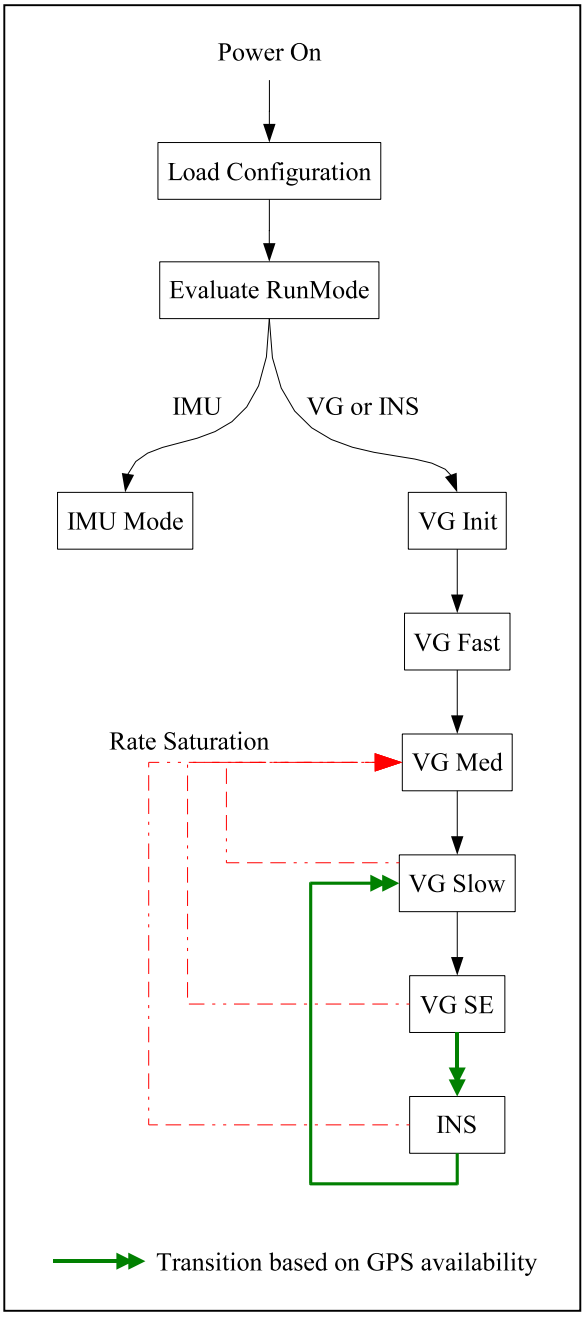
MIDG II Operating Modes

The MIDG II has three distinct modes of operation: IMU, VG (vertical gyro), and INS. The modes are mutually exclusive and the active mode is determined based on user configuration and internal operating criteria. The figure below depicts the possible mode transitions from power-on.

At power-on, the MIDG II attempts to load user configuration data from non-volatile memory. If user configuration data is not present, the default configuration will be used. Run Mode is a configuration option which determines, in part, how the mode transitions occur. The default value for Run Mode is INS.



IMU Mode

IMU mode represents the most basic operation. In this mode, the MIDG II provides calibrated values for angular rate, acceleration, and magnetic field. Measurements from the GPS receiver are also available. However, none of the position/velocity/attitude estimation algorithms are executed. As a result, attitude is not available, and position and velocity are available directly from the GPS receiver at up to 5Hz.

VG Mode

VG mode adds 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 correct this drift, the gravity vector (as measured by the accelerometers) is used as an indication of whether the MIDG II is level. Additionally, the magnetometer data is used as an indication of North direction. The vertical gyro algorithm heavily relies on the rate sensors so that errors induced from vehicle acceleration are minimized.

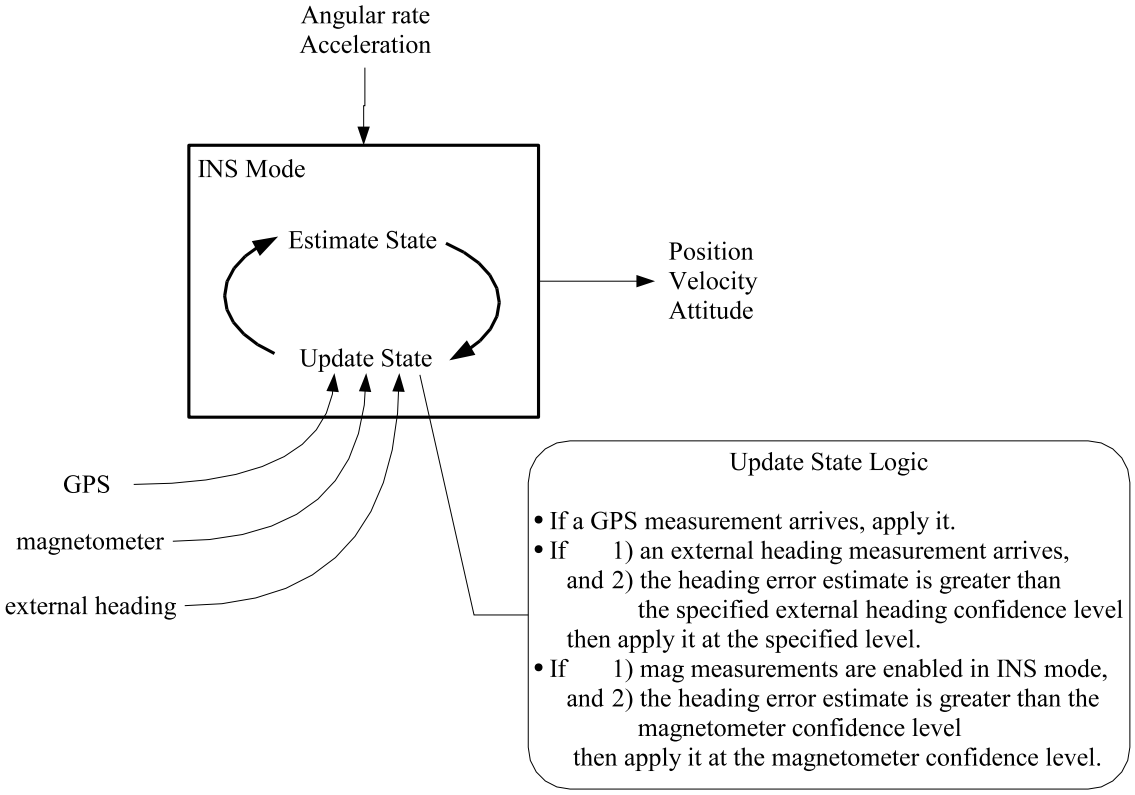
VG mode is further divided into sub-modes: VG_INIT, VG_FAST, VG_MED, VG_SLOW, and VG_SE. VG_INIT is the first mode that is entered after power-on if the user has configured the MIDG II to operate in either VG or INS mode. In VG_INIT, the accelerometer and magnetometer are taken with high confidence as indicators of attitude. VG_FAST, VG_MED, and VG_SLOW are successive modes in which confidence is gradually transferred from the accelerometers and magnetometer as indicators of attitude truth, to the rate sensors. VG_SE is the same as VG_SLOW, except that in VG_SE the MIDG II is eligible for transition into INS mode. The transitions from VG_INIT to subsequent VG modes occurs based on internal criteria. Complete transition to VG_SE typically occurs within one minute of power-on.

INS Mode

In INS mode, the MIDG II provides estimates of position, velocity, and attitude at up to 50Hz using a state estimation filter. Error-corrected angular rates and accelerations are provided as well. In order to enter INS mode, the MIDG II must be configured for INS operation (which is the default) and GPS must be available. The MIDG II will not transition into INS mode without GPS. The MIDG II 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 II will transition back to VG_SLOW mode, proceed to VG_SE mode, and then wait for GPS to become available once again.

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 figure below shows how the measurements are applied by the filter to update the estimates. Both the magnetometer update and the external heading update have an associated confidence level that represents the accuracy of the measurements. Confidence level is associated to one-sigma accuracy as shown in the table (applicable to firmware 2.0.4 and greater). If magnetometer measurements are enabled for INS mode, they are applied with a confidence level of 4. The confidence level associated with external heading measurements are specified with each measurement. See the MIDG II Message Specification Document for details on using the HDG_MEAS message to provide external heading measurements.



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

Rate Saturation

Rate saturation occurs when the INS rotates at an angular rate that is greater than what can be sensed by the rate sensors. In this case, the accumulation of angular rate fails to produce the correct attitude because some of the angular rate information is lost. Subsequently, when rate saturation occurs, the INS attitude estimate becomes uncertain. To deal with this special case, the MIDG II switches to VG_MED mode in an effort to recover. Note that rate saturation should never occur in normal operation.