Climb and Maintain *What*?

Cruising altitude rules increase your risk of a mid-air collision

By Robert Patlovany

Imagine for a moment you're cruising VFR at 8,500 feet on a heading of 183 degrees. You're using VORs to navigate and you're somewhat smug in the fact that the autopilot's turned off and you've got your altitude and CDI nailed.

Without warning, an aircraft flying the opposite direction, whose pilot is just as diligently holding 8,500 feet on a heading of 358 degrees, flashes into view and fills your windshield. A mid-air collision is imminent without immediate and extreme evasive action.

Think this scenario is far fetched? Midair collisions happen, and FAA regulations make them more likely.

Over 30 years ago, the FAA enacted the hemispherical cruising altitude regulations (FARs 91.159 and 91.179) requiring east-bound VFR pilots to fly at odd altitudes plus 50 feet and west-bound flights to be at even altitudes plus 500 feet. This rule presumably was aimed at reducing the threat of midair collisions. Prior to the hemispherical rule, all cruising pilots could legally follow their natural tendency to fly at altitudes like 2000', 3000', 4000', etc. Obviously, if every pilot flies with the big hand on the altimeter straight up, too many planes are using too little of the available airspace to systematically avoid collisions.

The hemispherical rule provides 1000' of vertical separation to VFR pilots closing head-on with easterly and westerly (non-polar) headings. In contrast, two pilots closing on nearly polar headings of 181° and 359° can easily and legally be at the same altitude pursuing a head-on collision with only seconds of visible threat time for detection and evasion.

This save-the-non-polar, heck-with-the-polar compromise may appear to be a pragmatic, unavoidable necessity to improve overall safety. However the validity of this compromise is easily questioned. After all, it leaves the vast majority of airspace technically illegal to use for systematically avoiding other VFR cruising traffic.

What a Waste of Space

To pilots flying north and south, the rule essentially is analogous to telling all automobile drivers to always drive on the centerline of a six-lane undivided highway, and to never use any of the other lanes unless a collision threat is detected. You probably will survive longer in rural Montana than in metropolitan New York with everyone using the centerline driving technique. However, this technique still increases overall risk no matter what the traffic density is.

The NTSB concluded that the accident was caused by "the inherent limitations of the see-and-avoid concept."

Since private pilot ground school, I wondered if the benefit for only non-polar pilots separated by 1000' was worth the increased risk for all pilots bunched together in narrow slabs of legal airspace. I constructed a computer model using the Monte Carlo computer modeling and mean free path techniques used to establish the safety of nuclear weapons parts by the Department of Energy. Whether testing the potential for neutrons to hit uranium nuclei or airplanes to hit other airplanes, the same fundamental rules of math are involved.

I defined each airplane to have a 50-foot "collision radius." Any contact within that radius was assumed to be a mid-air collision. I allowed those virtual airplanes to fly in one of two ways. Either they obeyed the current FARs on altitude with no more than 100 feet of "pilot error" holding the altitude, or they were outlaw pilots flying at random altitudes. I wondered which ones would live the longest.

As it turned out, the skillful, obedient pilots crashed more than four times as frequently as the renegades. To their benefit, the obedient pilots had about 20% more time to react to a potential collision than the renegade pilots. Unfortunately, the hemispherical rule's slight advantage there did not offset the significantly hazardous concentration of planes in artificially limited airspace.

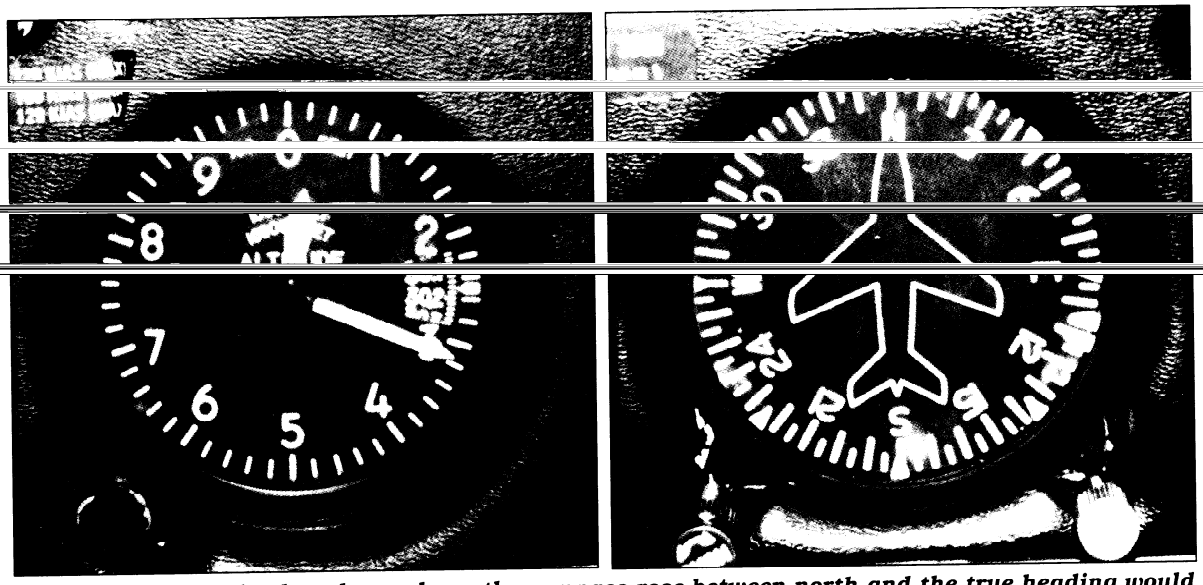
It is disturbing to imagine that a renegade pilot wandering vertically at random might in any way be safer from midair collisions than a highly skilled, experienced professional accurately obeying a safety rule.

I looked for a "do something, do anything" alternative that conscientious pilots could use to improve upon the anarchy alternative. The result was a remarkably simple expansion of the basic concept that your direction should determine your altitude.

A Rose by Any Other Name

Mentally superimpose a compass rose on your altimeter glass, with 360 at the top. Imagine that everyone is accurately cruising in a direction and at an altitude where actual heading is at the same relative angle on the compass rose as the 100' altimeter needle is. Everybody cruising at your altitude would be flying in the same direction. (If everybody trying this completely screwed it up at random, they would still have the significant safety

benefit of anarchy over the risk-seeking hemispherical rule.) You could only have a level flight cruiser-cruiser collision after a long chase into the tail of a slower airplane directly ahead (or directly aft if you are the slower one). Every collision threat would have the maximum possible visible time to collision for allowing detection and evasion of the threat. Head-on collisions could only happen with descending or climbing aircraft, which simply are not relevant to any discussion of cruising altitude rules.



Under the proposed rules, the angle on the compass rose between north and the true heading would match the angle of the 100' hand on the altimeter. For example, a heading of 110 leads to an altitude of XX,300 feet.

Before you object on the grounds that this technique is too difficult, try it while VFR below 3,000' agl and above legal terrain clearance altitude. My first time out, from a random altitude, it took about two minutes of altitude change to reach an altitude correlated to my heading. It only took about 10 minutes of practice to be fully competent maintaining what I call the altimeter-compass cruising altitude rule (ACCAR).

Plugging these rules into the computer model, it was clear that ACCAR pilots survived 14% longer than the renegades, and 4.6 times longer than the hemispherical rule pilots. Additionally, the visible time to collision of ACCAR pilots was almost double what renegade and hemispherical rule pilots may expect. While the renegade versus hemispherical rule comparison found a slightly offsetting compromise between the small renegade risk increase for visible time to collision versus the very large renegade risk decrease for frequency of collision, the ACCAR results were uncompromisingly safer in both risks categories.

I know of at least one jet captain whose first response when dealing with an ATC radar or communications outage is to immediately deviate somewhat from course centerline and precise altitudes to get a safety benefit from increased randomness. Intuitively, many pilots know that flying precise altitudes exactly on airway centerlines greatly increases their midair collision risk during temporarily uncontrolled (or erroneously controlled) periods.

Since the 1970s, R.E. Machol has called this problem the "navigation paradox." ACCAR eliminates the paradox of sloppy pilots being safer in any way than accurate ones.

In the event of radar, communications, or human failures at ATC, ACCAR pilots would require no particular compensatory action to maintain safety because ACCAR compliance already maximizes midair collision safety at all times. ACCAR could be a systematically effective backup collision avoidance system requiring no significant costs to either users or the FAA.

Unfortunately, legally using ACCAR above 3,000' agl for level cruising flight would require changes in the FARs – changes the FAA seems loath to make.

In mid-1997 I requested the FAA to issue a Notice of Proposed Rule-making. In my proposal I outlined a plan to replace FARs 91.159 and 91.179 with rules that would enhance safety.

The plan would have eight phases, with each phase refining the use of the new rule.

The first three phases would eliminate the current hemisphere cruising rules and replace them with the altimeter-based rule for both VFR and IFR traffic. Subsequent phases would apply the rule to ATC outages, airport traffic patterns and calculations of fault in the case of accidents.

The FAA, however, was less than receptive.

"The issues identified in your petition may have merit, but do not address an immediate safety concern," responded Lou Cusimano, acting director of Flight Standards Service, in a letter. Cusimano adds that the FAA is constrained to focus only on "the most pressing problems and issues associated with safety."

Cusimano denied the request and said the NPRM, Docket No. 28996, was being closed.

If This Ain't Pressing ...

My first thought was that, if the possibility of a mid-air collision isn't enough of a safety concern, perhaps the FAA would like to consider petitions from pilots who should otherwise be performing evasive maneuvers to avoid an imminent collision. In an attempt to be a little more constructive, I thoroughly reviewed the FAA's Web site of active NPRMs to see what qualified as a pressing problem or issue associated with safety.

I found none that would appear to be as real a threat to as many pilots as the risk of a mid-air collision. Some, such as the overflight restrictions on the Grand Canyon, actually decrease safety by further concentrating aircraft into a smaller slice of sky and appear to meet political objectives rather than safety objectives.

Avoidable Tragedy

To be sure, cruise-flight mid-air collisions are not very common. When they occur, however, they are usually fatal. Consider the crash last July between two ag planes in Iowa. One was returning to the airport for another load of chemicals, the other was heading out fully loaded. It was about 8 a.m. and the sun was low in the eastern sky. One plane was headed northeast and the other was headed southeast.

Under ACCAR, they would have had about 300 feet of vertical separation. Instead, each pilot was squinting into the sun and failed to see and avoid the other plane. Both pilots were killed.

In a widely reported collision involving a U.S. Navy A6E and an Agcat in 1993, both aircraft were low, about 200 feet. The A6E was tracking 033 degrees at 468 knots and the Agcat was headed 334 at 96 knots. With a closure speed of 429 knots, the NTSB concluded that the accident was caused by "the inherent limitations of the see-and-avoid concept of separation of aircraft."

While both the Naval training exercise and the agricultural application flight represent a tiny niche of aviation operations, the collision could just as well have been between a Cessna 172 and a Learjet during a period of ATC radar outage. One pilot missing the target altitude by 300 feet (perhaps aided by an incorrect altimeter setting) and annother who drifted up or down 200 feet is all it would take.

ACCAR could also be applied to ascent and descent during periods of ATC communications or radar failure and to airport traffic patterns, where the majority of mid-air collisions occur.

The FAA, however, is stuck on the current FARs. That means that ACCAR can only legally be used in uncontrolled airspace and under 3,000 feet agl in controlled airspace.

At the very least, this analysis should give you food for thought if ever faced with a controller who's missing traffic calls or during times of ATC radar or communications failures. Add a little randomness to your flying, and you may be rewarded with a safe landing. ■

Robert Patlovany is a commercial pilot and professional engineer. His primary work involves testing the safety of storage schemes for nuclear waste and radioactive weapons parts.

One Approach to Changing the Rules

Phase 1

Delete FARs 91.159 and 91.179

Phase 2

Replace FARs 91.159 and 91.179 with the ACCAR formula at all altitudes above terrain and obstruction clearance altitude (as specified in the existing FARs). All pilots, whether on VFR or IFR flight plans, flying level at a constant altitude for more than three minutes in VMC must cruise on an altitude and heading combination such that if a compass card is superimposed on the altimeter with 360 degrees at the top, then the angle of the actual heading and that of the 100-foot hand of the altimeter are the same.

Phase 3

All traffic on an IFR flight plan in straight and level flight for more than three minutes, whether in controlled or uncontrolled airspace, shall cruise at ACCAR altitudes in IMC.

Phase 4

During periods of Air Traffic Control difficulty due to radar, computer of communications failure, all aircraft normally required to be under ATC control shall cruise, descend and climb in constant conformance to the ACCAR.

Phase 5

All airports with one active runway, whether controlled or not, shall have a standard traffic pattern conforming to the ACCAR heading/altitude formula, unless constrained by other overriding safety concerns. Aircraft shall enter the downwind leg at an altitude corresponding to the runway downwind heading, then descend in a left turn, continuously conforming to ACCAR until intersecting the appropriate final approach glide path from which a normal landing may be made. Departing aircraft shall climb along the runway centerline until reaching an obstruction-clearing ACCAR altitude/heading combination, and then begin a climbing turn to the right in continuous conformity to ACCAR until clear of the standard traffic pattern.

Phase 6

All aircraft within five miles of an airport with one active runway shall conform to ACCAR at all times, unless specifically cleared or instructed otherwise by air traffic control.

Phase 7

All traffic within five miles of airports with any number of active runways shall follow ACCAR for altitude/heading combinations unless specifically cleared or instructed otherwise by air traffic control.

Phase 8

As a parallel path alternative to the implementation of Phases 1 through 7, revise FAR 91.113(b) to recognize that pilots cannot be fully responsible for seeing and avoiding oncoming traffic in certain ranges of closing angles and velocities. Calculations shall be used to evaluate the degree to which any pilot in a particular incident or accident could have been responsible for accident avoidance.

Cruisin' for Bruisin'

Are new cruising altitude rules needed, or is that just heading for trouble?

I really like *Aviation Safety*, but after I read "Climb and Maintain *What*?" [Risk Management, December] I wondered how it got there. Then I thought it might have really been a "plant" to get readers to write on this topic.

I agree that the hemispherical rule has its problems, exactly as outlined. To address these, I was taught during my primary instruction to "fudge" a bit on the altitude. Therefore I might cruise at 4400, or 5650, within 250 ft of the xx,500 ft levels during VFR. In fact, my instructor never wanted us at an even height of x,500 or x,000, even when too low for the hemispherical rule, and I stay away from those altitudes still. In 500 hours, I have had 3 near-misses, separated by only altitude, when I was at a non-even height, and the other airplane was. So, I agree with the premise that the hemispherical rule has its problems.

However, the ACCAR solution proposed has its serious flaws. First and foremost, it requires either a vertical card heading indicator (magnetic or gyroscopic), or some serious mental arithmetic (read: increased cockpit load), particularly during turns near an airport (Phases 5-7) when our primary concern should be eyeball use.

Although the author may always fly with a vertical card heading indicator, they are by no means universal. I have a magnetic compass (standard drum type) and an older AN style DG in my Tripacer. Many older airplanes, even up to the mid '60s came equipped with the AN style. This requires a smaller panel hole than the vertical type, making substitution non-trivial. Many, many aircraft out there have only the drum type magnetic compass, and no gyro capability. Replacement of all these with a vertical card is not feasible in these aircraft. In addition, if the photo of the altimeter and vertical card are in the same aircraft, it is at the wrong altitude. The heading says N, the altimeter 300 feet. If the DG reads the heading (110), as it should, then N would be at 8 o'clock, but the hundreds needle should point to 4 o'clock. (300 feet). Once we install vertical card compasses in every aircraft, shouldn't we at least reward these irate owners with an easier rule? Did the article mean to say the hundreds needle should point where N is? That would be the mirror image of what I read, but one heck of a lot easier to calculate from a vertical card. Furthermore, if Phases 5-7 were ever implemented, there would be a lot of climbing and diving in the traffic pattern. This would be entertaining from the ground, complete with burning mid-airs, but as a pilot I would find it not very much fun. Within 5 miles of an airport is not the time/place to be carving out a piece of sky 1,000 feet thick, as a 360 degree turn would require. I did find the article interesting, but after reading it I rather like the hemispherical rule.

Tom Lubben
Via e-mail

Mr. Patlovany's plan would not require the addition of a vertical card. If the rules were adopted, it would be a simple matter to create a transparent sticker that could be placed right on the altimeter glass, since the inner half of the altimeter face isn't used anyway. As for the confusion in the photograph, the intent was to show the relative angle between the 100' hand and the proper heading of 110 degrees. The bright orange heading bug on the DG washed out to white, making it less obvious than we had hoped. As for traffic pattern operations, the proposals on page 10 clearly gives priority to headings/altitudes assigned by ATC, as is now the case.

What Now for ACCAR?

Your article "Climb and Maintain *What*?" was truly interesting and thought-provoking. I've been reading *Aviation Safety* very appreciatively for years, and the ACCAR is the first really new practical idea for promoting the safety of general aviation that I've seen in a long while.

I didn't write only to convey my thanks and compliment you, however. As a retired federal government lawyer, as well as current general aviation pilot, I'm both interested and concerned about the FAA and its rulemaking practices. It is no surprise that the FAA gave you the back of its hand. A good idea alone is not enough; you need to have a political organization to promote it. I mean, you've got to get the organizations with you, such as EAA. You probably already know this. Do you have a plan to promote the ACCAR idea further? Do you have an expanded write-up, perhaps with more examples than were in the article? What could general aviation pilots such as myself do to help push ACCAR?

Pierre Hartman
Tehachapi, Calif.

For more detail on the mathematics that justify the proposal, Mr. Patolvany's original technical analysis of the cruising altitude rules appears in the April 1997 issue of Risk Analysis, *the monthly journal of the Society for Risk Analysis (703-790-1745). As for furthering the idea politically, we think informing readers is the place to start. The rest, we hope, will follow naturally.*

ACCAR Plan Needs Some Work

Robert Patlovany's suggestions for new cruising altitude rules to minimize the risk of midair collisions is an excellent idea, however, it needs some additional development work.

Execept for the special case where you are flying due north, 360 is not on the top of your compass. Except for an ADF with a non-rotating card, what is on top is your actual heading. So you would either have to reset the card to north, with the attendant risk of error in resetting it back to where it belongs, or so some mental arithmetics, with risk of its own.

Would it not be better to leave the card where it is – indicating the actual heading – and fly so that the 100' needle is where north is on the compass? The problem of light aircraft with nothing beyond a whiskey compass should be easily solved with a rotatable piece of cardboard with a compass rose on it. Having to fly an altitude where the 100' needle points to where north is would eliminate sev-

eral points of potential error, or at least unnecessary distraction.

The article also does not mention altitudes above FL 290, where current rules call for 2,000-foot separation between opposite traffic. Also, how would ACCAR work where it is ATC who assigns the altitude? Would a 747 cruising at FL 390 need a clearance to climb or descend 100 feet when the course changes by 10 degrees? What about the transition to oceanic rules? IFR and VFR mix?

Good idea, but it needs work.

K.A. Skapa
Denver, Colo.

Aircraft operating in Class A airspace would not need ACCAR except during periods of radar outage because they do not rely on "see and avoid," nor do they contain a mix of VFR and IFR traffic. ATC could still assign an altitude of its choice, as happens now when you are assigned altitudes that do not follow the hemispheric cruising altitude rule.

ACCAR an Unnecessary Solution

I am still enjoying your *Aviation Safety* magazine after 45 years flying. I fly IFR almost all of the time, and use ATC flight following as much as possible when VFR. See and avoid is difficult. There are times, when the sun is low, that it blinds us so much we can only hope that someone else can see better than we can. There are times when both of us look at the same thing inside the cabin for periods of a half minute. There are times when the pilot not flying is dealing with paperwork, and the pilot flying is tuning a radio, or trying to get his trim set, or doing something besides looking out the window for traffic. When I fly single pilot I have to do all of this myself. So, when one is available, I enlist a passenger to sit up front and look out too.

Concerning establishing a greater number of VFR altitudes: let me say that the author's proposal to match one's altitude with the relative position of one's heading on the compass rose would be only a little more likely to provide more separation between cruising aircraft. At the same time, the confusion factor is raised again for the pilot trying to memorize another rule.

Now, lets see if actually a lot of people are flying at the same altitude, after all. How many of you know how accurate your altimeters are at any given altitude above 1000 ft? Is the current FAR keeping us apart, is it errors in the altimeters?

As a quick check, dial in the local altimeter setting and see how close you are indicating to field elevation, then go down the flight line and check out 10 more airplanes. If they have all been checked within the last 24 months, as required, two of them may be within 20 feet of each other on the ground. Next check all of the navigation radios and see how accurate they are, then get 10 pilots to see if they can all maintain the same altitude and exact course for over two minutes. In fact, launch them for the same destination at the same time and see if you don't have more random separation than you have random collision factor.

My point is, that actually there is no truth to an equation that assumes that aircraft supposed to be maintaining a given altitude and course line are actually doing so!

There's nothing wrong with staying slightly off of one's selected cruising altitude, except for the potential rule violation, is there? I don't need a computer to do this, nor an FAR, all I need is to pick my own random correction of say 50 feet up or down and I have further decreased the odds of hitting someone else using the same FAA approved altitude. Don't leave out the part where I am saying that we still need to look out and maintain contact with ATC! The next time you survive a near miss, and see another aircraft go just under or over you, wipe your brow and thank the law of natural randomness. It's an automatic separation, that has allowed us to keep things simple and still survive.

John C. Miller
Randleman, NC

We certainly agree with your strategy of introducing an element of randomness, and Mr. Patlovany covers this in his article. Under his plan, however, your risk would decrease even more. Yes, it is more complicated, but his point is that the more closely you conform to the regs the more likely you are to be in a mid-air collision. That's not exactly what we call good incentive for precise flying.

ACCAR Too Extreme a Solution

Robert Patlovany has done an excellent job of documenting the need for a rules change, and his proposed ACCAR, if used properly, would improve altitude separation.

When trying to effect needed change, it may help to consider not only what would be ideal, but also what is most likely to receive serious consideration in an environment where any change is difficult. I speculate that one reason the ACCAR proposal was turned down by the FAA is that it is a radical change that could also be perceived as being too complex to be consistently used properly. Perhaps a compromise proposal could be found that would be more acceptable to the FAA and still be a significant improvement over the current hemispheric rule.

For example, one could substitute a "quadrant rule" in which a magnetic course of 0-89 degrees corresponds to an MSL flight altitude ending in 250, eg. 3,250, 7,250, or 11,250, and then add 250 feet every 90 degrees.

Please continue all your efforts to make aviation as safe as possible.

Geoffrey Swain
Grafton, Wisc.

Keep Berge Coming

I am writing to you to congratulate you on publishing the writing of an absolutely engaging author.

Perhaps you knew the humor potential when you signed up Paul Berge to write the "Pattern of Abuse" article [Proficiency, December]. If true, you are to be commended for knowing how much humor can add to the impact of communications. You earn a Laugh-Out-Loud award for "... the controller tells you how to enter the pattern: 'Make straight in,' 'Enter left base,' 'Go away'..." To know that it's a controller writing the article adds immeasurably to the enjoyment.

Those who lampoon themselves truly know their subjects well.

Perhaps you didn't know about his sense of humor, but had to make an executive decision on whether or not to abide a decidedly off-beat delivery in your august publication, for which I have an enduring respect. If so, good call. Five points and a few options for