

# G1000 Autopilots Compared

## G1000 Autopilots Compared

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## Overview

- G1000/Perspective autopilots
  - Garmin GFC 700
  - Bendix/King KAP 140
- Functions compared
- Level of integration compared
- Operating procedures
  - Similarities
  - Differences
- Suggestions for training

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## Some opening philosophy

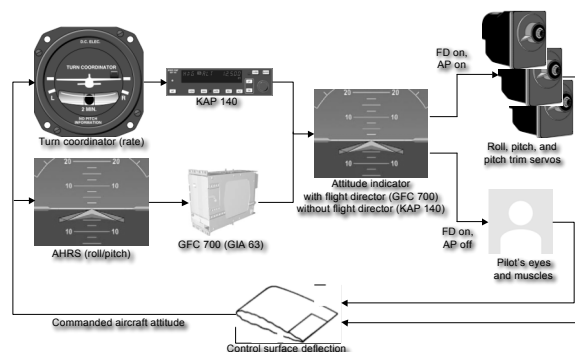
- Is the autopilot a
  - tool?
  - crutch?
- Does using the autopilot
  - atrophy the human pilot's skills?
  - demonstrate use of all available resources?
- Is thorough autopilot knowledge a
  - luxury?
  - skill pilots are required to demonstrate?

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## System diagram



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## What does 2-axis mean?

- How many aircraft axes autopilot controls
  - 1-axis
    - Roll
  - 2-axis
    - Roll, pitch; or
    - Roll, pitch, pitch trim
  - 3-axis
    - Roll, pitch, yaw (damper)
- G1000/Perspective systems are
  - 2-axis with pitch trim (Cessna)
  - 3-axis (Cirrus, optional yaw damper)

## Basic modes

- Horizontal
  - ROL Wing leveler
  - HDG Heading
  - NAV Navigation
    - APR Approach
    - REV/BC Reverse approach; back course
- Vertical
  - ALT Altitude hold
  - VS Vertical speed
  - GS Glideslope
  - FLC/IAS/PIT/VNV Other

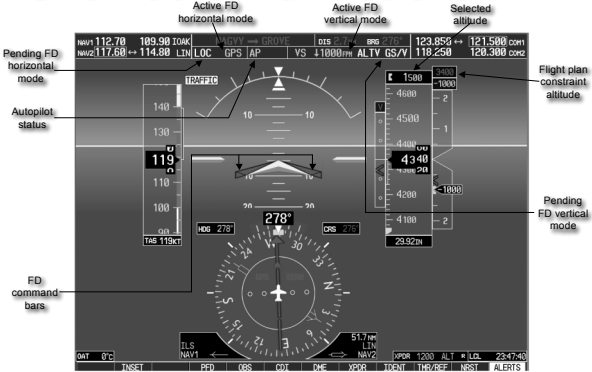


## What is a flight director?

- Shows what the autopilot brain is thinking
  - “Command bars” show the aircraft attitude the autopilot is commanding to achieve the selected flight mode
- If autopilot engaged (AP), aircraft body symbol is steered into command bars
- If autopilot disengaged, human pilot can do the same

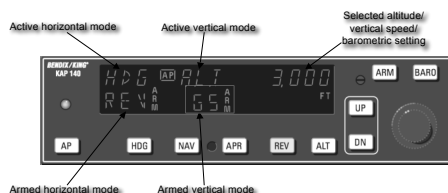


## GFC 700 annunciations



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## KAP 140 annunciators



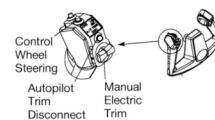
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## Control wheel steering

- CWS yoke button
  - Temporarily disconnects autopilot servos



- Autopilot itself is *not* disconnected
- G1000 status annunciates CWS
- With CWS depressed,
  - Aircraft can be hand-flown in roll and pitch
  - Upon release, ROL and PIT modes capture new airplane attitude

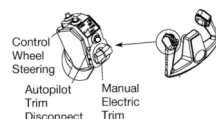
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## Manual electric trim (MET)

- Intimately connected and integrated with pitch trim 2-axis autopilot



- Must be separately tested
- Pilot must thoroughly understand disconnect
  - Autopilot and MET disconnect are different
  - Trim runaway is an ever-present danger
    - You should train for it

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## Pre-flight testing

- Power-on self-test
  - Ending in success
    - No annunciations
  - Ending in failure
    - Permanently flagged annunciation
    - Autopilot cannot be engaged for duration
- *Minimum* pre-takeoff test
  - MET function and disconnect
  - Autopilot disconnect
  - Pilot able to forcibly override servos



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# G1000 Autopilots Compared

## Push then verify!

- **Push** a function button
  - Once
  - Don't push GFC 700 or KAP 140 buttons twice
    - Generally this *cancels* labeled mode
      - NAV, HDG become ROL
      - ALT becomes VS or PIT
- *then,*
- **Verify** expected response
  - Annunciation
    - Active state (green or top line)
    - Pending/armed state (white or lower line)

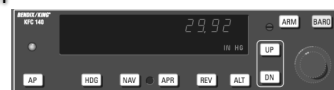
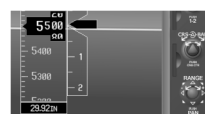
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## Setting barometric reference

- GFC 700
  1. G1000 BARO set knob
- KAP 140
  1. G1000 BARO set knob
  2. KAP 140 controller
    - BARO button
    - Large/small knobs
    - Five-second timeout



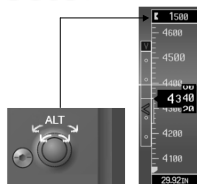
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## Setting altitude selector

- GFC 700
  1. G1000 ALT knob/knobs
- KAP 140
  1. G1000 ALT knobs
  2. KAP 140 controller
    - Large/small knobs
    - Arming is automatic (don't press ARM button, generally)
- Maintain G1000 and KAP 140 altitudes equal
- KAP 140 provides altitude alerter function



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## GFC 700 mode selection

- Pressing mode button
  - FD, HDG, NAV, ALT, VS, ...
  - results in flight director mode(s) *only*
  - autopilot is *not* automatically engaged
- Mode surprise:
  - Autopilot not flying!
  - Most common error



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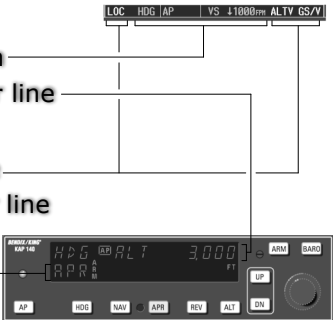
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## Armed modes

- Active mode
  - GFC 700 green
  - KAP 140 upper line
- Armed mode
  - GFC 700 white
  - KAP 140 lower line
- Armed to active
  - Color, position



## HDG mode

- FD/AP follows heading bug
  - Same operation for both
  - Push HDG knob to synchronize



## NAV mode

- FD/AP follows selected course
  - GPS-computed DTK
  - CRS knob
    - GPS OBS mode
    - VOR/LOC mode
- NAV button
  - KAP 140 NAV
  - GFC 700
    - GPS
    - VOR
    - LOC



## GPS steering (GPSS)

- Compared to basic NAV mode
  - NAV mode maintains selected course deviation needle centered
    - Only option for VOR, LOC, BC LOC, ILS
  - GPSS mode steers to GPS-supplied digital DTK
    - Non-EHSI (non-G1000) insensitive to OBS setting
- Filleted turns (fly-by waypoints)
- Charted procedure tracks:
  - Procedure turns
  - Holding patterns
- G1000 software-level dependent:
  - Cessna Nav III 0563.00+
    - Airways, altitude milestone waypoints, GFC 700
    - Does not depend on installation of WAAS

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## Capturing an altitude

1. Select target altitude
  - KAP 140: Both altitude selectors
  - KAP 140: ALT ARM
  - GFC 700: ALTS
2. Select climb/descent mode
  - Both: VS
  - GFC 700: FLC/IAS, PIT
3. Set climb/descent reference



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## Capturing a glideslope/path

- APR mode
  - More sensitive NAV mode
  - Tracks glideslope
- From below
  - ALT mode active
  - GS mode pending
- From above
  - Not advised



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## Landing from an approach

- Disconnect autopilot
  1. At AP limitation minimum altitude
  2. At IAP charted minimum coupled altitude
  3. At decision altitude (height)
  4. Upon making decision to land
    - Use the yoke disconnect button
    - Remain on instruments
- GFC 700 flight director remains engaged
  - Can be continued without limitation to landing
  - Recommended, especially for ILS
  - In some cases, authorizes lower minimums

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## Missed approach

- GFC 700
  - Press go-around (GA) button by throttle
    1. Autopilot disconnects
    2. GA/GA horizontal/vertical mode annunciated
    3. Straight-ahead guidance provided
    4. GPS sequences to missed approach (un-SUSP)
    5. CDI nav source switches to GPS
- KAP 140
  1. Press yoke AP disconnect
  2. Climb, stay on final approach course
  3. Press OBS/SUSP when SUSP annunciated
  4. Press CDI to switch nav source to GPS

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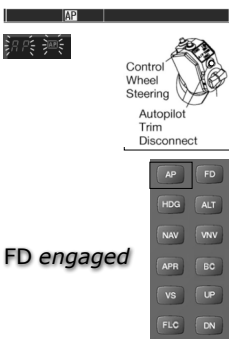
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## Go-around (GA)



## Disconnects

- Automatic
  - Equipment failure
  - Pitch/roll excession
  - Accelerometer
- Manual
  - Yoke pushbutton
  - Manual electric trim use
  - Panel AP button
  - Electric power
- GFC 700 disconnects leave FD *engaged*



## Failures

- Autopilot disconnect with warning
  - Audible alert
  - Flashing AP annunciation
    - GFC 700
    - KAP 140
- Autopilot does not disconnect?
  - Absolute pilot requirement to know how!
    - Yoke AP disconnect button
    - Circuit breaker (often collared)
    - Avionics MASTER



## Dangers

- GA autopilots lack auto-throttle
  - Stall possible in any flight attitude
    - Especially risky in climb
    - GFC 700 FLC (IAS) mode offers protection
- Complacency
  - Programming (heads down) instead of flying
  - Loss of hand flying skills
  - Fear of turning off autopilot
- Cross-unit operating differences
  - Double button-pushes (toggle mode)
  - Multi-finger gestures (ALT + VS, HDG + NAV)
- Mode confusion
  - Failure to verify mode

# G1000 Autopilots Compared

## Limitations

- Factory-provided or aftermarket
  - POH Chapter 2 (Limitations)
  - POH Chapter 9 (Supplements)
- Autopilot limitations
  - Airspeeds
  - Flap setting maximums
  - Minimum altitudes
  - Icing
  - Approach minimums

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## Mode errors

- AP off, FD on
  - False belief autopilot is controlling aircraft
- HDG mode to track a course
  - Aircraft will drift from track
  - Caused by lack of NAV mode understanding
- NAV mode to track an ILS or LPV
  - Glideslope or glidepath will be ignored
  - Appropriate for LOC or LNAV minimums
- Altitude capture not armed
  - Climb/descent direction opposite target altitude
  - Failure to arm
- Misunderstanding ALT mode vice altitude capture
  - GFC 700 ALT vice ALTS or ALTV annunciations



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## Summary

- What have we missed?
  - Not enough time
    - Too many modes
    - Too many edge cases
    - Too much "buttonology"
  - Not enough scenarios
- What have we seen?
  - Aircraft/autopilot differences critical
  - Experiencing scenarios is crucial
  - Standardization is a key tool

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## Recommendations

- Know your autopilot before using it
- Don't
  - experiment in solo flight
  - ignorantly launch into IMC
  - ignorantly attempt an instrument approach
  - be a HDG mode-only user
- Do
  - know the difference between ALT mode and altitude capture
  - know how to disconnect autopilot and manual electric trim

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## G1000 Autopilots Compared

### References and resources

- Cessna POH/PIMs
  - KAP 140 equipped (Chapter 9)
    - Cessna 172SIMAUS/172SPHAUS
    - Cessna 182TIMAUS/182TPHAUS
  - GFC 700 equipped (Chapter 7)
    - Cessna 172SIMBUS/172SPHBUS
    - Cessna 182TIMBUS/182TPHBUS
- Garmin G1000 for Cessna Nav III Pilot's Guide
  - Software Version 0563.00 or higher
  - Automatic Flight Control System
- Bendix/King KAP 140 Pilot's Guide
  - 2-axis with altitude preselect

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### References and resources

- G1000 Trainer for Cessna Nav III
- G1000 simulator
  - PFC MFD MD G1000
- KAP 140 equipped
  - C172S N1004E
  - C172S N646DW
  - C182T N182BG
- GFC 700 equipped
  - C172S N63251
  - C182T N1483L

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