

# Understanding the G1000 Holding Pattern

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## Overview

Recent technological advances have allowed GPS units to not only display moving maps but also draw flight paths and even holding patterns. This paper reviews the holding pattern functions of the Garmin 1000 (G1000) and provides guidance on the use of GPS displayed holding patterns. Below are the questions that were posed at the onset of recent research which was conducted in both a G1000 equipped simulator and a Cessna 172 with a flight director equipped G1000 system.

## Questions

- How does the G1000 determine the size of the holds displayed on the MFD?
- How does the G1000 determine the shape of holds displayed on the MFD?
- What indications does the G1000 provide on the CDI during a published hold?
- How are entry procedures determined and drawn on the MFD?
- May a hold be flown by tracking the MFD?
- How does a flight director behave during a published hold?
- How may GPS published holding best be flown?

## Brief Answers

The G1000 determines holding size based on ground speed and reshapes the holding pattern based on wind information. The course deviation indicator (CDI) operates the same with a published hold as it does in OBS mode or with a VOR. The CDI does not follow the path displayed on the multi-function display (MFD.) Entries are determined by comparing ground track to the FAA standard procedure for determining entry. The straight segments of entry procedures are drawn without consideration for wind or turns occurring on the holding fix. Curved portions of the entry are adjusted for ground speed and wind. All turns are assumed to be standard rate. While the CDI does not track the MFD while holding, the flight director does. Aircraft with integrated autopilots may fly a hold by selecting NAV. Aircraft without a flight director should fly inbound with the GPS driven CDI but fly outbound with standard holding methods.

## **Full Explanation**

### Determining the Size of the Holds Displayed on the MFD

The G100 determines the size of the hold (including straight segments and turns) based on groundspeed. Airspeed does not factor into the size of the hold. A failure of the airspeed indicator or lack of wind information has no bearing on the size of the holding pattern presented on multi-function display (MFD.) As ground speed changes, the size of the hold is updated. This update process occurs before, during and after entry into the hold and continues throughout the holding pattern. In the event that no wind information is available the G1000 will assume that no wind is present and use groundspeed (not airspeed) to determine the size of the hold presented on the MFD. If the aircraft's groundspeed is affected by the wind, the hold will change size every time the aircraft changes direction before and during the hold.

### Determining the Shape of Holds Displayed on the MFD

The shape of the holding pattern presented on the MFD is created based on the ground speed of the aircraft and wind information. The shape of the hold updates when ground speed and/or wind change. This update process occurs before, during and after entry into the hold and continues throughout the holding pattern. The projected shape of the hold will be inaccurate anytime that wind information is incorrect. Inaccurate or missing airspeed input does not directly affect the size or shape of the hold presented. However, incorrect airspeed information will result in inaccurate wind information, thereby affecting the shape of the hold. In the event that no wind information is available the G1000 will assume that no wind is present and draw a symmetrical racetrack pattern based on ground speed and standard rate of turn (3 degrees per second.)

### Indications on CDI During a Published Hold

When the G1000 navigates a published hold, the CDI aligns with the inbound leg and provides lateral navigation to the fix. The CDI course (CRS) remains the same throughout the hold and CDI indicates in the same manner as it would in OBS mode or VOR (NAV) mode. The TO/FROM flag changes from TO to FROM when crossing the fix inbound and changes back to TO as the aircraft passes the abeam point on the outbound leg. The CDI does not track the holding pattern displayed on the MFD. Therefore, pilots flying without a flight director (FD) should use normal outbound procedures to fly the hold and not attempt to track the MFD. For aircraft with FDs see below.

## Entry Procedures

As the aircraft approaches a published hold, the G1000 determines the appropriate method using the FAA's standard method, comparing the track of the aircraft to the direction of the hold. Note that the G1000 uses ground track (not magnetic heading) to determine the entry. Therefore, a partial or complete failure of the magnetometer will not prevent the G1000 from recommending an entry. Note that G1000 does not consider heading or wind information when determining the entry procedure; therefore, it will not return an optimal entry for all conditions. Less than optimal entries are more likely to be presented when the track is close to a decision point (choosing between two possible entries) and/or during high winds. Once an entry has been selected by the G1000 it is displayed on the MFD. The groundspeed and wind speed (when available) is used to determine the size, shape and location of the inbound turn on the entry procedure. The straight segments of the entry procedure displayed on the MFD during teardrop and parallel entries is drawn straight from the holding fix and does not account for a turn over the fix to begin the entry.

## Flight by Tracking the MFD

While a published hold is presented on the multi-function display (MFD), the course deviation indicator (CDI) does not track the path display. When flying without a flight director (FD) the only way for the MFD path to provide direct guidance is by attempting to match the aircraft path on the MFD with the hold displayed. Navigation by an MFD without CDI support is not generally an approved method of navigation because the MFD does not have a standard scale to display lateral displacement. Further, the present aircraft track displayed on the MFD lags behind the actual aircraft position, making navigation solely by MFD map difficult.

## Flight Director (FD) During a Published Hold

When entering a published hold with a FD the CDI will provide lateral navigation only on the inbound leg. The FD, however, will track the holding pattern displayed on the MFD and provide attitude commands to follow the path. The FAA allows the use of a FD for lateral navigation for holding patterns. At times, the FD may command turns at less than standard rate; this is acceptable and the aircraft should be banked as commanded. While the use of a FD is permitted, it is not required, and FD indications may be disregarded. When choosing not to use a FD, it is advisable to turn off the FD display to avoid confusion.

## Best Use of GPS Published Holding

For aircraft equipped with a flight director (FD), use of the FD and autopilot (if equipped) is recommended in order to reduce pilot work load and decrease the possibility of encountering an unusual attitude while multi-tasking. For aircraft not equipped with a FD, the CDI should be used to navigate inbound to the fix and standard holding methods (using headings) should be used for the outbound leg. Attempting to visually track the pattern displayed on the MFD is not advisable for several reasons: the GPS lags behind the aircraft's actual position and track, the size and shape of the hold displayed may change multiple times during the hold, the hold may be incorrectly drawn due to inaccurate or missing wind information, and excess pilot attention to the MFD may result in an unusual attitude.

## **Summary**

Many new students see the G1000 and its large, complex screens as a one-stop-shop for all navigation needs. However, the G1000 is like any other navigation equipment, with its own applications and limitations. The G1000 provides a multi-function display with moving map for the purpose of supporting situational awareness and not to replace existing lateral navigation. The CDI should be flown anytime the aircraft is inbound to the holding fix, and normal headings, times and distances should be flown when outbound, unless a FD is in use. Ultimately, the purpose of GPS technology should be to help the pilot gain and maintain situation awareness, not to relieve him of that responsibility, and the only way to properly use any equipment is to fully understand how and why it functions.

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