Non-Powerplant System Failure

A CONTINUE AND CONFIRM. Keep flying and don't do anything drastic yet. Take the time to make a correct diagnosis.

B COMPLETE MEMORY ITEMS AND THE CHECKLIST. Most system failures don't require immediate action. There's usually time to consult the written checklist.

C ASSESS AND MITIGATE THE LIMITATIONS. When a system goes down, so do certain capabilities. Time may also be a major limitation—or not. Sometimes a simple action will buy more time.

D PLAN FOR THE LIKELY, PREP FOR THE WORST. Enact Plan A, with Plan B at the ready.

KEY SKILLS

- *Know your systems*
- *Work the system*
- *Slow down*

SCENARIO 1
Alternator Failure in Night VMC

It's a clear VFR night as you return home from Galveston, TX (KGLS) to Stinson Muni (KSSF) in San Antonio, in your Bonanza. With 75 NM remaining, a red light on the panel catches your attention: Alternator Out.

A Continue and Confirm

Remind yourself to keep flying the airplane. Sure, the autopilot has it now, but if there's an electrical problem it might disconnect and you'll need to hand fly. Ditto if you decide to turn it off to save power.

Next, diagnose the problem. It could be an alternator issue, but you wouldn't want to rush into a wrong action on account of a faulty sensor. On this panel, the only other electrical indicator is the ammeter. Here it shows a negative value, meaning that power is being drawn from the battery. That's a problem.

B Complete Memory Items and the Checklist

The V35B has no "official" bold memory items on the checklist, but some timely, basic load shedding will buy time. Flow across the switch panel and turn off anything nonessential. This Bonanza has old-school discharge strobes and a mechanical rotating beacon. These draw a lot of power, so turn them off. (Yes, the beacon is required, but you have PIC authority and can turn it back on if necessary when you come in to land.) If this plane had LED lights, it would be fine to leave the beacon on, but the rest should be turned off. Since icing isn't a concern, turn the pitot heat off. You're not using the second nav/com radio at the moment, so turn it off.

TIP Make note of how much power different pieces of equipment draw in your airplane and keep it with your checklists. This can be a huge help in deciding what to shed in flight.

The autopilot draws significant power, so turn it off if you're confident you can hand fly while troubleshooting. However, remember that aircraft control is the number one priority. It's reasonable to leave the autopilot on for now if it helps you to troubleshoot more effectively. You can always turn it off later if your checklist efforts to restore power fail. If you do turn off the autopilot, pull the breaker as well, as many autopilots draw power even in "standby" mode.

Now it's checklist time. The V35B has a four-item checklist for "alternator-out light illuminated." It says simply to verify the failure with the ammeter (which you already did), then cycle the alternator switch off and back on. If the problem was a momentary overvoltage that tripped the overvoltage relay,

you may find the problem is "solved" by cycling the alternator to reset the relay. You should still monitor closely in case it recurs.

If the problem persists, the final checklist items call for turning off the alternator, as well as all nonessential electrical equipment. When considering which items to turn off, weigh the electrical draw saved (i.e., the time bought by turning it off) against the limitations incurred.

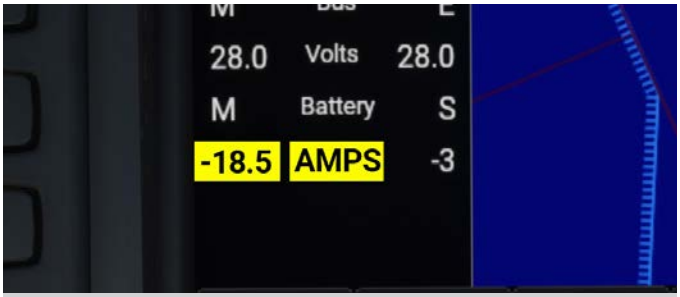
You've already turned off nonessential lights and switches in Step 1. Can you turn all exterior lights off and go completely dark? The risk is collision and, in the big skies of Texas, it's incredibly small. Turning off all lights is reasonable as long as you keep a vigilant eye outside. (Fortunately, other aircraft are easy to see at night … unless they lost an alternator, too.) Make a note to upgrade your Bonanza to LED lighting that you can keep on if this ever happens again.

Radios are usually not critical for VFR navigation, and a GPS nav/com can draw significant power. If you already have a tablet with a GPS source, turn off the panel GPS and use the second com radio for communication. On this clear night, it won't be long before the lights of San Antonio come into view (assuming no diversion), making navigation trivially easy. If you must keep the GPS online, dim the screen as much as practical.

Modern transponders don't draw much power, and you'll appreciate ATC having their eyes on you. ATC can also track your primary return if you tell them in advance that you're going to switch off the transponder.

Avoid radio transmissions or actuating electric flaps or landing gear except when essential. They all draw significant power.

In a pinch, you can turn everything off and turn it back on later. (See "Turn It All Off" on page 75.)



An ammeter (as in this Cessna) in the negative range means the battery is being discharged. In other words, the alternator isn't working.

ALTERNATOR-OUT PROCEDURE

An inoperative alternator will place the entire electrical operation of the airplane except engine ignition on the battery. An alternator failure will be indicated by illumination of the warning light, located on the instrument panel below the flight instruments.

The warning light will not illuminate until the alternator output is almost zero. A verification of alternator malfunction would be a discharge shown on the ammeter. There is no indication of overvoltage except that the warning light will illuminate as though the alternator is out.

Alternator Warning Light Illuminated:

1. Verify alternator out with ammeter - will show discharge.

NOTE

If the ammeter does not show a discharge, a malfunction in the warning light system is indicated, and the alternator switch should be left ON.

2. If ammeter shows a discharge, Alternator Switch - OFF MOMENTARILY, THEN ON (this resets the overvoltage relay).

If the warning light does not illuminate, continue to use the alternator.

3. If the warning light illuminates, Alternator Switch - OFF.
4. Nonessential Electrical Equipment - OFF to conserve battery power.

The V35 has a four-item checklist for when the alternator light illuminates.

C Assess and Mitigate the Limitations

Unless there's a quick fix available, handling failures requires an evaluation of what tools are compromised, what are still available, and how much time exists for the solution. Time is your first limitation. How long will you have power?

In general, you should expect at least 30-60 minutes assuming a healthy battery and a minimal load. But those are assumptions that can't be made here. You might not have noticed the failure right away. Your battery may be older than you think. Old or corroded connections can draw more power than

A loadmeter (as in older Pipers like this one) shows the output of the alternator. When the alternator fails, the loadmeter reads zero.

the book values. Without more equipment, like a voltmeter, you have no idea when this panel will go black. Your plan must include flexibility to account for uncertainty.

Since you don't know how much time you have, filling in ATC on the situation *before* it all goes dark is a top priority. Not doing so would incur a serious limitation. You're already on flight following with Houston Center, so tell them now. It's not enough to simply tell ATC you have an alternator failure. The controller at Houston Center may not know that means you have limited time with electricity. As far as they know, you have two alternators. Instead, declare an emergency and tell Center that you're on battery power alone, and you may lose power completely any minute. Then, tell them what you intend to do and what assistance you need. If you're not yet sure of the plan, tell them to stand by for now—at least they'll have eyes on you in the meantime.

Consider how you could mitigate the limitations incurred by a failing electrical system.

The loss of communications means you'll be unable to communicate, of course, and it also prevents you from turning on pilot-controlled runway lights. By coordinating your intentions in advance with Houston Center, someone can leave the lights on for you at a towered destination and ensure your path is clear. Houston Center could even coordinate to have pilot-controlled lights turned on for you at a non-towered airport.

Loss of the transponder means ATC will lose your Mode C and ADS-B data, but they should still be able to track a primary target if they know to look.

Loss of exterior lights slightly increases the collision risk. Again, ATC can help monitor and clear your way. You'll also need to land without the landing light—a non-event if you've practiced it. Loss of interior lights could be an issue with reading your instruments if you don't have a good flashlight. With so many people relying on their phones for a flashlight, it's something that's too often overlooked. Or the flashlight becomes little more than a holder for dead batteries.

The vacuum (air) powered attitude indicator will keep working fine. The HSI in this Bonanza is electric and will stop working. (Some HSIs use vacuum for heading, but they are in the minority.)

Flaps and landing gear are electric in the Bonanza, but you can hand-crank the gear if necessary, and no-flap landings are no problem with sufficient runway. It's not a trivial task to hand-crank a Bonanza's landing gear while hand flying, so you'll need distraction-free time for that.

The bottom line is that even in the event of total electrical failure, all of the limitations can be mitigated with prior coordination.

Why You Need a Voltmeter

If your panel doesn't have a voltmeter, get one that plugs into the cigarette lighter and also includes USB ports. Presuming you use more USB devices than cigarettes in flight, that's a win. Make sure it can handle your airplane's system voltage. Many work in both 12- and 24-volt systems.

This gives you vital information to judge the health of your charging system and the time you have left if it fails. A voltmeter shows the total bus voltage, which should usually be the nominal voltage of the alternator. For 14-volt systems, like the one in the V35, that should be roughly 14 volts. With the alternator offline, a voltmeter provides an indication of how much juice the battery has left. A fully charged "12-volt" battery should show 12.5-13.2 volts. By the time the voltage drops to around 10 volts, expect electrical components to behave erratically and drop offline.

For 28-volt systems (with 24-volt batteries), roughly double these numbers.

TIP Handheld radios are great insurance, but they're surprisingly range-limited if they're not connected to an external antenna.

The nearby airports aren't the easy outs you'd like them to be. Maybe it's better not to rush. Stinson Tower is open until 10 PM local. If it were closed, you might consider nearby Kelly Field (KSKF) with its full-time tower and 11,500′ runway. The Chart Supplement also lists a phone number for San Antonio Approach, so if you can't reach anyone by the radio, your cellphone may work.

STINSON MUNI (SSF)(KSSF) 6 S UTC–6(–5DT) N29°20.22′
578 B NOTAM FILE SSF
RWY 09–27: H5000X100 (ASPH) [illegible] MIRL
[illegible]: S4 [illegible] PAEW A **LGT** MIRL Rwy 09–27 [illegible]
14–32 preset med ints when twr clsd.
AIRPORT REMARKS: Attended 1300–0400Z‡. Numerous acft opr at or abv 2,500′ MSL in the Stinson Arpt traffic area under the ctl of San Antonio Apch. PAEW adjacent all twys and ramp areas Mon–Fri 1300–2359Z‡.
AIRPORT MANAGER: 210-207-1800
WEATHER DATA SOURCES: ASOS (210) 927–9391 LAWRS.
COMMUNICATIONS: CTAF 118.2 **ATIS** 128.8 **UNICOM** 122.95
Ⓡ **SAN ANTONIO APP/DEP CON** 125.7
TOWER 118.2 (1300–0400Z‡) **GND CON** 121.7 **CLNC DEL** 121.7
CLEARANCE DELIVERY PHONE: For CD when ATCT is clsd ctc sat Apch at 210-805-5516.
AIRSPACE: CLASS D svc 1300–0400Z‡; other times CLASS G.

Ⓓ Plan for the Likely, Prep for the Worst

A quick landing could put an end to this situation while all systems are still available. Essentially, you have an "abnormal" situation where the charging system doesn't work, which will eventually become an emergency when electrically powered items stop functioning. However, the nearby runways are remote, short, likely unattended, and use pilot-controlled lighting. And, you haven't prepared for them.

It may be better to continue for the next big airport with services—which is probably home at KSSF—even though flying longer may incur further limitations as electrical components fail.

The best way out of this situation is probably to continue to the planned destination (KSSF). There's a good chance you'll have total electrical failure by then, so tell Houston Center to coordinate with KSSF Tower for your arrival. Now, the worst-case situation is a manual gear extension, followed by a no-flap landing without a landing light. That's manageable.

The *true* worst case would happen if the panel went dark *before* any coordination. If that happened, a handheld radio transmission—or even a cellphone call to an ATC facility—could achieve the same coordination. (You could try texting a friend somewhere who could relay a phone call as texts sometimes work better than calls from the air.) Every airport with IFR procedures publishes a phone number for the overlying Center or Approach facility in the Chart Supplement.

Turn It All Off

With electrical failures, context is everything. In clear blue daytime skies, it's usually a non-event. At night it's a bit more serious. In IMC, the inability to navigate creates a serious emergency.

If there's no viable instrument approach (or better, VFR conditions) in range on battery power, tell ATC you're going to turn everything off to preserve power. Then navigate by iPad or dead reckoning until in range before turning the master back on.

Even if the nearest VFR is hours away, this strategy will get you there if you have enough fuel. That's a consideration for IFR flight planning in an airplane with one alternator: Have enough fuel to reach a VFR alternate in the worst-case scenario.

Digital Instruments and Backup Batteries

If this Bonanza had a pair of Garmin G5s as a PFD and HSI, each G5's internal backup batteries could provide up to four hours of power in the event of an electrical failure. Unfortunately, they only switch to internal power after the ship's voltage becomes unusably low.

Pulling the breakers for the G5s forces them onto internal power. Note that some of the information presented by the G5s is still dependent on the electrical system. Namely, the magnetometer and GPS navigation information. When the battery fails, the HSI will revert to a simple track indicator (using its internal GPS) with no navigation information.

Other digital instruments are different. For example, an Aspen EFD1000 can automatically switch to its internal battery when the alternator fails. That switch might even be your first clue of a problem. However, Aspen only claims a minimum of 30 minutes of useful battery life.

Some aircraft have multiple batteries and/or alternators. You should know the exact load-shedding procedures and vulnerabilities for the aircraft you fly.

CONTINUE AND CONFIRM

Overvoltage

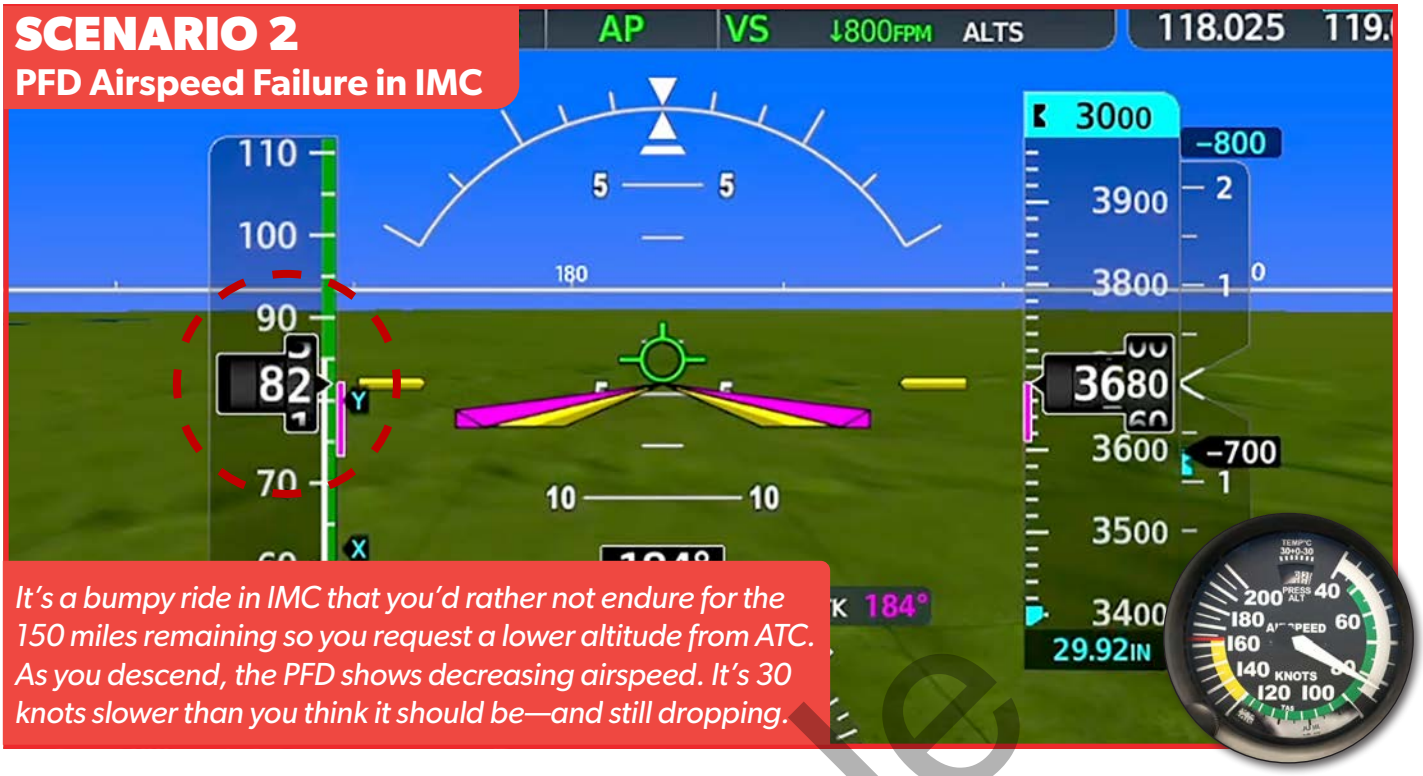
Is a charging system value that's atypically high a problem or "bonus power"?

Overvoltage may or may not come with a light or annunciator. An ammeter will show a greater than normal rate of charge. A digital voltmeter might show over 15 volts on a 14-volt system or over 30 volts for a 28-volt system. This is probably an issue with the voltage regulator. Load shedding won't help. The checklist is nearly identical to the one for "no alternator." You should first cycle the alternator switch to reset the overvoltage relay. If the situation resolves, you're (in theory) good to go, but keep an eye out for another overvoltage. If the situation persists, turn the alternator off and proceed like it has failed.

If the overvoltage is high enough, most aircraft are protected by an overvoltage relay and will disengage the alternator to protect the system. To the pilot, that will appear as an undervoltage situation. Usually the overvoltage relay trips around 32 volts in a 28-volt system, or 16-17 volts for a 14-volt system.

If the voltage isn't high enough to trip the overvoltage relay, there's probably little chance of fire, component damage, or battery overheat—those are what the overvoltage relay protects against. But "probably" doesn't sound great when paired with words like "fire," so switch off the alternator if you can to prevent that worst-case situation. Leave it on if you really need it, like when you must fly an instrument approach that's otherwise out of range. If you do keep it on (or just energize it periodically to recharge your battery) be on extra alert for any indication of fire and have a plan for that emergency (page 40).

SCENARIO 2
PFD Airspeed Failure in IMC



It's a bumpy ride in IMC that you'd rather not endure for the 150 miles remaining so you request a lower altitude from ATC. As you descend, the PFD shows decreasing airspeed. It's 30 knots slower than you think it should be—and still dropping.

A Continue and Confirm

The deadly part of an instrument failure is usually the seconds immediately after, when confusion and disorientation lead to loss of control. Instrument failures can be insidious, and the urge to follow a failed instrument can be overwhelming.

When things seem wrong, first take a deep breath and do nothing. Airspeed is falling, but you're still descending at a normal pitch and normal vertical speed. Power and configuration are appropriate. The autopilot is still engaged here, but if you were hand flying and the plane was trimmed hands-off, it's still trimmed hands-off. Drastic control inputs aren't required.

A glance at the mechanical airspeed indicator shows it's also heading for zero, which confirms this is an airspeed indication problem. Airspeed dropping to zero in a descent is a classic symptom of a fully blocked pitot tube. The mechanical airspeed indicator and PFD share the same pitot air source, so they're subject to the same insidious failure modes. Most PFDs only X-out airspeed for an air data computer (ADC) fault. They have no logic to detect pitot-static problems.

B Complete Memory Items and the Checklist

Surprisingly, neither the Cessna POH nor the G1000 NXi pilot supplement says anything about a blocked pitot tube's effect on airspeed.

Triangles of Agreement

If you suspect an instrument is lying to you, check another. But if they disagree, which one is the culprit? You need a third to break the tie, and all three need to be on independent systems. For example, agreement between the VSI and altimeter isn't helpful—they're both static instruments.

In the case of suspected airspeed failure, the triangle of pitch instruments includes airspeed (pitot), altitude or vertical speed (static), and attitude (AHRS on the PFD and vacuum for the backup in this Cessna).

Two should agree, and the outlier is the liar. Above you see the vertical speed (to the right of the altimeter tape) is showing -700 FPM. That's what you expect in a descent at this pitch attitude and your normal descent power setting. Those two agree, so airspeed is the "out-liar." (Sorry, we couldn't resist.)

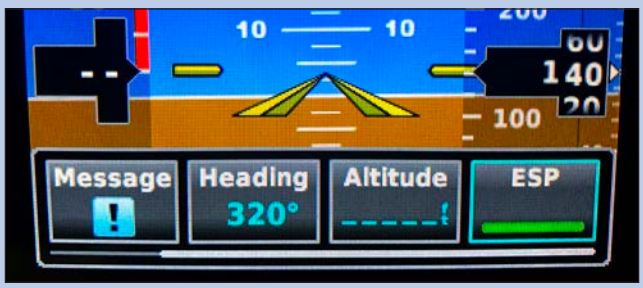
Groundspeed is also an option. Sure, it's influenced by wind, but if it's not changing and your airspeed is falling toward zero (as shown by the magenta trend indicator to the right of the airspeed), you can be fairly certain what's happening.

A 60-knot tailwind? The wind information on these G5s is calculated from indicated airspeed (70), groundspeed (131), heading, ground track, altitude, and temperature. An erroneous indicated airspeed variable messes up the equation here. The computer thinks the massive difference between the calculated true airspeed and measured groundspeed must be due to an extreme tailwind component. It's actually a clogged pitot tube. When airspeed reaches zero, the wind vector will disappear.

Autopilots and Airspeed

Attitude-based autopilots as in the G1000 NXi remain mostly functional with airspeed failure. FLC (airspeed) mode will be lost and any ESP (Electronic Stability and Protection) may kick in to prevent a perceived underspeed condition.

In some cases, the GFC autopilots are smart enough to recognize the large discrepancy between groundspeed and airspeed and automatically disable ESP, but don't count on it. It's not enough to turn off the autopilot, as ESP works even with the autopilot disengaged. ESP can usually be disabled from a menu somewhere in the system. Pulling the autopilot circuit breaker will also do the job, but that will disable the autopilot too.



There's no checklist for this specific problem and only one action might restore function: turning on pitot heat. Having pitot heat always on in IMC is a good policy regardless of temperature, but it can fail like anything else. And you're not in icing conditions in a Cessna 172… right? It could be a bug or water in the pitot tube. Either way, if pitot heat doesn't help, you're not fixing it.

C Assess and Mitigate the Limitations

Time is not a limitation … at least not until you run out of gas. The loss of primary, required instruments in IMC is an emergency. However, everything *besides* airspeed is working and the plane will continue to fly.

Missing airspeed on the approach and landing means you'll need to rely on a known combination of power, pitch, and configuration to get predictable results. Groundspeed can be used as a sanity check, keeping in mind any headwind or tailwind component. Most pilots fly too fast in this situation, so trust your performance profiles. (See "Performance Profiles" on page 79.) And don't pick a short runway.

There's a regulatory consideration here too: 14 CFR 91.7 says, "The pilot in command shall discontinue the flight when unairworthy mechanical, electrical, or structural conditions occur." You have *some* leeway to find the most suitable airport and approach, but you'd have a hard time justifying a 150-mile trip home just because you'd rather be home.

D Plan for the Likely, Prep for the Worst

You can fly an instrument approach without airspeed all the way to minimums using performance profiles, but ideally you don't have to. If VFR conditions are easily in range, consider it. Your "PIC authority" card (14 CFR 91.3) trumps the requirement to discontinue the flight with inoperative equipment (14 CFR 91.7). Otherwise, look for an instrument approach with official vertical guidance and ceilings and visibility well above minimums.

As in many emergencies, the worst things that can happen are self-induced. Even after the failure has been recognized, erroneous airspeed indications will be distracting and could lead to disorientation and loss of control. Have something close on hand to cover failed instruments. It could be a simple Post-it note. And use the autopilot.

Performance Profiles

When the airspeed indicator fails, it's not such a problem if you know your typical performance profiles. But even when everything is working, knowing exactly how to make the airplane do what you want through all the normal flight regimes enables you to fly more precisely and efficiently. And when something's wrong (like you forgot to lower the gear), you'll notice the difference.

Here's an example of IFR performance profiles you might record for the V35 Bonanza. Even aircraft of the same type will have slightly different numbers, so record your own.

Performance profiles aren't just for IFR. From Day 1, all pilots should learn the golden rule: Attitude + Power + Configuration = Performance. In visual flying, attitude is set by outside reference. In fact, you should practice flying VFR traffic patterns with the entire instrument panel covered (and a CFI on board). With a little practice, an actual airspeed indicator failure will no longer feel like an emergency.

Profile	Power	Attitude	Config	AS	VS
Vy Climb	Max	+10	Clean	95	1200
Cruise climb	FT 2500	+6		115	800
Cruise	23 2300	0		155	0
Cruise Descent		-3		165	-500
Approach Level 1	17 2300	1		125	0
Approach Level 2			Flaps APR	110	
Precision Descent		-2	Flaps APR; Gear DN		-500
Steep Descent	14 2300	-4			-900
Level MDA	22 2300	1			0
Missed Approach	FT 2500	+7	Clean		900

SCENARIO 3
Misbehaving Autopilot

It's an especially hazy summer afternoon with low forward visibility as you drone along in your Cirrus SR22 with the autopilot in altitude and GPS steering (GPSS) modes. The ***autopilot enters a shallow right bank*** *and slowly begins to drift off course.*

TIP Always keep the heading (HDG) bug synced to the current heading. That way HDG mode is one button press away.

A Continue and Confirm

Since you noticed it before the airplane reached an unusual attitude, this is not an emergency. Verify that the autopilot is indeed engaged and indicates the proper modes. In this case that's ALT and NAV/GPSS selected on the S-TEC 55X autopilot.

B Complete Memory Items and the Checklist

Many pilots are trained to immediately disengage the autopilot when it does something unexpected. But that immediately increases pilot workload and may be unnecessary. Instead, build a habit of downgrading to a lower level of automation first.

Here you could switch from GPSS to HDG mode by pushing HDG on the autopilot. If the autopilot now follows the heading bug, you can investigate further without completely reverting to hand flying. Similarly, if ALT or approach (APR) mode misbehaves, you can try switching to vertical speed (VS) before completely disengaging. If downgrading doesn't work—or if the autopilot deviation is dramatic and needs quick action—disengage it completely.

There isn't a checklist in the Cirrus Emergency or Abnormal Procedures section of the POH, because this autopilot was optional equipment that changed over time. Checklists for that equipment are in the Supplements section of the POH (usually Section 9).

There's not much to see there either. All it says is to disengage the autopilot if it's malfunctioning. It's up to you to decide how much of a "malfunction" warrants completely doing away with autopilot assistance.

GPS Steering (GPSS) is a good way to get the GPS to speak directly to the autopilot. It's often more precise and smoother. It's done different ways on different systems, and it's important to know the details. Some autopilots use GPS Steering automatically when you use a NAV mode (GFC 500, DFC 90). Some, like this S-TEC, require manually activating it. (You press NAV twice to see a tiny "GPSS" appear.) Some autopilots that only have a heading mode can get GPSS added with an emulator, as is available with a G5 and a menu setting. Be sure you know the eccentricities of your systems to prevent "pilot-induced malfunctions."

C Assess and Mitigate the Limitations

Time is not a limitation—the plane will fly until fuel runs out with a broken autopilot. Disengage it and continue if reverting modes doesn't fix it. However, hand flying in low visibility can be a real hazard to a VFR-only pilot. If you're having trouble controlling the aircraft, you need to find a way out (page 81).

D Plan for the Likely, Prep for the Worst

While you work on finding a way to better visibility, focus on the instrument scan. (See "Perfect Your IMC Control-Performance Loop" on page 85). Haze can exist in layers. Sometimes climbing above an inversion helps, sometimes descending can help (or at least improve ground contact).

Worst case is loss of control. If you do lose control, get it back (page 53).