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Missed Approach from a Circling Procedure

Aircraft Type: TBM 900	Pilots: Ryan Van Haren & Mel Rushton
Avionics: Garmin G1000 NXi	Date: May 7, 2020
Firmware Version: Socata TBM850 3086.00	Applicability: All Garmin G1000 Equipped Aircraft & Possibly Other Garmin Installations with Some Variations

Introduction:

This report has been created due to some uncertainty and confusion surrounding the behavior of the Garmin G1000 during a missed approach from a circling procedure. This is a required maneuver by both the FAA and Transport Canada on check-rides and must be understood. As flying coaches and consultants, we have been asked several times about what would happen with the avionics logic and how best to address this event. At Cardinal Aviation, when we do not know the answer, we do what we can to find it to the best of our ability.

After surveying several well-respected industry pilots and instructors to no avail, we chose to conduct a test flight to observe and record what will happen in the event that a missed approach must be executed once a circling procedure has been commenced.

Note:

1. This document is **NOT** to be interpreted as flight instruction or the publishing of a procedure. This document's sole purpose is to identify what we observed and how we chose to manipulate the avionics to achieve our desired outcome.
2. Circling procedures carry **INCREASED RISK** compared to a straight-in approach. This is due to operating an aircraft at low altitude (300ft obstacle clearance) in sometimes limited visibility at reduced airspeeds and high bank angles in close proximity to an airport and terrain. Many renowned aircraft training organizations strongly recommend that circling procedures be avoided.



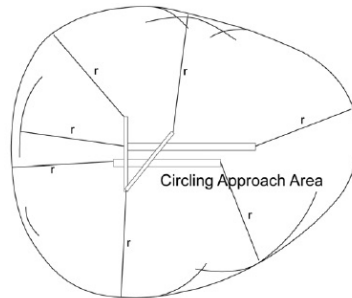
Missed Approach from a Circling Procedure

Circling Procedure Background Information:

- A circling procedure is the visual manoeuvring required, after completing an instrument approach, to bring an aircraft into position for a landing on a runway which is not suitably located for a straight-in approach.
- The straight-in instrument approach from which the circling procedure will begin must have published circling minima to be eligible for a circling procedure.
- Pilots must use the circling minima that applies to their category of aircraft. The category is determined based on the indicated airspeed that the manoeuvre will be flown at. If there are no circling minima published for your category then a circling procedure is not authorized.

Aircraft Categories (Speed)				
A	B	C	D	E
Up to 90 KTS	91 – 120 KTS	121 – 140 KTS	141 – 165 KTS	Military

- Based on the category of aircraft, 300ft of obstacle clearance is provided within the following distances. The distances are based on drawing concentric radii from the threshold of each runway at the aerodrome.



Aircraft Categories (Protected Distance)				
A	B	C	D	E
1.3 NM	1.5 NM	1.7 NM	2.3 NM	Military

- Pilots should pay particular attention on the approach plate to any restrictions involving quadrants of the airport that may not be used for circling due to terrain.
- In the event that the aircraft inadvertently re-enters IMC or loses visual contact with the airport the pilot is required to navigate toward the center of the airport and fly the published missed approach procedure for the straight-in approach that they were cleared for prior to commencing the circling procedure.

Note:

- In the event that a pilot must fly a circling procedure, Cardinal Aviation recommends that the circling minima and protected distance used are the ones for the next category higher than your aircraft in order to provide an increased margin of safety to an already inherently higher risk manoeuvre.



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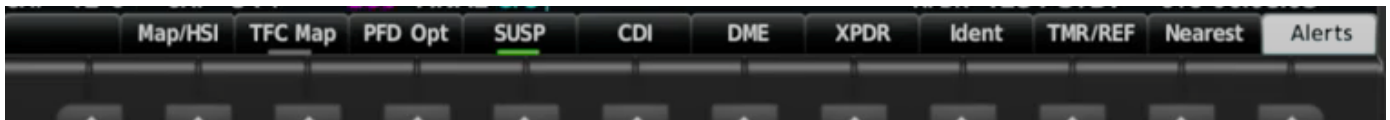
AFCS Status Box / Mode Annunciator Display / Flight Mode Annunciator / Scoreboard

- These are all names given to the top section of the PFD which tells the pilot what modes are active or in standby for the Flight Director or Autopilot. Active modes are displayed in **GREEN** while modes that are in standby are displayed in **WHITE**.
- At Cardinal Aviation, we refer to this as the "SCOREBOARD". Much like the jumbotron at a sporting event the score board is where we go to see what is happening with our flight guidance system and to verify that the modes that we have selected with various buttons have actually been armed or engaged in the FD/AP.
- It is imperative that after selecting a FD/AP mode with a button that they verify its status on the scoreboard/AFCS status box. Simply selecting a vertical or lateral mode by pressing a button without also checking its status is a recipe for trouble.
- In order to effectively check the scoreboard pilots must first know what they expect to see displayed based on their current NAV source and which lateral or vertical mode they select.

Garmin System Logic for Missed Approaches from a Straight-In Approach:

- The waypoints of the loaded approach will sequence as the aircraft passes each waypoint until the missed approach point (MAP). For RNAV approaches this is typically identified as RWY##.
- At the MAP the Garmin will SUSPEND (SUSP) sequencing. (The OBS softkey will change to SUSP)
- This means that if nothing is done and the aircraft does not land, the lateral flight guidance will be straight ahead on the approach's inbound track forever unless something is done.
- The logic behind this is that if in the late stages of the approach the pilot looks down at the chart and looks back up there is a clear indication that the MAP has been passed and that a missed approach must be commenced.
- Upon reaching the MAP the pilot will conduct a missed approach. In order to command the lateral navigation mode to sequence to the missed approach procedure the pilot will need to UNSUSPEND the sequencing of the loaded approach. If the approach flown was an ILS, the pilot may need to change the source of their CDI from NAV to FMS or GPS (Green to Pink Needles).
- Unsuspending of approach sequencing can be accomplished by:
 - A) Pressing the PROC key > Turn FMS Knob to highlight 'Activate Missed Approach > Press ENT Key
Or
 - B) Flying past the MAP and select the SUSP Softkey on the PFD
Or
 - C) Press the Go-Around Button on the power lever (If equipped)
- The pilot will then select NAV on the FD/AP and a vertical mode on the FD/AP mode selector panel which will allow the Flight Director or guide the pilot through the missed approach.

This is all fine for a missed approach from a straight-in approach but there are still two big questions that remain which is the purpose of this report.





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Missed Approach from a Circling Procedure

Question #1

If I fly a circling procedure and commence circling prior to the MAP will waypoint sequencing be suspended and if so when?

- Garmin used some common sense on this one. After a series of 3 trials on our test flight we observed that the waypoint sequencing will be SUSPENDED during a circling procedure when the aircraft passes ABEAM the MAP.

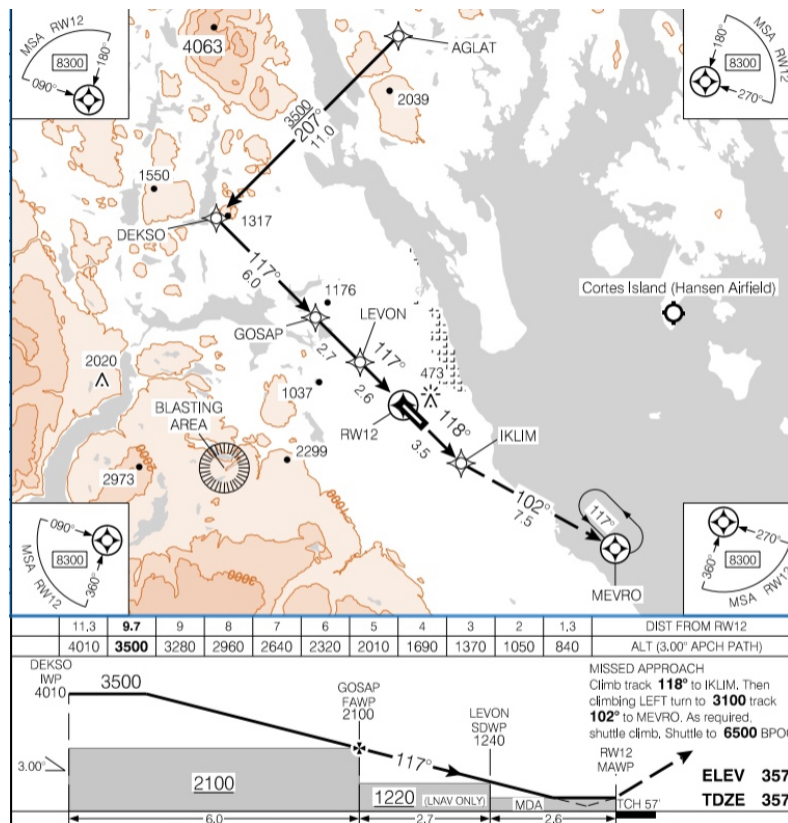
Question #2

If during the circling procedure I need to execute a missed approach how should I manipulate the G1000?

****YOU WANT TO READ THIS****

First of all, we are NOT going to tell you what you should do but we will tell you what we observed and what we chose to do after a series of four practice approaches trialing different solutions. What we observed has the potential to be deadly if the pilot does not pay attention to the Navigation/AFCS Status Box (Scoreboard) which is the top part of the PFD that displays the active and standby modes of the Flight Director and Autopilot.

To answer this question, we conducted a series of 4 approaches with a circling procedure. These were conducted under VFR at an airport with very little traffic. A depiction of the lateral track of the approach and the missed approach is included below for reference.



Note: Modes in GREEN are Active and modes in WHITE are in Standby

For the purpose of simplicity let us assume that we are starting each example just inside DEKSO level at 3500ft. The way we will control the vertical profile for a circling procedure in this case is by manually controlling the rate of descent using VERTICAL SPEED so as to not descend below the selected minimums.



Missed Approach from a Circling Procedure

Approach Sequence

Leg of the Procedure	OBS or SUSP	Lateral / Vertical Button Pressed	Expected Lateral / Vertical Mode on the Scoreboard	Actual Lateral / Vertical Mode on the Scoreboard
On final outside the FAF GOSAP				
DEKSO -> GOSAP faf	OBS	APP / ALT	FMS / ALT	FMS / ALT
Intercepting the vertical path between DEKSO & GOSAP				
DEKSO -> GOSAP faf	OBS	APP / VS	FMS / VS	FMS / VS
Passing GOSAP for the final leg to RWY12 MAP				
GOSAP faf -> RWY12 map	OBS	APP / VS	FMS / VS	FMS / VS
1.7 NM Before RWY12 Breaking off for the Circling Procedure				
GOSAP faf -> RWY12 map	OBS	HDG / ALT	HDG / ALT	HDG / ALT
Passing ABEAM RWY12 MAP during the Circling Procedure				
GOSAP faf -> RWY12 map	SUSP	HDG / ALT	HDG / ALT	HDG / ALT
Turning base to final for the runway of intended landing (Reciprocal of the runway for which the approach was flown)				
GOSAP faf -> RWY12 map	SUSP	HDG / ALT	HDG / ALT	HDG / ALT

Scenario 1 (BAD)

MISSED APPROACH INITIATED (Assuming GO-AROUND BUTTON installed and pressed)

RWY12 map -> IKLIM	OBS	GO AROUND BUTTON	GA / GA	GA / GA
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Lateral Note: The Go-Around Button automatically unsuspends the waypoint sequencing and sequences the leg from RWY12 to IKLIM. It is important to realize that **IKLIM is actually behind us** at this point and the CDI will be pointed behind us. In GA mode the lateral guidance of the FD bars will sync with the bank of the aircraft and will not provide lateral navigational guidance.

IT IS CRITICAL THAT PILOT VERIFY THE NAV SOURCE THAT IS COMMANDING THEIR CDI
(FMS vs. VOR / Green Needles vs Magenta Needles)

Vertical Note: The GA bars will command a predetermined pitch angle based on aircraft type.

THIS IS WHERE THINGS GET TRICKY

The aircraft has re-entered IMC and this is a high workload period where things happen fast. **The pilot's first instinct is to reduce workload and press NAV to command the lateral guidance to steer the aircraft down the missed approach.** Chances are they did this prior to reaching the center of the airport **which is a BIG NO NO.**

REMEMBER: THE FIRST PRIORITY IS TO CLIMB THE AIRCRAFT TO THE MISSED APPROACH ALTITUDE WHILE SIMULTANEOUSLY STEERING THE AIRCRAFT TOWARD THE CENTER OF THE AIRPORT

(This takes place immediately after GA has been selected and the missed approach altitude has been set)

Leg of the Procedure	OBS or SUSP	Lateral / Vertical Button Pressed	Expected Lateral / Vertical Mode on the Scoreboard	Actual Lateral / Vertical Mode on the Scoreboard
RWY12 map -> IKLIM	OBS	NAV / FLC	FMS / FLC	FMS ROLL / FLC ALTS

If the pilot selects NAV and fails to check the scoreboard, they may assume that the aircraft is now steering them down the missed approach when in fact the flight director is commanding a roll that mirrors the aircraft's bank angle at the time the NAV button was pressed. **Left unrecognized this could lead to a continuous turn into terrain.**

This is because the missed approach track is in the opposite direction that the aircraft is headed, and the system cannot compute an intercept.

In a panic the pilot then selects the first waypoint on the missed approach and does a DIRECT TO. In doing so they are now deviating from the missed approach because the system will draw a track from the present position to the selected waypoint. The pilot may have to reselect NAV on AFCS control panel.

D -> IKLIM	OBS	NAV / FLC	FMS / FLC ALTS	FMS / FLC ALTS
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While this solution is better than nothing, it technically does not comply with the published missed approach track.

Level at missed approach Altitude crossing IKLIM

IKLIM -> MEVRO mahp	OBS	NAV / ALT	FMS / ALT	FMS / ALT
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At this point you enter the hold as published or have received ATC instructions and can complete your checklists and catch your breath.



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Scenario 2 (BETTER)

MISSED APPROACH INITIATED (Assuming GO-AROUND BUTTON installed and pressed)

RWY12 map -> IKLIM	OBS	GO AROUND BUTTON	GA / GA	GA / GA
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Lateral Note: The Go-Around Button automatically unsuspends the waypoint sequencing and sequences the leg from RWY12 to IKLIM. It is important to realize that **IKLIM is actually behind us** at this point and the CDI will be pointed behind us. In GA mode the lateral guidance of the FD bars will sync with the bank of the aircraft and will not provide lateral navigational guidance.

IT IS CRITICAL THAT PILOT VERIFY THE NAV SOURCE THAT IS COMMANDING THEIR CDI
(FMS vs. VOR / Green Needles vs Magenta Needles)

Vertical Note: The GA bars will command a predetermined pitch angle based on aircraft type.

THIS IS WHERE THINGS GET TRICKY

The aircraft has re-entered IMC and this is a high workload period where things happen fast. **This time the pilot leaves the lateral mode in HDG as to have more control over the aircraft's lateral path. This time under full control the pilot begins a climb and turns the HDG bug towards the center of the airport.**

REMEMBER: THE FIRST PRIORITY IS TO CLIMB THE AIRCRAFT TO THE MISSED APPROACH ALTITUDE WHILE SIMULTANEOUSLY STEERING THE AIRCRAFT TOWARD THE CENTER OF THE AIRPORT

(This takes place immediately after GA has been selected and the missed approach altitude has been set)

Leg of the Procedure	OBS or SUSP	Lateral / Vertical Button Pressed	Expected Lateral / Vertical Mode on the Scoreboard	Actual Lateral / Vertical Mode on the Scoreboard
RWY12 map -> IKLIM	OBS	HDG / FLC	HDG / FLC	HDG / FLC ALTS

Having selected HDG the pilot can now steer the flight director to guide the aircraft towards the center of the airport. This gives the pilot some valuable time to set up the next lateral mode.

All things being equal, having pressed GA or by manually pressing SUSP on the PFD or MFD the flight plan would have sequenced from RWY12map -> IKLIM and the CDI would be showing a course behind the aircraft with the corresponding deviation from that course.

If the flight plan did not sequence, the pilot can go into the flight plan in the PFD or MFD and:

Flight Plan > [Highlight Next Waypoint] IKLIM > MENU > Highlight "Activate Leg" > Press ENTER

Or

Press the "Activate Leg" soft key on the MFD. If you do this be sure to verify what the commanded leg is which will be MAGENTA in the Navigation Status box at the top of your PFD.

Reaching the center of the airport the pilot then turns the HDG knob in the direction of the protected airspace and manually sets a heading to intercept the missed approach course at a 30 - 45deg intercept angle.

RWY12 map -> IKLIM	OBS	HDG / FLC	HDG / FLC	HDG / FLC ALTS
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Established on the 45deg intercept to the missed approach course on the CDI (still in HDG mode).

Press NAV and confirm that FMS is armed

RWY12 map -> IKLIM	OBS	NAV / FLC	FMS HDG / FLC	FMS HDG / FLC ALTS
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Established on the RWY12map -> IKLIM Track

RWY12 map -> IKLIM	OBS	NAV / FLC	FMS / FLC	FMS / FLC ALTS
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Level at missed approach Altitude crossing IKLIM

IKLIM -> MEVRO mahp	OBS	NAV / ALT	FMS / ALT	FMS / ALT
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At this point you enter the hold as published or have received ATC instructions and can complete your checklists and catch your breath.

Scenario 3 (BEST)

AVOID CIRCLING PROCEDURES IF THERE IS ANY CHANCE OF RE-ENTERING IMC

A good cut off is avoiding a circling procedure if the ceiling is below the FAF crossing altitude.



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Applicability To Other Avionics:

- While the sequence of button pushing, or the name of the various modes may be different in your installation the principle and theory remains the same.
- Selecting NAV on the AFCS panel may display FMS, GPS or NAV in some installations.
- FLC may be interchangeable with IAS in some installations.
- On aircraft that do not have a FLC or IAS vertical mode, VS may be used with **EXTREME CAUTION** as there is no under speed protection built in and the commanded vertical rate must be verified and monitored. Watch your airspeed!
- On aircraft that are not equipped with a GO AROUND button you can manually press SUSP to sequence the flight plan and select the desired vertical mode to begin the climb. (**See note above regarding the use of VS**)
- On installations such as Avidyne, the colour coding of Green and Magenta needles is reversed.

Conclusion:

This report has been generated as a way to bring attention to a manoeuvre that can have undesirable results if not fully understood. Our sole goal is to educate pilots, to further flight safety and to reduce accident rates. The contents of this report are based on the observations and thoughts of two pilots and we acknowledge that there may be other ways to safely achieve a desirable outcome and welcome any feedback or suggestions.

If you wish to practice and experience the observations outlined in this report, we recommend doing so with a safety pilot and while VFR.

About Cardinal Aviation:

Cardinal Aviation is a full-service aviation coaching and consulting company. We specialize in working with pilots to implement procedures and systems that have proven effective in commercial aviation for decades. We train our clients based on our coach's extensive real-world experience in an effort to enhance safety, decision making, comfort and overall handling of the aircraft. Cardinal Aviation is a solutions-based company and also provides aircraft ferrying, management, pilot and owner concierge service.

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