vertical gyro algorithm relies heavily on the rate sensors so that errors induced from vehicle acceleration are minimized.

4 INS mode. In INS mode, the MIDG Series INS/GPS provides estimates of position, velocity, and attitude at rates up to 50Hz via a state estimation filter and error-corrected angular rates and accelerations are provided. In order to enter INS mode, the unit must be configured for INS operation (which is the default) and GPS must be available. The MIDG Series INS/GPS will not transition into INS mode without GPS. The MIDG Series INS/GPS will remain in INS mode until the accuracy of its estimates degrade to an unacceptable level due to lack of GPS measurements. In this case, the MIDG Series INS/GPS will transition back into the Fine Alignment mode, then proceed to Vertical Gyro mode, and then wait for GPS to become available once again Refer to the Figure 1.
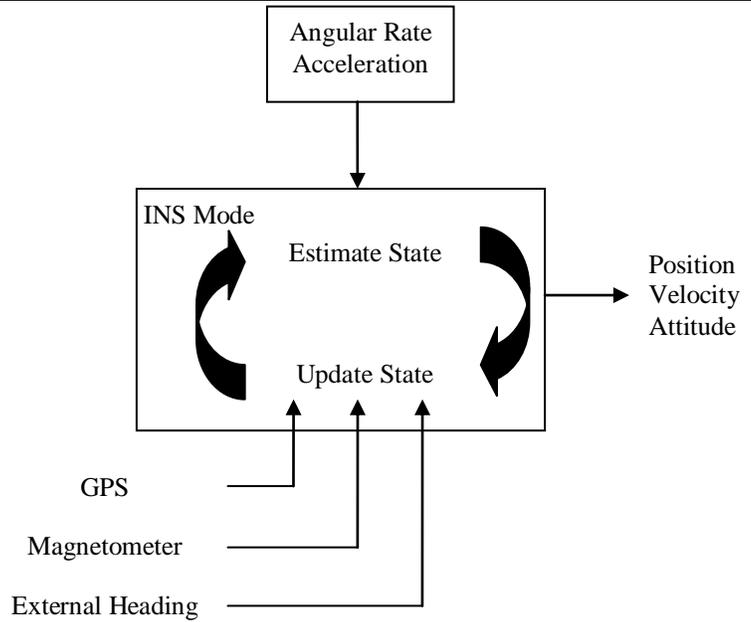
Figure 2. Update State Flow

Table 1	
Update State Logic	
If a GPS measurement arrives	Apply it.
If 1) An external heading measurement arrives, and 2) The heading error estimates is greater than the specified external heading confidence level	Apply at specified level
If 1) "Mag" measurements are enabled in INS modes, and 2) The heading error estimates are greater than the magnetometer confidence level	Apply at Magnetometer confidence level

The INS filter uses measurements from the internal GPS receiver, internal magnetometer, and an external heading source to produce accurate estimates of position, velocity, and attitude. The Update State flow is diagramed in Figure 2 shows how the measurements are applied by the filter to update the estimates. Table 1 displays the "Update State Logic" as it is used in the INS solution. Both the magnetometer update and the external heading update have an associated confidence level that represents the accuracy of the measurements. Table 2 displays the confidence level associated with the

magnetometer and external heading updates. The confidence level is also associated to one sigma accuracy applicable to all firmware versions 2.0.4 and higher. If magnetometer measurements are enabled for INS mode, they are applied with a confidence level of 4 by default; however, this value can be changed by the user. The confidence level associated with external heading measurements are specified with each measurement. Refer to the MIDG Series INS/GPS Message Specification for details on using the HDG_MEAS message (ID 31) to provide external heading measurements.

5 Rate Saturation. Rate saturation occurs when the INS rotates at an angular rate which is greater than what can be sensed by the rate sensors. When this occurs, the accumulation of angular rate fails to produce the correct attitude because some of the angular rate information is lost.

Table 2	
Confidence Level	**Standard Deviation (Degrees)**
0	0.5
1	1.0
2	2.0
3	4.0
4	8.0
5	12.0
6	20.0
7	30.0

Subsequently, the INS attitude estimate becomes uncertain and unreliable. To compensate for this special case, the MIDG Series INS/GPS switches into the Medium Alignment mode in an effort to recover. Under normal operation, rate saturation should never occur.

6 Help and Support. Microbotics, Inc. is dedicated to supporting the missions of our clients and offers free thirty (30) days of support for all of our products. Visit Microbotics on our website at www.microboticsinc.com for more information about our entire product line. For pricing and availability, please visit our contact page at www.microboticsinc.com/contact.html. All technical inquires should be sent to support@microboticsinc.com